HIRSCHMANN IT

A BELDEN BRAND

User Manual

Configuration

MTS Series Switch

User manual
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Technical Support
http://www.belden.com

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Proprietary Notices

Safety Notice

IMPORTANT! Before powering on the product, please read the safety and compatibility information of the product.

Environmental Statement

This product meets the design requirements for environmental protection. The storage, use and disposal of the product shall comply with relevant national laws and regulations.

Target Readers

This manual mainly applies to the following persons:

- Commissioning Engineer
- Field Maintenance Engineer
- System Maintenance Engineer

Manual Conventions

Screen Output Format Conventions

FORMAT	Description
Screen print	indicates screen output information.
Keywords of Screen print	The red information represents the key information in the screen output.

Icon and Symbol Conventions

FORMAT	Description
 Note:	Supplements or emphasizes the foregoing information.
 Notice:	Indicates the content that needs to be paid attention to during the installation or use of the device, which is the key to the correct installation and operation of the device.
 Warning:	Operations prohibited or operations that must be performed in accordance with prescribed steps, otherwise they may cause personal injury or device damage.

Command Format Conventions

FORMAT	Description
bold	Command line keywords (the part of a command that remains unchanged and must be input so) are represented in **Bold** Font.
italic	Command line parameters (the part of a command that must be replaced by actual values) are represented in *Italic*.
Curly bracket "{ }"	Indicates that the option in the brackets is mandatory.
Square brackets "[ ]"	Indicates that the option in the brackets is optional.
Angle brackets "<>"	Indicates that the information in the brackets will not be displayed.
Boldface square brackets "**【】**"	Indicates that the content in the brackets requires the user's attention.
Pipe "|"	used for separating several options, and indicates selecting one of two or one of many.

FORMAT	Description
Slash "/"	For separating several options, it indicates that the separated options are applicable at the same time.
Sign "#"	Lines starting with a "#" are represented as comment lines.

The icons used in this manual and their meanings are as follows:

Icon	Description
	This icon and its related description represent the switch in a general sense.
	This icon and its related description represent a router in a general sense.

Access to Our Information

The latest version of this manual is available from the Hirschmann product website at:

www.doc.hirschmann.com.

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Revision History

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REVISION DATE	Revision Details
November 30, 2020	Released for the first time

Contents

1 System Operation Basics

1.1 Overview

System operation basics mainly describe the basic knowledge of device operations, including system operation basic functions, device configuration modes, command modes, and command line interface.

1.2 System Operation Basic Functions

Table 1-1 System Operation Basic Function Configuration List

Configuration Task	
Device configuration mode	Device configuration mode
Command operating mode	Command operating mode
Command line interface	Command line interface

1.2.1 Device configuration mode

Users can log in to the device for configuration and management in different modes. (For details of the login modes, please refer to the section on "System Login" in the User Manual) The device provides five typical configuration modes:

- Logging in to the device locally through the Console port. By default, users can configure the device directly in this mode.
- Logging in to the device by remote dial-up through a Modem. The device cannot be configured directly in this mode. That is, before configuration, some preparations need to be made.
- Logging in to the device remotely through Telnet. The device cannot be configured directly in this mode. That is, before configuration, some preparations need to be made.
- Logging in to the device remotely through SSH. The device cannot be configured directly in this mode. That is, before configuration, some preparations need to be

made.

- Logging in to the device remotely through WEB. The device cannot be configured directly in this mode. That is, before configuration, some preparations need to be made.

1.2.2 Command operating mode

The device provides a command processing subsystem for management and execution of system commands. The subsystem shell provides the following main functions:

- Registration of system commands
- Editing of system configuration commands by users
- Parsing of the commands that have been inputted by users
- Execution of system commands

If a user configures the device through shell commands, the system provides multiple operating modes for the execution of the commands. Each command mode supports specific configuration commands. In this way, hierarchical protection is provided to the system, protecting it from unauthorized access.

The shell subsystem provides multiple modes for the operating of configuration commands. These modes have different system prompts, prompting the current system mode of the user. The following lists common configuration modes:

- Common user mode (user EXEC)
- Privileged user mode (privilege EXEC)
- Global configuration mode (global configuration)
- Interface configuration mode (interface configuration)
- File system configuration mode (file system configuration)
- Access list configuration mode (access list configuration)
- Other configuration modes (They will be described in the related sections and chapters.)

The following table shows how to enter the common command modes and switch over between the modes.

Table 1-2 System Modes and Methods of Switching Over Between the Modes

Mode	How to Enter the Mode	System Prompt	How to Exit the Mode	Functions
Common user mode	Log in to the device.	Hostname>	Run the **exit** command to exit the mode.	·Change the terminal settings ·Perform basic tests.

Mode	How to Enter the Mode	System Prompt	How to Exit the Mode	Functions
				·Display the system information
Privileged user mode	In common user mode, run the **enable** command.	Hostname#	Run the **disable** or **exit** command to exit to the common user mode.	·Configure the operating parameters of the device ·Display the operating information of the device
Global configuration mode	In privileged user mode, run the configure terminal command.	Hostname(config)#	Run the **exit** command to exit to the privileged user mode.	·Configure the global parameters that are required for the device operation
Interface configuration mode	In global configuration mode, run the **interface** command (while specifying the corresponding interface or interface group).	Hostname(config-if-xxx[number])# or Hostname(config-if-group[number])#	Run the **exit** command to exit to the global configuration mode. Run the **end** command to exit to the privileged user mode.	In this mode, configures device interfaces, including: ·Interfaces of different types ·Interface groups
File system configuration mode	In the privileged user mode, run the **filesystem** command.	Hostname(config-fs)#	Run the **exit** command to exit to the privileged user mode.	·Manage the file system of the device
Access list configura	In global configuration mode, run the **ip**	Hostname(config-std-nacl)# Hostname(config-ext-nacl)#	Run the **exit** command to exit to the global	Configures the Access Control List (ACL). The configuration tasks include:

Mode	How to Enter the Mode	System Prompt	How to Exit the Mode	Functions
tion mode	**access-list standard** or **ip access-list extended** command.		configuration mode. Run the **end** command to exit to the privileged user mode.	·Configure standard access control list ·Configure extended access control list

Note:

- Hostname is the system name. In global configuration mode, a user can run the **hostname** command to modify the system name, and the modification takes effect immediately.
- If a user is not in privileged user mode while the user wants to run a privileged mode command, the user can use the do command to run the required command without the need to returning back to the privileged mode. (For details, refer to the related sections in "System Operation Basics" of the command manual.) Note that the mode switchover command such as *do configure terminal* is not included.

1.2.3 Command line interface

The command line interface is a man-machine interface that is provided by the shell subsystem to configure and use the device. Through the command line interface, users can input and edit commands to perform the required configuration tasks, and they can also query the system information and learn the system operation status.

The command line interface provides the following functions for the users:

- System help information management
- System command inputting and editing
- History command management
- Terminal display system management

Command Line Online Help

The command line provides the following types of online help:

- help
- Full help

- Partial help

Through the above types of online help, users can obtain various help information. The following gives some examples.

- To obtain a brief description of the online help system, enter the **help** command in any command mode.

```
Hostname#help
Help may be requested at any point in a command by entering
a question mark '?'.  If nothing matches, the help list will
be empty and you must backup until entering a '?' shows the
available options.
Two styles of help for command are provided:
1. Full help is available when you are ready to enter a
   command argument (e.g. 'show ?') and describes each possible
   argument.
2. Partial help is provided when an abbreviated argument is entered
   and you want to know what arguments match the input
   (e.g. 'show pr?'.)
And "Edit key" usage is the following:
   CTRL+A -- go to home of current line
   CTRL+E -- go to end of current line
   CTRL+U -- erase all character from home to current cursor
   CTRL+K -- erase all character from current cursor to end
   CTRL+W -- erase a word on the left of current cursor
   CTRL+R -- erase a word on the right of current cursor
   CTRL+D,DEL -- erase a character on current cursor
   BACKSPACE -- erase a character on the left of current cursor
   CTRL+B,LEFT -- current cursor backward a character
   CTRL+F,RIGHT -- current cursor forward a character
```

- To list all commands and their brief description in any command mode, type "?" in the command mode.

```
Hostname#configure terminal
Hostname(config)#?
   aaa                Authentication, Authorization and Accounting
   access-list        Access List
   alarm              Set alarm option of system
   arl                Address translation item
   arp                Set a static ARP entry
   arp-security       To CPU arp security
   autosave           Auto save the startup configuration
   banner             Define a login banner
   bgp                BGP information
   cable-diagnostics  Cable Diagnostics on physical interface
..................................................... ......... .....
```

- Type a command followed by "?", and all sub-commands that can be executed in the current mode are displayed.

```
Hostname#show ?
   access-list        List access lists
   acl-object         Show acl object
   arl                Address translation item
   arp                Command arp
   arp-security       To CPU arp security
   bfd                BFD  Protocol information
   bgp                BGP information
   cable-diagnostics  Cable Diagnostics on physical interface
   card_list          Show information of hardware modules
   clock              Print system clock information
   cluster            Config cluster
```

```
  cpu                Show CPU use per process
..... .....
```

- Type a character string followed by "?", and all the key words starting with the character string and their description are displayed.

```
Hostname#show a?
  access-list        List access lists
  acl-object         Show acl object
  arl                Address translation item
  arp                Command arp
  arp-security       To CPU arp security
```

Command Line Error Messages

For all commands that are typed by users, the command line performs a syntax check. If the commands pass the syntax check, they are executed properly; otherwise, the system reports error messages to the users. The following table shows common error messages.

Table 1-3 Command Line Error Messages

Error Message	Error Cause
% Invalid input detected at '^' marker.	No command or key word is found, the parameter type is incorrect, or the parameter value is not within the valid range.
Type “*** ?” for a list of subcommands or % Incomplete command	The inputted command is incomplete.
Hostname#wh % Ambiguous command: wh % Please select: whoami who	The inputted character string is a fuzzy command.

History Commands

The command line interface provides a function that is similar to the Doskey function. The system automatically saves the user inputted commands into the history command cache. Then, users can invoke the history commands saved by the command line interface at any time and execute the command repeatedly, reducing unnecessary efforts in re-typing the commands. The command line interface saves up to 10 commands for each user that is connected to the device. Then, new commands overwrite old ones.

Table 1-1 Accessing History Commands of the Command Line Interface

To...	Press...	Execution Result
Access the previous history command	The up arrow key ↑ or Ctrl+P keys	If an earlier history command is available, it is displayed. If no earlier history command is available, an alarm sound is played.
Access the next history command	The down arrow key ↓ or Ctrl+P keys	If a later history command is available, it is displayed. If no later command is available, the commands are cleared, and an alarm sound is played.

Note:

- If you want to access history commands by using the up and down arrow keys, when you telnet to the device in the Windows 98 or Windows NT OS, set Terminals > Preferred Options > Simulation Options to VT-100/ANSI.
- History command display is based on the current command mode. For example, if you are in privileged mode, only history commands in privileged mode are displayed.

Editing Features

The command line interface provides basic command editing functions. It supports multi-line editing. Each line of command can contain up to 256 characters. The following table lists the basic editing functions that are provided by the shell subsystem for the command line interface.

Table 1-4 Basic Editing Functions

Press...	Function
A common key	If the edit buffer is not full, the character is inserted to the position of the cursor, and the cursor moves to the right. If the edit buffer is full, an alarm sound is played.
The Backspace key	Deletes the character before the cursor and moves the cursor backward. If the cursor reaches the beginning of the command, an alarm sound is played.
The Delete key	Deletes the character behind the cursor. If the cursor reaches the end of the command, an alarm sound is played.

Press...	Function
The left arrow key ← or Ctrl+B keys	Moves the cursor one characters to the left. If the cursor reaches the beginning of the command, an alarm sound is played.
The right arrow key → or Ctrl+F keys	Moves the cursor one characters to the right. If the cursor reaches the end of the command, an alarm sound is played.
The up and down arrow keys ↑↓	Display history commands.
Ctrl+A	Moves the cursor to the beginning of the command line.
Ctrl+E	Moves the cursor to the end of the command line.
Ctrl+U	Deletes all characters on the left of the cursor till the beginning of the command line.

Display Features

To facilitate users, the command line interface provides the following display features:

If the information to be displayed is more than one screen, the pause function is provided, and the prompt "---MORE---" is displayed at the lower left corner of the screen. At this time, the options displayed in the following table are available for users.

Table 1-5 Display Features

Press...	Function
Space key, down arrow key ↓, or Ctrl-F	Display the next screen.
The up arrow key ↑ or Ctrl-B keys	Display the previous screen.
The Enter key, right arrow key → or equal key =	Scroll the displayed information one line down.
The left arrow key ← or the minus key-	Scroll the displayed information one line up.
Ctrl-H	Returns back to the topmost part of the displayed information.

Press...	Function
Any other keys	Exits the display. Then, the information that has not been displayed will not be displayed.

2System Login

2.1 Overview

The device supports the following system login modes:

- Logging into the device through the Console port for management and maintenance.
- Telnet (remote login). Users can manage and maintain the device remotely in this mode.
- Secure Shell (SSH). Through its encryption and authentication technology, SSH provides secure remote login management services for users.
- WEB (remote login). Users can manage and maintain the device remotely in this mode.

2.2 System Login Function Configuration

Table 2-1 System Login Function Configuration List

Configuration Task	
Logging in to the device through the Console port	-
Logging in to the device through the AUX port	-
Configuring remote login through Telnet	Enable the Telnet service of the device.
	The device acts as a Telnet client for remote login.
Configuring remote login through SSH	Enable the SSH service of the device.
	The device acts as an SSH client for remote login.

Configuration Task	
Configure remote login through WEB.	Configure remote login through HTTP.
	Configure remote login through HTTPS.

Note:

- For the related user configuration of Telnet and SSH remote login, refer to the section on "Login Control and Management" in the User Manual.

2.2.1 Logging in to the device through the Console port

To connect a terminal to the device through the Console port to configure the device, perform the following steps:

Step 1: Select a terminal.

The terminal can be a terminal with a standard RS-232 serial port or an ordinary PC, and the latter one is more frequently used. If the remote dial-up login mode is selected, two Modems are required.

Step 2: Connect the physical connection of the Console port.

Ensure that the terminal or the device that provides the Console port has been powered off, and then connect the RS-232 serial port of the terminal to the Console port of the device. The following figure shows the connection.

Figure 2-1 Connection for Login via the Console Port

Step 3: Configure the HyperTerminal.

After powering on the terminal, you need to set the communication parameters of the terminal, that is, baud rate of 9600 bps, 8 data bits, 1 stop bit, no parity check, and no data stream control. For a PC with the Windows XP or Windows NT OS, run the HyperTerminal program, and set the communication parameters of the serial port of the HyperTerminal according to the previously mentioned settings. The following takes the HyperTerminal in the Windows NT OS for example.

- Create a connection:

Input a connection name, and select a Windows icon for the connection.

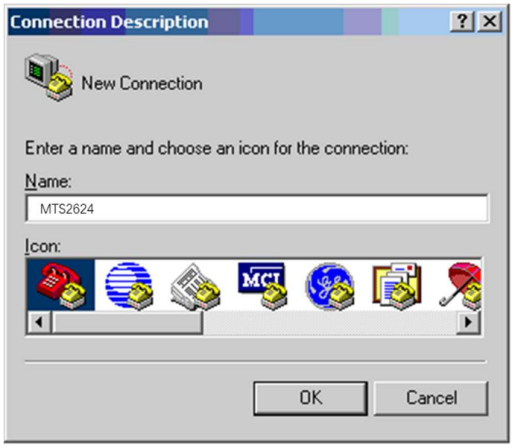


Figure 2-2 Creating a Connection

- Select a serial communication port:

According to the serial communication port that has been connected, select COM1 or COM2.

Figure 2-3 Selecting a Serial Communication Port

- Configure parameters for the serial communication port:

Baud rate: 9600 bps

Data bit: 8 bits

Parity check: None

Stop bit: 1 bit

Data stream control: None

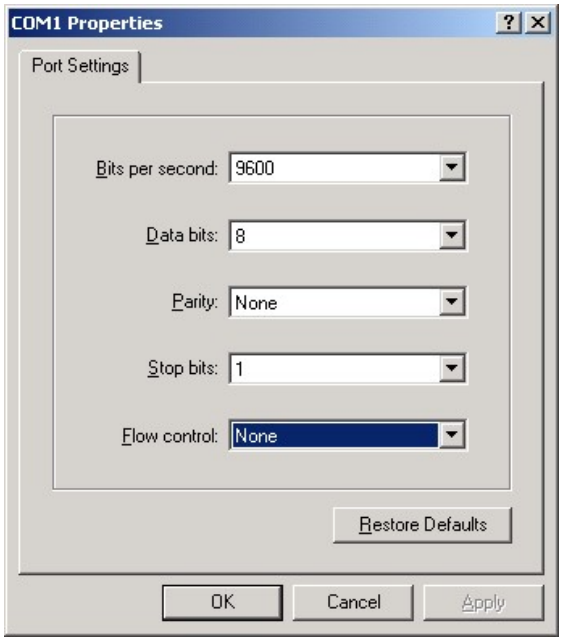


Figure 2-4 Configuring Parameters for the Serial Communication Port

- Login success authentication:

After the device with the Console port is powered on, the startup information of the device is displayed on the terminal. After the startup is completed, the "Press any key to start the shell!" message is displayed. If login authentication is configured to be required, input the user name and password; otherwise, press any key to log in directly. After the login succeeds, the "Hostname>" prompt is displayed on the terminal. Then, you can configure the device.

2.2.2 Configuring remote login through Telnet

Configuration Condition

None

Enable the Telnet service of the device.

A user can log in to the device remotely through Telnet for management and maintenance. Before using the Telnet service, enable the Telnet service of the device. After the Telnet service of the device is enabled, the Telnet service port 23 is monitored.

Table 2-2 Enabling the Telnet Service of the Device

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enable the Telnet service of the device.	**telnet server enable**	Mandatory By default, the Telnet service is enabled.

The device acts as a Telnet client for remote login.

The user takes the device as a Telnet client to log in to the specified Telnet server for configuration and management.

Table 2-3 Taking the Device as a Telnet Client for Remote Login

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the Telnet client of the device.	**telnet client enable**	Optional By default, the Telnet client is enabled.
The device acts as a Telnet client for remote login.	**telnet** [**vrf** *vrf-name*] { *hostname* | *remote-host* } [*port-number*] [**ipv4** | **ipv6**] [**source-interface** *interface-name*]	Mandatory

Note：

- The Telnet client can log in to a remote device only when the Telnet server function of the remote device is enabled, and the network between the Telnet client and the remote device is normal.

2.2.3 Configuring remote login through SSH

Configuration Condition

None

Enable the SSH service of the device.

After the SSH server of a device is enabled, the device accepts the connection request initiated by the user from the SSHv1 or SSHv2 client. After the client passes the authentication, the client can access the device. After the SSH service of the device is enabled, the SSH service port 22 is monitored. If the **ip ssh server** command is configured without parameter **sshv1-compatible**, it indicates that an SSH client can log in only through SSHv2.

Table 2-4 Enabling the SSH Service of the Device

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enable the SSH service of the device.	**ip ssh server** [*listen-port*][**sshv1-compatible**] [*listen-port*]	Mandatory By default, the SSH service is disabled.

The device acts as an SSH client for remote login.

The device acts as an SSH client to log in to the specified SSH server remotely through the SSHv1 or SSHv2 protocol. During the login, a user name and a password are required for authentication from the SSH server.

Table 2-5 Taking the Device as a Telnet Client for Remote Login

Step	Command	Description
The device acts as an SSH client for remote login.	**ssh** [**vrf** *vrf-name*] **version** { **1 | 2** } *remote-host port-number***[source-interface** *interface-name* **]** *user* **auth-method 1** *password*	Mandatory

Note：

- The Telnet client can log in to a remote device only when the SSH service of the remote device is enabled, and the network between the SSH client and the remote device is normal.

The Device Acts as an SFTP Client to Access SFTP Server

The device acts as an SFTP client to log in to a specified SFTP server remotely through the SSHv2 protocol. During the login, a user name and a password are required for authentication from the SFTP server. The SFTP client can download files from the SFTP server or upload files to the SFTP server upon successful login.

Table 2-6 Taking the Device as an SFTP Client to Access SFTP Server

Step	Command	Description
The Device Acts as an SFTP Client to Access SFTP Server	**sftp {get | put}** [**vrf** *vrf-name*] *remote-host port-number* [**source-interface** *interface-name*] *user password src-filename dst-filename* **[compress]**	Mandatory

Note：

- The SFTP client can log in to a remote device only when the SSH service of the remote device is enabled, and the network between the SFTP client and the remote device is normal.

2.2.4 Configure remote login through WEB.

To facilitate the configuration and maintenance of network devices, the device provides WEB-based network management function. The device provides a built-in WEB server that allows you to log in to the device from PC and use the WEB interface to configure and maintain the device directly.

The device supports two login modes for the built-in WEB server: HTTP login mode and HTTPS login mode.

The device supports IPv4 WEB login and IPv6 WEB login.

Configuration Condition

None

Configure remote login through HTTP.

A user can log in to the device remotely through HTTP for management and maintenance. Before logging in to the HTTP device via HTPP, enable the HTTP service of the device.

Table 2-7 Configuring Remote Login Through HTTP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the HTTP server.	**ip http server**	Mandatory By default, the WEB server is not enabled.
Configure the HTTP server port.	**ip http port** *port_number*	Optional By default, the HTTP server port number is 80.

Note：

- Before starting the HTTP server, copy the corresponding WBROM files to /flash.

Configure remote login through HTTPS.

A user can log in to the device remotely through HTTPS for management and maintenance. Before logging in to the HTTPS device via HTPP, enable the HTTPS service of the device.

Table 2-8 Configuring Remote Login Through HTTPS

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the HTTP server.	**ip http server**	Mandatory By default, the WEB server is not enabled.
Enable the HTTPS server.	**ip http secure-server**	Mandatory By default, the WEB server is not enabled.
Configure the HTTPS server port.	**ip http port** *port_number*	Optional By default, the HTTPS server port number is 443.

Step	Command	Description
Configure certificates used in the HTTPS service.	**ip http certificate** *ca-store*	Optional By default, the HTTPS service uses self-signed certificate.

Note:

- For the configuration of trust domain and certificate import, please refer to the section on "PKI".

2.2.5 System Login Monitoring and Maintaining

Table 2-9 System Login Monitoring and Maintaining

Command	Description
show fingerprint	Display the fingerprint information of the SSH public key.
show ip http	Display the WEB configuration information.
show ip http login-user	Display the user information after successful WEB login.
show ip http restricted-user	Display the user information after failed WEB login.
show ip http statistics	Display the WEB server statistics information.

2.3 Typical Configuration of System Login Example.

2.3.1 Configure a Local Terminal to Telnet to the Device.

Network Requirements

- A PC is used as a local terminal to log in to the device through Telnet.

- A route must be available between the PC and the device.

Network Topology

Figure 2-5 Network Topology for Configuring a Local Terminal to Telnet to the Device

Configuration Steps

Step 1: Create Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure the enable password.

```
Device#configure terminal
Device(config)#enable password admin
```

Step 4: Telnet to the device.

#On the PC, run the Telnet program, and input the IP address of VLAN 2.

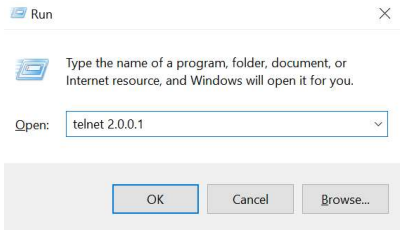


Figure 2-6 Telnet to the Device on PC

Step 5: Check the result.

#If the login succeeds, a window as shown in the following figure is displayed.

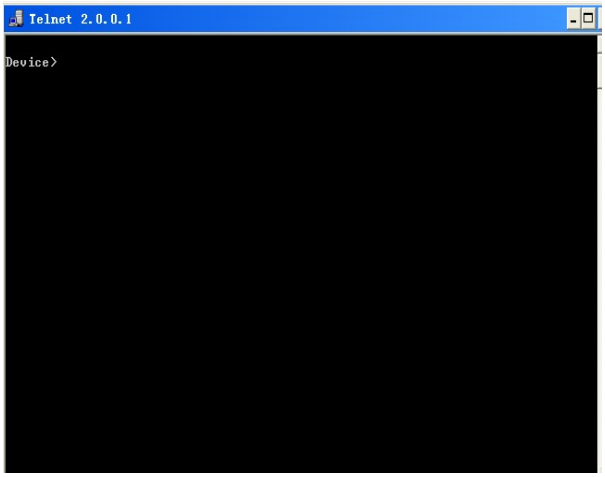


Figure 2-7 Window Displayed after Telnet Success

After logging in to the device Device successfully, input the correct enable password to obtain the required operation rights of the device. To log out of the device, input the exit command continuously.

Note：

- If the "Too many clients or invalid access" message is displayed, it indicates that the number of login users has reached the maximum allowed number of login users of the device. In this case, wait a while and try to log in again.
- If the "%enable operation is locked by login-secure service" message is displayed, it indicates that the number of enable password input errors exceeds the number of continuous login authentication failures. If the number of enable password input errors reaches the number specified by the system, the system rejects the login connection request from the IP address during the specified time.
- If the "Password required, but none set" message is displayed, it indicates that no login password has been configured.

2.3.2 Configure a Local Device to Log in to a Remote Device via Telnet

Network Requirements

- The local device Device1 acts as the Telnet client, while the remote device Device2 acts as the Telnet server.
- A route must be available between the two devices.
- The PC can normally log in to Device1.

Network Topology

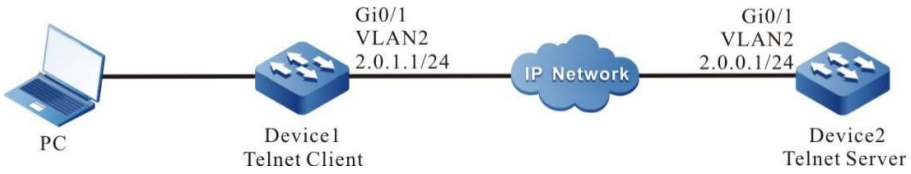


Figure 2-8 Network Topology for Configuring a Local Device to Telnet to a Remote Device

Configuration Steps

Step 1: Create Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Log in to Device1 through the PC. (Omitted)

Step 4: On Device1, run the following command to Telnet to Device2.

```
Device1#telnet 2.0.0.1
```

#Enter the shell screen of Device2.

```
Connect to 2.0.0.1 ...done
Device2>
```

After logging in to the device Device2 successfully, input the correct enable password to obtain the required operation rights of the device. To log out of the device, input the exit command continuously.

Note

- If the "Too many clients or invalid access" message is displayed, it indicates that the number of login users has reached the maximum allowed number of login users of the device. In this case, wait a while and try to log in again.
- If the "%enable operation is locked by login-secure service" message is displayed, it indicates that the number of enable password input errors exceeds the number of continuous login authentication failures. If the number of enable password input errors reaches the number specified by the system, the system rejects the login connection request from the IP address during the specified time.
- If the "Password required, but none set" message is displayed, it indicates that no login password has been configured within line vty.

2.3.3 Configure a Local Device to Log in to a Remote Device via SSH

Network Requirements

- The local device Device1 acts as the SSH client, while the remote device Device2 acts as the SSH server.
- A route must be available between the two devices.
- The PC can normally log in to Device1.

Network Topology

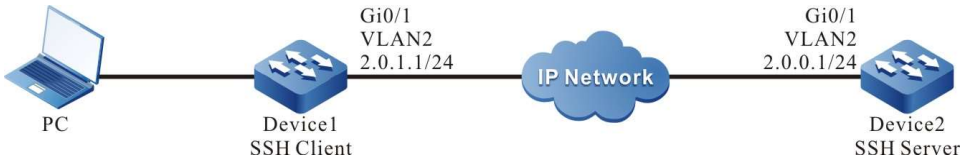


Figure 2-9 Network Topology for Configuring a Local Device to Log in to a Remote Device via SSH

Configuration Steps

Step 1: Create Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure a local user and the related properties.

#Configure the user name and password of Device2.

```
Device2#configure terminal
Device2(config)#local-user admin1 class manager
Device2(config-user-manager-admin1)#service-type ssh
Device2(config-user-manager-admin1)#password 0 admin1
Device2(config-user-manager-admin1)#exit
```

Step 4: Enable the SSH server function of Device2.

```
Device2(config)#ip ssh server
```

Step 5: Set the login authentication mode to local authentication.

```
Device2(config)#line vty 0 15
Device2(config-line)#login aaa
Device2(config-line)#exit
```

Step 6: #On Device1, log in to Device2 through SSH.

#Configure Device1 to log in to Device2 through SSH.

```
Device1#ssh  version 2 2.0.0.1 22 admin1 auth-method 1 admin1
The authenticity of host '2.0.0.1' can't be established
RSA key fingerprint is 7b:ed:cc:81:cf:12:36:6f:f7:ff:29:15:63:75:64:10.
Are you sure you want to continue connecting (yes/no)? yes
Device2>
```

Step 7: Check the result.

If the login succeeds, the shell screen of Device2 is displayed.

Note:

- If the "Connection closed by foreign host" message is displayed, it indicates that the SSH service of the peer end is disabled, or the inputted user name or password is incorrect.
- The SSH server can be configured not to use authentication. If the SSH server does not use authentication, when a client logs in, a user can use any character string as the user name and password.

2.3.4 Configure a Device as an SFTP Client

Network Requirements

- Take the PC as an SFTP server, and the device acts as an SFTP client. The network between the server and the device is normal.
- On the SFTP server, the user name for a device to log in to the FTP server is admin, and the password is admin. The files to be downloaded are placed in the SFTP server directory.
- The device acts as the SFTP client to upload files to and download files from the SFTP server.

Network Topology

Figure 2-10 Network Topology for Configuring the Device as an SFTP Client

Configuration Steps

Step 1: Create Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configure an SFTP server, and place the files to be downloaded in the SFTP server directory. (Omitted)

Step 3: Configure the IP addresses of the devices so that the network between the client and the server is normal. (Omitted)

Step 4: Device acts as the SFTP client to upload files to and download files from the SFTP server.

#Download a file from the SFTP server to the file system of the device.

```
Device#sftp get 2.0.0.1 22 admin admin sp8-g-6.6.7(46)-dbg.pck sp8-g-6.6.7(46)-dbg.pck
The authenticity of host '2.0.0.1 (2.0.0.1)' can't be established.
RSA key fingerprint is e4:dd:11:2e:82:34:ab:62:59:1c:c8:62:1d:4b:48:99.
Are you sure you want to continue connecting (yes/no)? yes

Downloading##############################################################################################
##############################################OK!
```

#Upload the startup file in the file system of Device to the SFTP server.

```
Device#sftp put 2.0.0.1 22 admin admin startup startup.txt
The authenticity of host '2.0.0.1 (2.0.0.1)' can't be established.
RSA key fingerprint is e4:dd:11:2e:82:34:ab:62:59:1c:c8:62:1d:4b:48:99.
Are you sure you want to continue connecting (yes/no)? yes


Uploading###############################################################################################
#################################################################OK!
```

Step 5: Check the result.

#After the copy process is completed, check whether the downloaded file exists in the file system of the device. In the SFTP server, check whether the uploaded file exists. (Omitted)

```
Device(config-fs)#dir
  size         date      time      name
--------      ------    ------   --------
101526     MAR-01-2015  01:17:18   logging
10147      MAR-26-2015  07:58:50   startup
10207      MAR-01-2015  01:17:54   history
11676148   MAR-26-2013  07:51:32  sp8-g-6.6.7(46)-dbg.pck
2048       JAN-10-2015  17:30:20   snmp            <DIR>
```

2.3.5 Configure a Device as an SFTP Server

Network Requirements

- The device acts as an SFTP server, while PC acts as an SFTP client. The network between the client and the server is normal.
- On the SFTP server Device, the user name is admin1, and the password is admin1. The file system directory of the device acts as the root directory of the SFTP server.
- The PC acts as the SFTP client to upload files to and download files from the SFTP server device.

Network Topology

Figure 2-11 Network Topology for Configuring the Device as an SFTP Server

Configuration Steps

Step 1: Create Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports so that the network between the PC and the device is normal. (Omitted)

Step 3: On Device, enable the SFTP service, and configure the authorized user name and password.

#On the SFTP server Device, configure the authorized user name and password.

```
Device#configure terminal
Device(config)#local-user admin1 class manager
Device(config-user-manager-admin1)#service-type ssh
Device(config-user-manager-admin1)#password 0 admin1
Device(config-user-manager-admin1)#exit
```

#Enable SSH service on Device (SFTP is a sub-module of the SSH protocol)

```
Device(config)#ip ssh server
```

Step 4: The PC acts as the SFTP client to upload files to and download files from the SFTP server Device.

#In the following part, the Linux system is taken as an example to illustrate the process.

#Input the correct IP address, user name, and password to log in to the SFTP server.

```
[root@aas ~]# sftp admin1@2.1.1.1
Connecting to 2.1.1.1...
admin@2.1.1.1's password:
sftp>
```

#Obtain the startup file in the file system of the SFTP server Device.

```
sftp> get startup startup
Fetching /flash/startup to startup
/flash/startup                                    100%   13KB  12.9KB/s   00:00
```

#After the file copy process is completed, the file is available in the specified operation directory.

```
sftp> ls
sp8-g-6.6.7(74)-dbg.pck   sp8-g-6.6.7(76)-dbg.pck   startup          tech          test_pc
sftp>
```

#Upload the files in the PC to the file system of SFTP server Device.

```
sftp> put sp8-g-6.6.7(76)-dbg.pck sp8-g-6.6.7(76)-dbg.pck
Uploading sp8-g-6.6.7(76)-dbg.pck to /flash/ sp8-g-6.6.7(76)-dbg.pck
sp8-g-6.6.7(76)-dbg.pck                           100% 11424KB  16.0KB/s   00:00
```

#After the file copy process is completed, the file is available in the file system of the device.

```
Device(config-fs)#dir
  size          date         time       name
------------    ------       ------    --------
2048            JUN-30-2015  16:35:50   tech             <DIR>
10229           JUN-12-2015  14:31:22   history
101890          JUN-30-2015  17:46:40   logging
39755           JUN-30-2015  16:33:56   startup
740574          MAY-27-2014  18:55:14   web-Spl-1.1.243.rom
2048            JUN-27-2015  16:26:10   snmp             <DIR>
11698172        JUN-30-2015  10:36:18   sp8-g-6.6.7(76)-dbg.pck
```

2.3.6 Configure a Local Device to Log in to a Remote Device via SSH Public Key Authentication

Network Requirements

- A PC is used as a local terminal where the SecureCRT software is installed.
- A PC is used as a local terminal to log in to the device via SSH public key.

Network Topology

Figure 2-12 Network Topology for Configuring a Local Device to Log in to a Remote Device via SSH Public Key Authentication

Configuration Steps

Step 1: Configure IP addresses for the ports and configure the routing protocol to enable intercommunication between the PC and Device. (Omitted).

Step 2: Configure SSH service and FTP function.

```
Device#configure terminal
Device(config)#ip ssh server
```

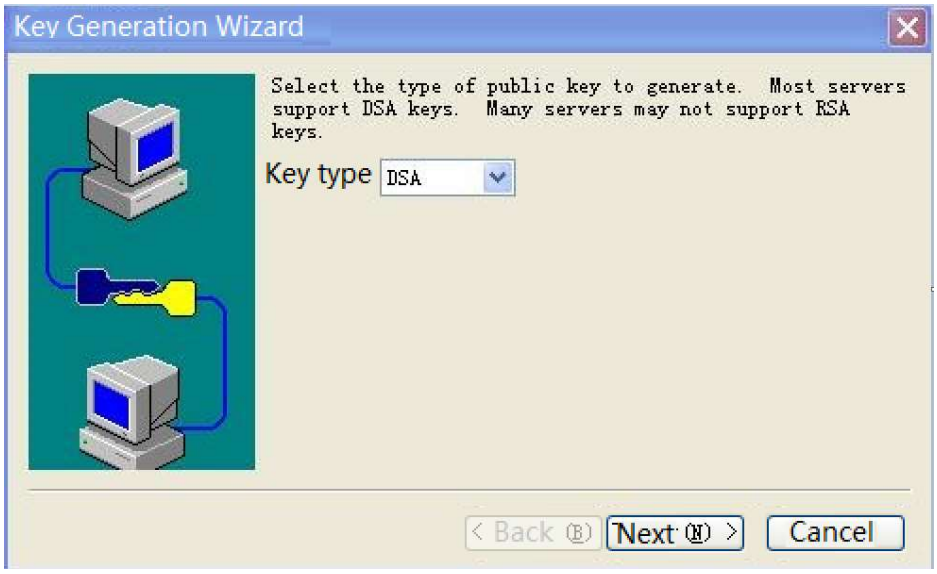
Step 3: Configure the login user name for Device.

```
Device(config)#local-user user1 class manager
Device(config-user-manager-user1)#service-type ssh
Device(config-user-manager-user1)#exit
```

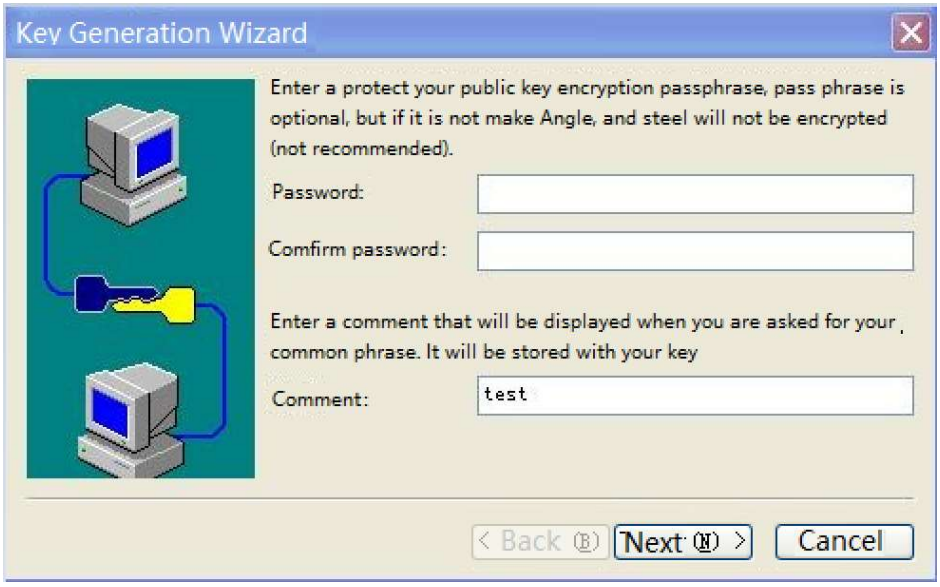
Step 4: Generate the SSH public key file on the PC.

Windows operating system is used as an example herein, and Version 6.1.2 of SecureCRT is used. Open the SecureCRT software toolbar on the PC and click on "Tools", then click on "Create Public Key (C)" in the drop-down menu, the key generation wizard will pop up, click on Next.

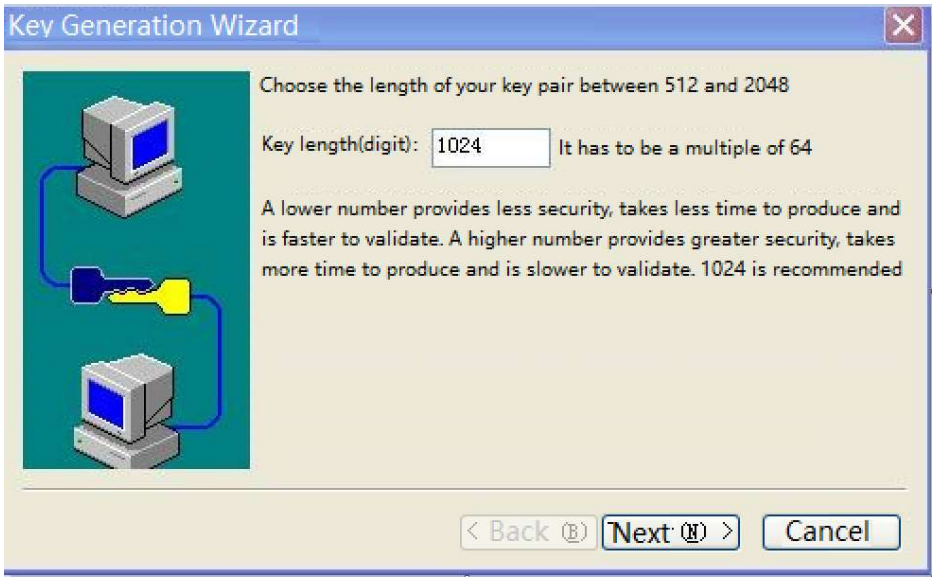
Key type, choose either from DSA and RSA, here DSA is chosen as an example, click on Next.



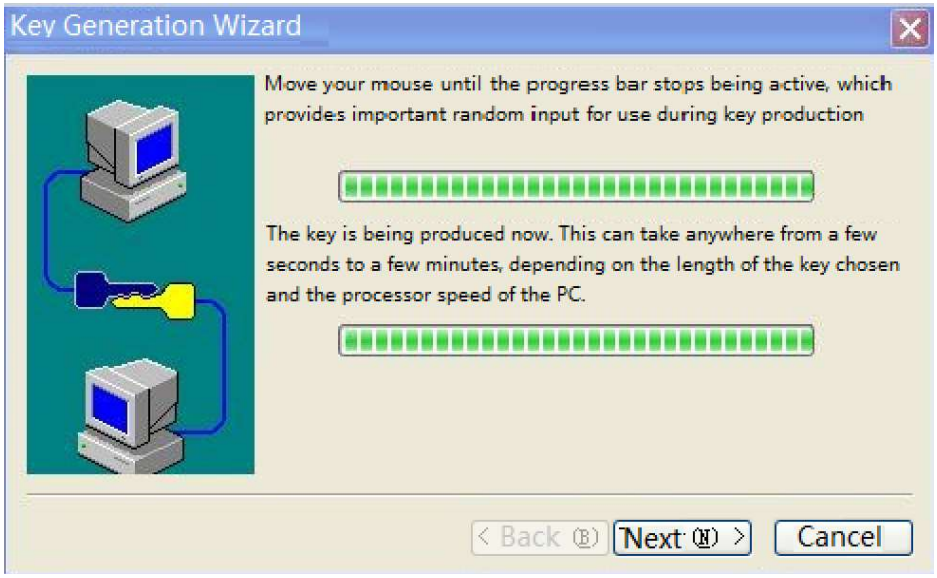
#Passphrase is locally valid and can be ignored, click on Next.



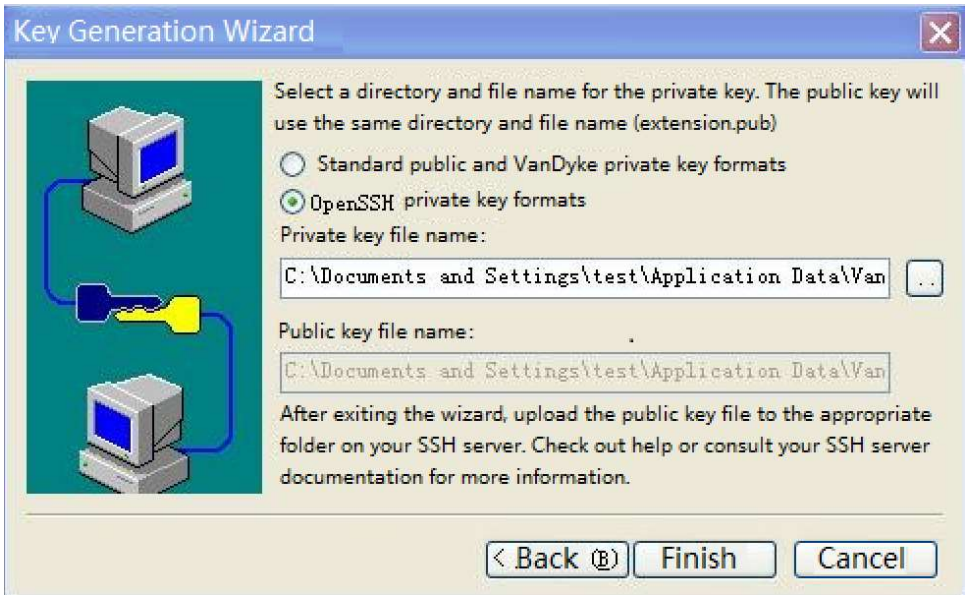
\#Key length to be filled in according to the instructions, click on Next.



#Key generation, you need to keep moving the mouse, after the key is generated, click on Next.



#Select the storage key format, note that here you must select the OpenSSH key format, click "Finish".



#Create the file "authorized_keys" in the FTP server path of the PC, copy all the contents of the public key file "Identity.pub" to "authorized_keys". authorized_keys", and Device will copy the file "authorized_keys" to the path /flash/sshpubkey/user1/.

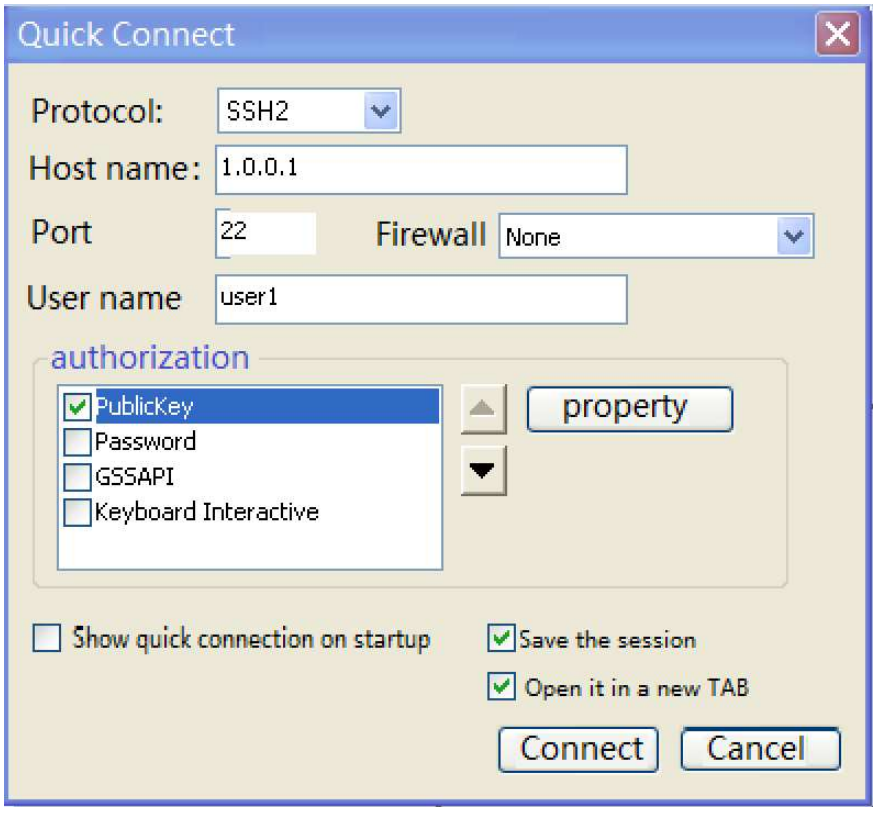
```
Device#filesystem
Device(config-fs)#mkdir sshpubkey
Device(config-fs)#cd sshpubkey
Device(config-fs)#mkdir user1
Device(config-fs)#cd user1
Device(config-fs)#copy ftp 2.0.0.1 username password authorized_keys file-system authorized_keys
```

Note:

- OpenSSH must be selected as the storage key format, other formats are not supported.
- When copying the content of "Identity.pub", you need to select all and then copy it without line breaks.
- When there are multiple clients logging in with the same user name, paste another public key after the public key information stored in "authorized_keys" in a new line, and so on.
- By default, the device does not have the directory /flash/sshpubkey/user1/ and needs to be created in filesystem, where user1 is the user name used for authentication and the user name is the user existing on the device, if the user name is user2, then /flash/sshpubkey/user2/ needs to be created.
- SSH public key authentication does not support SSHv1 version.

Step 5: Check the result.

The PC uses SecureCRT software to establish an SSH connection, using publickey priority or unique authentication, click on "Connect" to see that the connection will not be asked for a password and can log in to the device directly.



3System Control and Management

3.1 Overview

To enhance the operation security of the device, in user login or enable operation, the device provides multiple authentication management types (including AAA. Refer to the related sections and chapters in AAA configuration manual.) Only the user with the required operation rights can log in or perform the enable operation successfully.

To authorize different set of executable commands to different level of users, the device commands are divided into levels 0-15, and user levels are divided into levels 0-15. Among the levels, level 0 has the lowest rights while level 15 has the highest rights.

3.2 Login Control and Management Function Configuration

Table 3-1 Login Control and Management Configuration List

Configuration Task	
Switch over between user levels.	Switch over between user levels.
Configure the command level.	Configure the command level.
Configure the enable password.	Configure the enable password.
Configure users and the related properties.	Configure auto commands.
	Configure no password authentication during login.
	Configure user passwords.
	Configure the user privilege level.
Configure line properties.	Enter the line configuration mode of the Console port.

Configuration Task	
	Enter the line configuration mode of the Telnet or SSH user.
	Configure Absolute Time for Login User Operation
	Configure the privilege level of the login user.
	Configure users to automatically execute commands after login.
	Configure auto command execution options.
	Configure login user idle timeout time.
	Configure the line password.
	Configure the login authentication mode.
	Configure the line authorization mode.
	Configure the line accounting mode.
	Enable the Modem function of the Console port.
	Configure the user login timeout time.

3.2.1 Switch over between user levels.

If a user name and password of the corresponding level is configured, the user can run the enable level (0-15) command and then enter the correct password to enter the required user level. Meanwhile, the user has the execute permission of the user level and the lower levels.

If the current user level is higher than the user level that the user wants to enter, then no authentication is required, and the user directly enters the required user level. If the user level that the user wants to enter is higher than the current user level, authentication is required according to the current configuration, and the authentication mode is selected according to the configuration.

If the enable password of the corresponding level has been configured (by using the **enable password level** command), while the enable authentication of Authorization, Authentication and Accounting (AAA) is not configured or the AAA enable authentication is set to use the enable method, use the enable password for authentication.

If the enable password of the required level has not been configured, but the enable authentication method is set to use the local enable password for authentication, there are two cases:

a) In the case of a Telnet user, the login fails. If AAA has not been configured, the "% No password set" is prompted. If AAA has been configured, the "% Error in authentication" message is prompted.

b) For a Console port user, if AAA has been configured, try to use the enable password for authentication during the login. If the enable password has not been configured, use the none authentication method. That is, the login passes the authentication by default. If AAA has not been configured, the "% No password set" message is prompted, and the authentication fails.

If enable authentication succeeds, the user enters the specified user level and the user has execution permission of the level. To query the user level of the current user, run the **show privilege** command.

If the aaa authentication enable-method is configured and a related method list is used to enable authentication, then the related method is required for authentication, including:

a) If aaa authentication enable-method none is configured, no password is required.

b) If aaa authentication enable-method enable is configured, and the enable password is configured, use the password for authentication. Otherwise, the "% Bad passwords" message is prompted, and the authentication fails.

c) If aaa authentication enable default radius is configured, Remote Authentication Dial in User Service (RADIUS) authentication is used. Note that the enable authentication user names for RADIUS are fixed, that is, $enab+level$. Here "level" is a number in the range of 1-15, that is, the level that the user wants to enter. The RADIUS user names are fixed, therefore, during authentication, no user name is required. The user needs only to input the password. If passwords have been set for users of different levels on the RADIUS server, after inputting the correct password, the login succeeds; otherwise, the login fails. For example, in running the enable 10 command, the fixed user name is $enab10$. If the user name exists on the RADIUS server, input the password corresponding to the user name, and then the authentication succeeds.

d) If aaa authentication enable default tacacs is configured, Terminal Access Controller Access Control System (TACACS) authentication is used. If the user name is displayed during login, keep the user name for login, and input the enable password of the user name. Otherwise, input a user name and the enable password of the user name. If the inputted user name exists in the TACACS server and the enable password of the TACACS has been set, the authentication succeeds; otherwise, the authentication fails.

Note:

- The previously mentioned enable authentication methods can form a combination in use.

None

Switch over between user levels.

If a user has the corresponding authority, the user can switch from the common user mode to the privileged user mode by switching over between user levels with a command. Then, the user has the authority of the user level. If a user runs the command in the privileged user mode, the user level switchover is performed according to the command parameter.

Table 3-2 Switching Over Between User Levels

Step	Command	Description
Switch over between user levels.	**enable** [*level-number*]	Mandatory By default, the user level is level 15.

3.2.2 Configure the command level.

Configuration Condition

None

Configure the command level.

In the application program, each shell command has a default level, which can be modified through the **privilege** command. A user can execute only the commands with the level equal to or smaller than the user level. For example, a user with the user level 12 can execute only the commands with the levels 0-12. In configuring the command level, you need to make use of command modes. You can modify the level of a single command or all commands in a specified command mode.

Table 3-3 Configuring the Command Level

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the command level.	**privilege** *privilege-mode* **level** *level-number* [**all | command** *command-line*]	Mandatory

3.2.3 Configure the enable password.

Configuration Condition

None

Configure the enable password.

The enable password is the password that is used by a level of users to enter the local level. If no level is specified in the enable command, the password is set as the enable password of level 15 by default.

Table 3-4 Configuring Enable Password

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the enable password.	**enable password** [**level** *level-number*] [**0**] *password*	Mandatory By default, no enable password is configured.

3.2.4 Configure line properties.

The device supports up to one Console port user and 16 Telnet or SSH users to log in at the same time. Line commands can set different authentication and authorization properties for the login users.

Configuration Condition

None

Enter the line configuration mode of the Console port.

To configure the Console port properties, you need to enter the line configuration mode of the Console port.

Table 3-5 Entering the Line Configuration Mode of the Console Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Console port.	**line con 0**	Mandatory

Enter the line configuration mode of the Telnet or SSH user.

To configure the Telnet or SSH properties, you need to enter the line configuration mode of Telnet of SSH.

Table 3-6 Entering the Line Configuration Mode of the Telnet or SSH User

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Telnet or SSH user.	**line vty** { *vty-min-number* } [*vty-max-number*]	Mandatory

Configure Absolute Time for Login User Operation

The absolute time for the login user operation refer to the timeout time from the successful login of a user to the automatic exit of the user, in the unit of minute. If the absolute time is set to 0, it indicates that the time is not limited. By default, the time is 0. In addition, five seconds before the configured time expires, the following prompt message is displayed: Line timeout expired.

Table 3-7 Configuring the Absolute Time for the Login User Operation

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Console port or Virtual Type Terminal (VTY).	**line** { **con 0** | **vty** *vty-min-number* [*vty-max-number*] }	Mandatory
Configure the absolute time for the login user operation.	**absolute-timeout** *absolute-timeout-number*	Mandatory By default, the absolute time is 0, that is, no time limit.

Configure Privilege Level of Login User

Configure the privilege level of the login user. The default privilege level is 1. A user can execute only the commands with the level equal to or smaller than the current level.

Table 3-8 Configuring the Privilege Level of the Login User

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the line configuration mode of the Console port or Virtual Type Terminal (VTY).	**line** { **con 0** | **vty** *vty-min-number* [*vty-max-number*] }	Mandatory
Configure the privilege level of the login user.	**privilege level** *level-number*	Mandatory By default, the authorized user level is 1.

Configure Access Control List

Configure the user Access Control List (ACL) so that only hosts allowed by the ACL can log in to the device.

Table 3-9 Configuring Line Access Control List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of Virtual Type Terminal (VTY).	**line** { **vty** *vty-min-number* [*vty-max-number*] }	Mandatory
Configure Access Control List	**access-class** { *access-list-number* | *access-list-name*} { **in | out**}	Mandatory
Configure ipv6 ACL Control List	**ipv6 access-class**{*access-list-number* | *access-list-name* }{ **in | out**}	Optional

Configure users to automatically execute commands after login.

Configure the commands to be automatically executed after users successfully log in. By default, no command is to be automatically executed.

Table 3-10 Configuring the Commands to be Automatically Executed after Successful Login

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Console port or Virtual Type Terminal (VTY).	**line** { **con 0** | **vty** *vty-min-number* [*vty-max-number*] }	Mandatory
Configure the commands to be automatically executed after successful login.	**autocommand** *command-line*	Mandatory

Configure auto command execution options.

You can configure delay time for auto commands, and configure whether to disconnect the user connection after the commands are executed automatically. By default, the command execution is not delayed, and the user connection is disconnected after the commands are executed automatically.

The auto command execution options include delay and whether to disconnect the user connection after command execution.

Table 3-11 Configuring Auto Command Execution Options

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Console port or Virtual Type Terminal (VTY).	**line** { **con 0** | **vty** *vty-min-number* [*vty-max-number*] }	Mandatory
Configure the auto command execution options.	**autocommand-option** { **nohangup** [**delay** *delay-time-number*] | **delay** *delay-time-number* [**nohangup**] }	Mandatory

Note:

- The autocommand-option command is valid only after the autocommand function is

configured.

Configure login user idle timeout time.

If the time in which login user does not perform any operation on the device is longer than the idle timeout time, the device make the current login user to log out. The default idle timeout exit time is 5 minutes. If the time is set to 0, then idle timeout does not take effect.

Table 3-12 Configuring the Idle Timeout Exit Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Console port or Virtual Type Terminal (VTY).	**line** { **con 0** | **vty** *vty-min-number* [*vty-max-number*] }	Mandatory
Configuring the idle timeout exit time.	**exec-timeout** *exec-timeout-minute_number* [*exec-timeout-second_number*]	Mandatory The default idle timeout exit time is 5 minutes.

Configure the line password.

Use 0 and 7 to indicate whether the line password is in plain text or cipher text. 0 indicates that the password is in plain text while 7 indicates that the password is in cipher text. In interaction mode, only plain-text password is allowed. That is, in this mode, only the parameter value 0 is used.

Table 3-13 Configuring the Line Password

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Console port or Virtual Type Terminal (VTY).	**line** { **con 0** | **vty** *vty-min-number* [*vty-max-number*] }	Mandatory
Configure the line password.	**password 0** *password*	Mandatory

Configure the login authentication mode.

The device supports the following login authentication modes:

Login authentication using login password: the line password authentication is used.

Login authentication using login aaa: AAA authentication is used.

No login means that no authentication is required to log in.

Telnet uses the no login authentication mode by default, and SSH uses the local user authentication mode by default.

Table 3-14 Configuring Login Authentication Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Console port or Virtual Type Terminal (VTY).	**line** { **con 0** | **vty** *vty-min-number* [*vty-max-number*] }	Mandatory
Configure the login authentication mode.	**login {aaa [** *domain-name* **| default] | password}**	This command affects AAA authentication, authorization, and billing.

Configure the user login timeout time.

When a user logs in to the device, if the waiting time for entering the user name or password times out, then the system will prompt a login failure. By default, the timeout time for login is 30 seconds. Users can configure the timeout time for login using this function.

Table 15-3 Configuring the Timeout Time for User Login

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the line configuration mode of the Console port or Virtual Type Terminal (VTY).	**line** { **con 0** | **vty** *vty-min-number* [*vty-max-number*] }	Mandatory

Step	Command	Description
Configure the timeout time for user login.	**timeout login respond** *respond-time-value*	Mandatory By default, the time to enter the username or password before the session timeout is 30 seconds.

3.2.5 System Control and Management Monitoring and Maintaining

Table 3-16 System Control and Management Monitoring and Maintaining

Command	Description
clear line { **con** *con-number* | **vty** *vty-number* }	Clear a terminal service.
show privilege	View the privilege level of the current user.
show users	Display the configured user information.

4FTP, FTPS, TFTP and SFTP.

4.1 Overview

File Transfer Protocol (FTP) is used between a server and a client to transmit files. It improves file sharing, and provides an efficient and reliable data transmission mode between the user and remote computer. The FTP protocol usually uses TCP port 20 and 21 for transmission. Port 20 transmits data in active mode, and port 21 transmits control messages.

Similar to most Internet services, FTP uses the client/server communication mechanism. To connect to an FTP server, usually you are required to have the authorized account of the FTP server. On the Internet, a large number of FTP servers are anonymous FTP servers, which aim at provide file copying services to the public. For this type of FTP server, users need not register with the server or obtain authorization from the FTP servers.

FTP supports two types of file transmission modes:

- ASCII transmission mode, in which text files are transmitted.
- Binary transmission mode, in which program files are transmitted.

If the device acts as an FTP client, only the binary transmission mode is supported. If the device acts as an FTP server, both transmission modes are supported.

FTP supports two working modes:

- Active mode: An FTP client first sets up a connection with an FTP server through the TCP21 port and sends commands through this channel. If the FTP client wants to receive data, it sends the PORT command through this channel. The PORT command contains through which port the client receives data. Then the FTP server connects its TCP20 port to the specified port of the FTP client to transmit data. The FTP server must set up a new connection with the FTP client to transmit data.
- Passive mode: The method of setting up the control channel in passive mode is similar to that in active mode. However, after the connection is set up, the PASV command instead of the PORT command is sent. After the FTP server receives the PASV command, it opens a high end port (with the port number larger than 1024) and inform the client to transmit data through this port. The FTP client connects to the port of the FTP server, and then the FTP server transmits data through this port.

Many Intranet clients cannot log in to the FTP server in active mode, because the server fails to set up a new connection with an Intranet client.

When the device acts as an FTP client, it sets up a data connection in active mode.

FTPS is an enhanced FTP protocol that uses standard FTP protocols and commands at the Secure Sockets Layer (SSL), adding SSL security features to the FTP protocol and data channels. FTPS is also known as "FTP-SSL" or "FTP-over-SSL". SSL is a protocol that encrypts and decrypts data in a secure connection between a client and an SSL-enabled server. Only the FTP client on the device supports this feature. Trivial File Transfer Protocol (TFTP) is a simple file transfer protocol which is based on the User Datagram Protocol (UDP). It transmits data through UDP port 69. The protocol is designed for transmission of small files; therefore, it does not have as many functions as the FTP protocol. It does not support list of directories or authentication. The device only implements the functions of the TFTP client.

SFTP (Secure File Transfer Protocol /Secure FTP) is a new feature added in SSH 2.0. SFTP is built on top of SSH connection, which allows remote users to securely log in to the device and perform operations such as file management and file transfer, providing a higher level of security for data transfer. SFTP provides a secure method for transferring files. SFTP is a sub-function of SSH that enables secure file transfer. SFTP encrypts the transmission of authentication information and the transmitted data, so it is very safe to use SFTP. If you have high requirements for network security, SFTP can be used to replace FTP. However, since SFTP file transfer uses encryption/decryption technology, the transfer efficiency is lower than FTP file transfer.

4.2 FTP, FTPS, TFTP and SFTP Function Configuration

Table 4-1 FTP and TFTP Function Configuration List

Configuration Task	
Configure an FTP server.	Configure the functions of an FTP server.
Configure an FTP client.	Configure the functions of an FTP client.
Configure a TFTP client.	Configure the functions of a TFTP client.
Configure an SFTP Server	Configure the functions of an SFTP Server.
Configure an SFTP client.	Configure the functions of an SFTP client.

4.2.1 Configure an FTP server.

Configuration Condition

None

Configure the functions of an FTP server.

Before configuring the device as the FTP server, first enable the FTP server function. Then, the FTP client can access the FTP server. For security sake, the device provides the FTP service only to authorized users, and it limits the maximum allowed number of concurrent login users.

Table 4-2 Configuring FTP Server Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the FTP server function.	**ftp enable**	Mandatory By default, the FTP server function is disabled.
Create an user administrator and enter the user administrator mode	**local-user** *user-name* **class manager**	-
Configure service-type that supports FTP for users	**service-type ftp**	-
Configure user password	**password 0** *password*	Mandatory By default, the user name and password are not configured. For details of the command, refer to the section on "LUM".
Configure the FTP service listening port number	**ftp listen-port** [*port-num*]	Optional By default, the FTP service listening port number is 21.
Configure the maximum allowed number of concurrent login users.	**ftp max-user-num** *user-num*	Optional By default, the maximum allowed number of concurrent login users is 1.
Configure the connection timeout time.	**ftp timeout** *time*	Optional

Step	Command	Description
		By default, the connection timeout time is 300 seconds.

4.2.2 Configure an FTP client.

Configuration Condition

None

Configure the functions of an FTP client.

On the device, when you use the copy command to **copy** files (Refer to the related sections in "File System Management") or use the **sysupdate** command to upgrade the software version (Refer to the related sections in "Software Upgrade"), the device can be triggered to act as the FTP client and set up a connection with the remote FTP server.

The connection between an FTP client and an FTP server uses the address of the outgoing interface of the route to the FTP server as the source address by default. Users can also use the **ip ftp source-address** or **ip ftp source-interface** commands to specify the FTP client source address or source interface.

Table 4-3 Configuring FTP Client Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure FTP Client Source Address.	**ip ftp** { **source-interface** *interface-name* | **source-address** *ip-address* }	Optional By default, the address of the outgoing interface of the route to the FTP server is used as the source address.
Configure the FTP Client to Use Port Mode as a Priority.	**ip ftp port-first**	Optional By default, preference is given to passive mode for establishing data connections to the server

Note:

说明：

- In some network environments, because of security factors, the communication between the address of the outgoing interface of the route to the FTP server and the FTP server may be restricted, while communication with other service interface addresses are normal. In such case, you can use the ip ftp source-address, ip ftp source-interface commands to specify the FTP client source address or source interface.

4.2.3 Configure a TFTP client.

Configuration Condition

None

Configure the functions of a TFTP client.

On the device, when you use the **copy** command to copy files (Refer to the related sections in "File System Management") or use the **sysupdate** command to upgrade the software version (Refer to the relevant sections on "Software Upgrade"), the device can be triggered to act as the TFTP client and set up a connection with the remote TFTP server.

The connection between a TFTP client and a TFTP server uses the address of the outgoing interface of the route to the TFTP server as the source address by default. Users can also use the **ip tftp source-address** or **ip tftp source-interface** commands to specify the TFTP client source address or source interface.

Table 4-4 Configuring TFTP Client Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TFTP Client Source Address	**ip tftp** { **source-interface** *interface-name* | **source-address** *ip-address* }	Optional By default, the address of the outgoing interface of the route to the TFTP server is used as the source address to communicate with the TFTP server.

Note:

- In some network environments, because of security factors, the communication between the address of the outgoing interface of the route to the TFTP server and the TFTP server may be restricted, while communication with other service interface addresses are normal. In such case, you can use the ip tftp source-address, ip tftp source-interface commands to specify the TFTP client source address or source interface.

4.2.4 Configure the TFTP Server

Configuration Condition

None

Configure TFTP Server Function

Before configuring the device as the TFTP server, first enable the TFTP server function. Then, the TFTP client can access the TFTP server.

Table 4-5 Configuring TFTP Server Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the TFTP server function.	**tftp enable**	Mandatory By default, the TFTP server function is disabled.

4.2.5 Configure an SFTP Server

Configuration Condition

None

Configure the functions of an SFTP Server.

Before configuring the device as the SFTP server, first enable the SFTP server function. Then, the SFTP client can access the SFTP server. Since SFTP is a sub-function of SSH, the configuration to enable SFTP service is the same as that to enable SSH remote login service.

Table 4-6 Configuring SFTP Server Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the SFTP server function.	**ip ssh server [sshv1-compatible] [listen-port]**	Mandatory By default, the SFTP server function is disabled.

4.2.6 Configure an SFTP client.

Configuration Condition

None

Configure the functions of an SFTP client.

The device acts as an SFTP client and connects to the SFTP server to download files from the SFTP server or upload files to the SFTP server.

Table 4-7 Configuring SFTP Client Function

Step	Command	Description
Configure the device to act as the SFTP client to upload files to and download files from the SFTP server.	**sftp { get | put } [vrf vrf-name] host-ip-address port-number [source-interface interface-name] user password src-filename dest-filename [compress]**	Optional

4.2.7 FTP and TFTP monitoring and maintaining

None

4.3 Typical Configuration Example of FTP and TFTP

4.3.1 Configure a Device as an FTP Client

Network Requirements

- A PC acts as an FTP server, and the device Device acts as an FTP client. The network between the server and the device is normal.
- On the FTP server, the user name for a device to log in to the FTP server is admin, and the password is admin. The files to be downloaded are placed in the FTP server directory.
- The device acts as the FTP client to upload files to and download files from the FTP server.

Network Topology

Figure4–1 Network Topology for Configuring a Device as an FTP Client

Configuration Steps

Step 1: Create Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configure an FTP server, and place the files to be downloaded in the FTP server directory. (Omitted)

Step 3: Configure the IP addresses of the devices so that the network between the client and the server is normal. (Omitted)

Step 4: Device acts as the FTP client to upload files to and download files from the FTP server. (Omitted)

#In the file system mode of Device, copy one file from the FTP server to the file system of Device.

```
Device#filesystem
Device(config-fs)#copy ftp 2.0.0.1 admin admin sp4-g-6.5.0(41).pck file-system  sp4-g-6.5.0(41).pck
Device (config-fs)#exit
```

#In the file system mode of Device, copy the startup file of Device into the FTP server.

```
Device#filesystem
Device(config-fs)#copy file-system startup ftp 2.0.0.1 admin admin startup.txt
```

Step 5: Check the result.

#After the copy process is completed, check whether the downloaded file exists in the file system of Device. In the FTP server, check whether the uploaded file exists. (Omitted)

```
Device(config-fs)#dir
  size        date      time      name
```

```
--------      ------    ------    --------
101526     MAR-01-2013  01:17:18   logging
10147      MAR-26-2013  07:58:50   startup
10207      MAR-01-2013  01:17:54   history
1372       MAR-23-2013  08:18:38   devInfo
6598624    MAR-26-2013  07:51:32   sp4-g-6.5.0(41).pck
1024       JAN-10-2013  17:30:20   snmp            <DIR>
0          JAN-31-2013  14:29:50   syslog
736512     MAR-27-2013  10:30:48   web-Spl-1.1.168.rom
```

Note:

- If the "FTP: Ctrl socket connect error(0x3c): Operation timed out" message is printed, it indicates that the server cannot be reached, and the cause may be that the route is not available or the server has not been started.
- If the "Downloading##OK!" message is printed, it indicates that the file is copied successfully.

4.3.2 Configure a Device as an FTP Server

Network Requirements

- Device1 acts as an FTP server, while PC and Device2 act as FTP clients. The network between the client and the server is normal.
- On the FTP server Device1, the user name is admin1, and the password is admin1. The file system directory of Device1 acts as the root directory of the FTP server.
- The PC and Device2 act as the FTP client to upload files to and download files from the FTP server Device1.

Network Topology

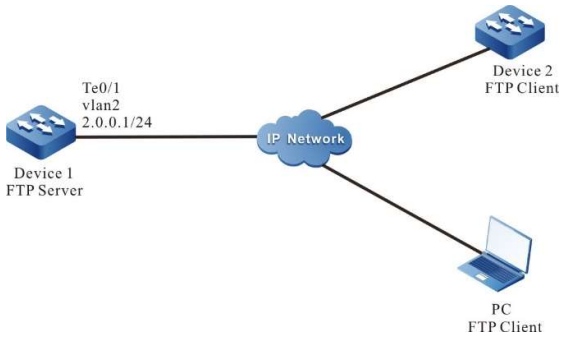


Figure4–2 Network Topology in Which a Device Acts as an FTP Server

Configuration Steps

Step 1: Create Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configure the IP addresses of the interfaces so that the network between the PC, Device 2, and Device 1 are normal. (Omitted)

Step 3: On Device1, enable the FTP service, and configure the authorized user name and password.

#On Device1, enable the FTP service, and configure the authorized user name and password.

```
Device1#configure terminal
Device1(config)#local-user admin1 class manager
Device1(config-user-manager-admin1)#service-type ftp
Device1(config-user-manager-admin1)#password 0 admin1
Device1(config-user-manager-admin1)#exit
```

#On Device1, enable the FTP service.

```
Device1(config)#ftp enable
```

#On Device1, set the maximum number of concurrent users to 2.

```
Device1(config)#ftp max-user-num 2
```

Step 4: Check the result.

#Check whether the FTP service function is enabled on Device1.

```
Device#show ip sockets
Active Internet connections (including servers)
PCB      Proto Recv-Q Send-Q  Local Address          Foreign Address          (state)
-------- ----- ------ ------  ---------------------- ---------------------    -------
27cf8a4  TCP       0      0  0.0.0.0.80             0.0.0.0.0                LISTEN
27ce0a4  TCP       0      0  130.255.104.43.22      130.255.98.2.3590        ESTABLISHED
27d0be4  TCP       0      0  0.0.0.0.21             0.0.0.0.0                LISTEN
27d0824  TCP       0      0  127.0.0.1.2622         127.0.0.1.1026           ESTABLISHED
```

If the FTP service function has enabled, you can find that port 21 is in the listen state.

Step 5: Use Device2 as an FTP client to copy a startup file from FTP server Device1 to local.

```
Device2#filesystem
Device2(config-fs)#copy ftp 2.0.0.1 admin1 admin1 startup file-system startup
```

Step 6: Use PC as an FTP client to copy a startup file from FTP server Device1 to PC.

#In the following part, the Windows DOS screens are taken as an example to illustrate the process.

#In the Windows DOS screen, input the correct IP address, user name, and password to log in to the FTP server.

```
D:\>ftp 2.0.0.1
```

```
Connected to 2.0.0.1.
220 FTP server ready
User (2.0.0.1:(none)): admin
331 Password required
Password:
230 User logged in
ftp>
```

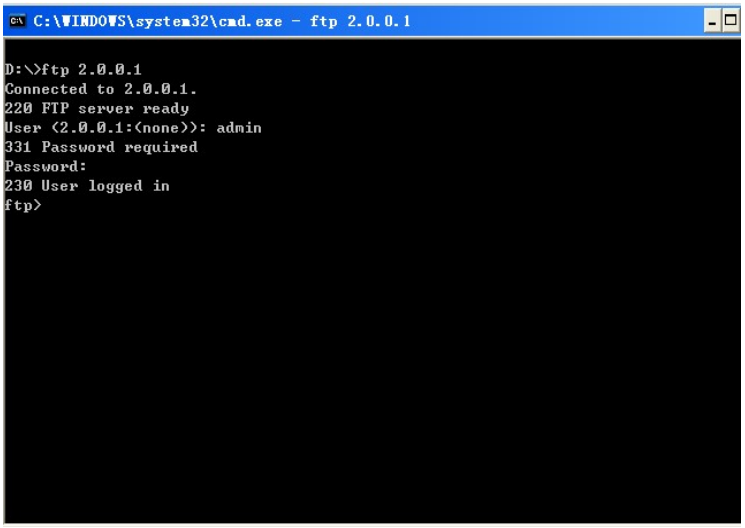


Figure 4–3 Logging in to the FTP server from the DOS interface

#Configure the PC and FTP server to transmit data in binary mode.

```
ftp>binary
```

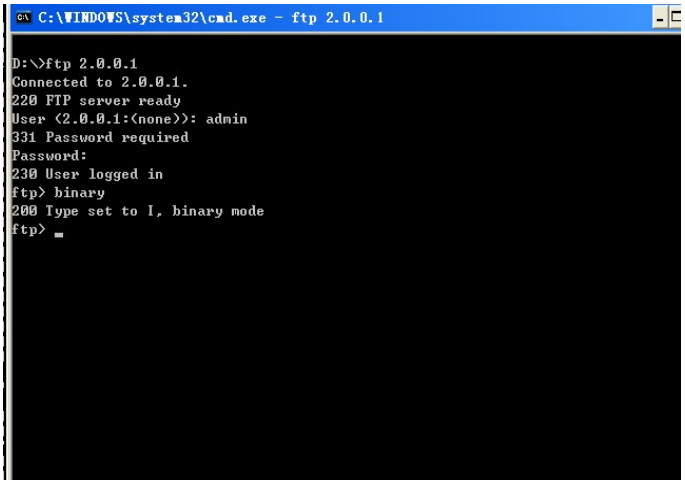


Figure 4–4 Configuring the PC and FTP Server to Transmit data in Binary Mode

#Obtain the startup file in the file system of the FTP server Device1.

```
ftp>get startup
```

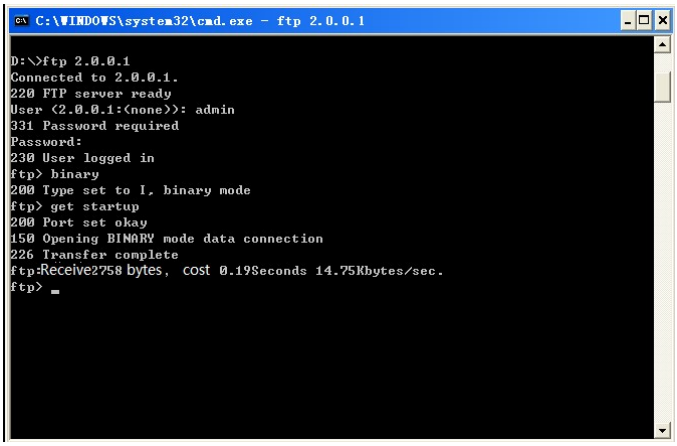


Figure4-5 Copying a Configuration File from the FTP Server

After the file copy process is completed, the file is available in the specified Windows directory.

Note:

- If the "421 Session limit reached, closing control connection" message is printed, it indicates that the number of connections has exceeds the maximum number allowed by the server.
- When you use a device to copy a file, if the " Ctrl socket connect error(0x3c): Operation timed out" message is printed, the cause may be that the server function is not enabled, or the route between the server and the client is not reachable.
- When you connect the FTP server through the FTP client PC, if the " connect :Unknown error number" is printed, the cause may be that the server function is not enabled, or the route between the server and the client is not reachable.

  ssac modessac mode

4.3.3 Configure a Device as an TFTP Client

Network Requirements

- A PC acts as a TFTP server, and Device acts as a TFTP client. The network between the server and the device is normal. The files to be downloaded are placed in the TFTP server directory.
- The device acts as the TFTP client to upload files to and download files from the TFTP server.

Network Topology

Figure 4–6 Network Topology in Which a Device Acts as a TFTP Client

Configuration Steps

Step 1: Create Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configure the IP addresses of all interfaces so that the network between the client and the server is normal. (Omitted)

Step 3: Enable the TFTP server function on PC, and place the files to be downloaded in the TFTP server directory. (Omitted)

Step 4: Device acts as the TFTP client to upload files to and download files from the TFTP server.

#On Device, copy a file from the TFTP server to the file system of Device.

```
Device#filesystem
Device(config-fs)#copy tftp 2.1.2.1 sp4-g-6.5.0(41).pck file-system sp4-g-6.5.0(41).pck
Device(config-fs)#exit
```

#On Device, copy the startup file from Device to the TFTP server.

```
Device#filesystem
Device(config-fs)#copy startup-config tftp 2.1.2.1 startup.txt
```

Step 5: Check the result.

After the copy process is completed, check whether the downloaded file exists in the file system of Device. In the TFTP server, check whether the uploaded file exists. (Omitted)

```
Device(config-fs)#dir
  size         date       time       name
--------       ------     ------     --------
102227     MAR-01-2013  05:24:32   logging
10147      MAR-26-2013  07:58:50   startup
10202      MAR-01-2013  05:26:46   history
6598624    MAR-26-2013  07:51:32   sp4-g-6.5.0(41).pck
1024       JAN-10-2013  17:30:20   snmp              <DIR>
0          JAN-31-2013  14:29:50   syslog
736512     MAR-27-2013  10:30:48   web-Spl-1.1.168.rom
```

Note:

- If the "Downloading####OK!" message is printed, it indicates that the file copy is successful. The message shows the file size, which is determined by the actual file size.
- When you use a device to copy a file, if the "tftp Failed! ErrorNum: 0x41, ErrorType: Host unreach." message is printed, the cause may be that the TFTP server function is not enabled, or the route between the server and the client is not reachable.

4.3.4 Configure a Device as an SFTP Client

Network Requirements

- Take the PC as an SFTP server, and the device acts as an SFTP client. The network between the server and the device is normal.
- On the SFTP server, the user name for a device to log in to the SFTP server is admin, and the password is admin. The files to be downloaded are placed in the SFTP server directory.
- The device acts as the SFTP client to upload files to and download files from the SFTP server.

Network Topology

Figure4–7 Network Topology for Configuring a Device as an SFTP Client

Configuration Steps

Step 1: Configure an SFTP server, and place the files to be downloaded in the SFTP server directory. (Omitted)

Step 2: Configure the IP addresses of the devices so that the network between the client and the server is normal. (Omitted)

Step 3: Device acts as the SFTP client to upload files to and download files from the SFTP server.

#Download a file from the SFTP server to the file system of the device.

```
Device#sftp get 2.0.0.1 22 admin admin sp8-g-6.6.7(46)-dbg.pck sp8-g-6.6.7(46)-dbg.pck
The authenticity of host '2.0.0.1 (2.0.0.1)' can't be established.
RSA key fingerprint is e4:dd:11:2e:82:34:ab:62:59:1c:c8:62:1d:4b:48:99.
Are you sure you want to continue connecting (yes/no)? yes

Downloading##########################################################################################
##########################################
```

#Upload the startup file in the file system of Device to the SFTP server.

```
Device#sftp put 2.0.0.1 22 admin admin startup startup.txt
The authenticity of host '2.0.0.1 (2.0.0.1)' can't be established.
RSA key fingerprint is e4:dd:11:2e:82:34:ab:62:59:1c:c8:62:1d:4b:48:99.
Are you sure you want to continue connecting (yes/no)? yes
Uploading##################################################################################################
##################################################################
```

Step 4: Check the result.

#After the copy process is completed, check whether the downloaded file exists in the file system of the device. In the SFTP server, check whether the uploaded file exists. (Omitted)

```
Device(config-fs)#dir
  size        date      time      name
--------      ------    ------    --------
101526     MAR-01-2015  01:17:18   logging
10147      MAR-26-2015  07:58:50   startup
10207      MAR-01-2015  01:17:54   history
11676148   MAR-26-2013  07:51:32  sp8-g-6.6.7(46)-dbg.pck
2048       JAN-10-2015  17:30:20   snmp            <DIR>
```

4.3.5 Configure a Device as an SFTP Server

Network Requirements

- Device acts as an SFTP server, while a PC acts as an SFTP client. The network between the client and the server is normal.
- On the SFTP server Device, the user name is admin1, and the password is admin1. The file system directory of Device acts as the root directory of the SFTP server.
- A PC acts as the SFTP client to upload files to and download files from the SFTP server Device.

Network Topology

Figure 4–8 Network Topology for Configuring a Device as an SFTP Server

Configuration Steps

Step 1: Configure IP addresses for the ports so that the network between the PC and the device is normal. (Omitted)

Step 2: On Device, enable the SFTP service, and configure the authorized user name and password.

#On the SFTP server Device, configure the authorized user name and password.

```
Device#configure terminal
Device(config)#local-user admin1 class manager
Device(config-user-manager-admin1)#service-type ssh
Device(config-user-manager-admin1)#password 0 admin1
```

```
Device(config-user-manager-admin1)#exit
```

#Enable SSH service on Device (SFTP is a sub-module of the SSH protocol)

```
Device(config)#ip ssh server
```

Step 3: The PC acts as the SFTP client to upload files to and download files from the SFTP server Device.

#In the following part, the Linux system is taken as an example to illustrate the process.

#Input the correct IP address, user name, and password to log in to the SFTP server.

```
[root@aas ~]# sftp admin1@2.1.1.1
Connecting to 2.1.1.1...
admin1@2.1.1.1's password:

sftp>
```

#Obtain the startup file in the file system of the SFTP server Device.

```
sftp> get startup startup
Fetching /flash/startup to startup
/flash/startup                                          100%   13KB  12.9KB/s   00:00
```

#After the file copy process is completed, the file is available in the specified operation directory.

```
sftp> ls
sp8-g-6.6.7(74)-dbg.pck   sp8-g-6.6.7(76)-dbg.pck   startup              tech                 test_pc
sftp>
```

#Upload the files in the PC to the file system of SFTP server Device.

```
sftp> put sp8-g-6.6.7(76)-dbg.pck sp8-g-6.6.7(76)-dbg.pck
Uploading sp8-g-6.6.7(76)-dbg.pck to /flash/ sp8-g-6.6.7(76)-dbg.pck
sp8-g-6.6.7(76)-dbg.pck                                                  100% 11424KB  16.0KB/s   00:00
```

#After the file copy process is completed, the file is available in the file system of the device.

```
Device(config-fs)#dir
  size         date         time      name
------------   ------       ------    --------
2048           JUN-30-2015  16:35:50   tech             <DIR>
10229          JUN-12-2015  14:31:22   history
101890         JUN-30-2015  17:46:40   logging
39755          JUN-30-2015  16:33:56   startup
740574         MAY-27-2014  18:55:14   web-Spl-1.1.243.rom
2048           JUN-27-2015  16:26:10   snmp             <DIR>

11698172       JUN-30-2015  10:36:18   sp8-g-6.6.7(76)-dbg.pck
```

4.3.6 Configure a Device as an FTPS Client

Network Requirements

- A PC acts as an FTP server, and the device Device acts as an FTP client. The network between the server and the device is normal.

- Secure data transmission is guaranteed by establishing secure data channels between the FTP Server and the FTP Client.
- FTP client can upload files to and download files from the FTP server.

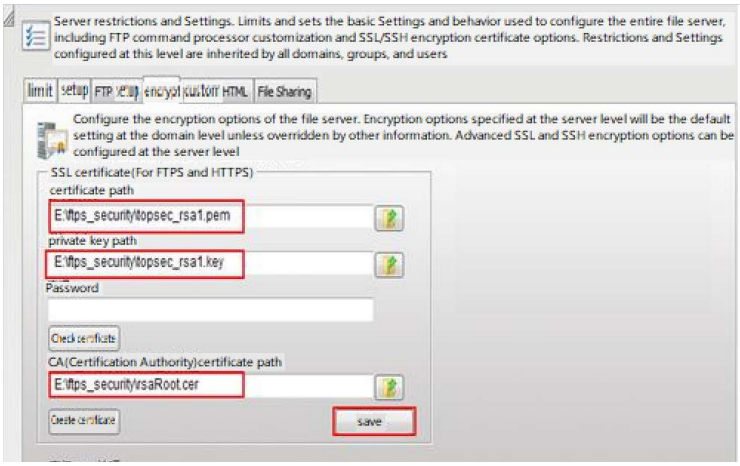
Network Topology

Figure 4–9 Network Topology for Configuring a Device as an FTPS Client

Configuration Steps

Step 1: Configure IPv4 addresses for the ports. (Omitted)

Step 2: Install certificate on FTP Server and set FTP user certificate path, private key path, and CA certificate path.



Step 3: FTP Client imports FTP CA certificate, user certificate, and private key.

#Create a domain test on the device:

```
Device#configure terminal
Device(config)#crypto ca identity test
Device(ca-identity)#exit
```

#ftp binds to domain test:

```
Device(config)#ip ftp secure-identity test
```

#Open the CA certificate (rsaRoot.cer) in Notepad, then copy the content, type crypto ca import certificate to test in shell, and follow the prompts to import the certificate into the device domain test:

```
Device(config)#crypto ca import certificate to test
```

```
% Input the certificate data, press <Enter> twice to finish:
-----BEGIN CERTIFICATE-----
MIIDBzCCAnCgAwIBAgIITpXH17Hj/AswDQYJKoZIhvcNAQEFBQAwYjELMAkGA1UE
BhMCQ04xEDAOBgNVBAgMB0JFSUpJTkcxDjAMBgNVBAoMBUNJRUNDMQ8wDQYDVQQL
DAZHRkEgQ0ExIDAeBgNVBAMMF01pbmlDQSBGcmVCU0QgUm9vdCBDZXJ0MB4XDTA5
MDgwMzA2MDY1MloXDTE5MDgwMzA2MDY1MlowYjELMAkGA1UEBhMCQ04xEDAOBgNV
BAgMB0JFSUpJTkcxDjAMBgNVBAoMBUNJRUNDMQ8wDQYDVQQLDAZHRkEgQ0ExIDAe
BgNVBAMMF01pbmlDQSBGcmVCU0QgUm9vdCBDZXJ0MIGeMA0GCSqGSIb3DQEBAQUA
A4GMADCBiAKBgHXZMtpxzH8p0uUt6QomUhuJNcy9iyYhoJVx4l3T6kpmx9cdzapM
RoKUa9eB/jCzhgctQc7ZDuKP+gafHWgZtbzwwSVksVsNmFqBivixveGx9dCrtequ
+vDiXVyDVPSNDDTmamMGYyCb0N7aSOzdgv6BYyQKyy/Y0FK6/v/v4NUxAgMBAAGj
gcYwgcMwPQYDVR0fBDYwNDAyoDCgLoYsaHR0cDovLzE2OC4xNjguMTcuNDY6OTAw
MC9nZmEvY3JsL2dmYWFwcC5jcmwwSAYDVR0gBEEwPzA9BggrBgEEAYcrMjAxMC8G
CCsGAQUFBwIBFiNodHRwOi8vd3d3LmdmYXBraS5jb20uY24vcG9saWN5LmRvYzAL
BgNVHQ8EBAMCAuQwDAYDVR0TBAUwAwEB/zAdBgNVHQ4EFgQUhnY8uZXbE2iX1mXO
ipvfuDUgAeswDQYJKoZIhvcNAQEFBQADgYEAcNPdTE+YpfOQn8lW1oF7TkGJ/Vzd
c0O5UUB+jPhYkj+fXUX8WyxabOxgl3u+7DJ/3gHw1rO8ZcDO94Wz+nBsile5tFv7
/bHz0yqJVoUJMIaWOdmLXJj5fI5GeBCprzLM88RJCv6LBHfg4ThOC4Ds80Ssive1
eAod+7kbmVPOZg8=
-----END CERTIFICATE-----

% Input the private key data, press <Enter> twice after data to finish or press <Enter> without data to ignore:

% The Root CA Certificate has the following attributes:
  Serial Number: 4e95c7d7b1e3fc0b
  Subject: C=CN, ST=BEIJING, O=CIECC, OU=GFA CA, CN=MiniCA FreBSD Root Cert
  Issuer : C=CN, ST=BEIJING, O=CIECC, OU=GFA CA, CN=MiniCA FreBSD Root Cert
  Validity
    Start date: 2009-08-03 06:06:52
    End   date: 2019-08-03 06:06:52
  Usage: General
  Fingerprint(sm3) :18d39e4c50c9ad8b11446ac7ac1736f853ac92e769994b98233b48787562429c
  Fingerprint(sha1):ab3559e26384539ffcac3c76b5a5e7a1f7073dfb

% Do you accept this root ca-certificate[yes]/[no]:
% Please answer 'yes' or 'no'.
% Do you accept this root ca-certificate[yes]/[no]:

Nov 11 2015 19:06:04: %PKI-CERTIFICATE_STATECHG-5: Certificate(issuer:C=CN, ST=BEIJING, O=CIECC, OU=GFA
CA, CN=MiniCA FreBSD Root Cert, sn:4E95C7D7B1E3FC0B, subject:C=CN, ST=BEIJING, O=CIECC, OU=GFA CA,
CN=MiniCA FreBSD Root Cert) state valid
% PKI: Import Certificate success.
```

#Open the user certificate (topsec_rsa2_myself.pem) and the private key certificate (topsec_rsa2_myself.key) with Notepad, then copy the content inside, enter the command crypto ca import certificate to test in shell, and follow the prompts to import the certificates in order into the device domain test:

```
Device(config)#crypto ca import certificate to test
% Input the certificate data, press <Enter> twice to finish:
-----BEGIN CERTIFICATE-----
MIIDVTCCAr6gAwIBAgIQEJ7twbl3pDlzJz99DFOKOzANBgkqhkiG9w0BAQUFADBiMQswCQYDVQQGEwJDTjEQMA
4GA1UECAwHQkVJSklORzEOMAwGA1UECgwFQ0lFQ0MxDzANBgNVBAsMBkdGQSBDQTEgMB4GA1UEAwwXTW
luaUNBIEZyZUJTRCBSb290IENlcnQwHhcNMTIwNjI2MDUwMTIzWhcNMzIwNjI2MDUwMTIzWjB/MQswCQYDVQQ
GEwJDTjEQMA4GA1UECAwHYmVpamluZzESMBAGA1UEBwwJZG9uZ2NoZW5nMQ4wDAYDVQQKDAVjaWVjYzE
MMAoGA1UECwwDZ2ZhMR0wGwYJKoZIhvcNAQkBFg50ZXN0QGVjLmNvbS5jbjENMAsGA1UEAwwEcnNhMjCBnz
ANBgkqhkiG9w0BAQEFAAOBjQAwgYkCgYEA6AlNqTnNsV9Yyij2tTMppB9C5VCLtkPh9KlIq/ZTlVhrJED+N5HVfQQy
ZYS/z4JWAip50dyP1+NP+bvP+pb9CfEaJ8+ObYQnfUH6qiPccLkWO3XYanu6Dw5EMJYntwglSKmk1Pcc+j+yzWnwYMD
FcbSsQ+8J5UzlesFhU7GnXacCAwEAAaOB7jCB6zA+BgNVHR8ENzA1MDOgMaAvhi1odHRwczovLzIxMS44OC4yNS4x
ODo4NDQ0L2dmYS9jcmwvUlNBMTAyNC5jcmwwUQYDVR0gBEowSDBGBggrBgEEAYcrMjA6MDgGCCsGAQUFBwI
BFixodHRwczovLzIxMS44OC4yNS4xODo4NDQ0L2dmYS9jcmwvUlNBMTAyNC5wbDALBgNVHQ8EBAMCA/gwCQY
DVR0TBAIwADAdBgNVHQ4EFgQUp/9/ODGLR84syxPaBkLG3mCpU5YwHwYDVR0jBBgwFoAUhnY8uZXbE2iX1mX
OipvfuDUgAeswDQYJKoZIhvcNAQEFBQADgYEAYrFZQrINHoLN9odcGctzTRGVmMcv9sJ0ncgUEfbrLu6QUodQy3jjx
WFIxheJK1btfF66/ShuKtZpqJ1WE9l92tflHwLpXT0gujtxNi02TOPBNEU7P9nUgxgfDG+uhyPTeufSkfn3LCTHmGfVORF2s
oGSlaUPV1Zy5E9hmFZoMhs=
-----END CERTIFICATE-----

% Input the private key data, press <Enter> twice after data to finish or press <Enter> without data to ignore:
```

```
-----BEGIN RSA PRIVATE KEY-----
MIICXQIBAAKBgQDoCU2pOc2xX1jKKPa1MymkH0LlUIu2Q+H0qUir9lOVWGskQP43kdV9BDJlhL/PglYCKnnR3I/X40/
5u8/6lv0J8Ronz45thCd9QfqqI9xwuRY7ddhqe7oPDkQwlie3CCVIqaTU9xz6P7LNafBgwMVxtKxD7wnlTOV6wWFTsaddpw
IDAQABAoGBAMnJNWliJFgI4+1CvHGN4buhmApWBnnmBL1A7jrlh4CMGPi5MJrgzvjeSnlwfWIXJXbSu4feuJT1UFqMk
uyIm9l+k8Rm3hjClXIlfNV/ykG6a6GIVFYGxQWhaL50Pm6S7xXL9Ryd6hnOHUUtwuLvkpBTx/4qvrIABDtXRjVglvApAk
EA9BN1ZxM31BOyeB6KXvvmXD6/+dGaDfE4Dbcijy1LgKliaEBJ00e/0R9ekg6myGTU2asJvPtkaXPqcwvU6+e2mwJBAPN
fRTk9LzUlNmTV2DrsE9k3rbPnqqS9wb/mLUNdv2FQeoY/Zf4qh0WXsug2q/6GPsvLUA7mbdArGFUwwQbw3+UCQQC8r2
5LSOgX40JM6g8+bq4fEcOHdSoLLTeQIststC9yP3/75/cqhoUbPYz2jK0SriB+RWM53X46p4nPdo4b8P2RAkBGjoBLL+nXx
ooWgcjGjFrUxsedOLTIPhtFvz2wIiWx2NsswISZQ0skae58VB1ZFSJvguoa58M+bsAHMrNDh+HhAkBcNAjKBDdVw0ll6bN
oRGugEvuo3Z3O0kbVcjzZld+4aVG4DzvEp1ZbsYRv9YPMtpnzmB7WZUshAL99nHnHxtbh
-----END RSA PRIVATE KEY-----

Nov 11 2015 19:06:56: %PKI-CERTIFICATE_STATECHG-5: Certificate(issuer:C=CN, ST=BEIJING, O=CIECC, OU=GFA
CA, CN=MiniCA FreBSD Root Cert, sn:109EEDC1B977A43973273F7D0C538A3B, subject:C=CN, ST=beijing,
L=dongcheng, O=ciecc, OU=gfa, E=test@ec.com.cn, CN=rsa2) state valid
% PKI: Import Certificate success.
```

#After the certificate is successfully imported, you can view the status as Valid using the show crypto ca certificates command:

```
Device#show crypto ca certificates
Root CA Certificate:
  Status: Valid
  Serial Number: 4e95c7d7b1e3fc0b
  Subject: C=CN, ST=BEIJING, O=CIECC, OU=GFA CA, CN=MiniCA FreBSD Root Cert
  Issuer : C=CN, ST=BEIJING, O=CIECC, OU=GFA CA, CN=MiniCA FreBSD Root Cert
  Validity
    Start date: 2009-08-03 06:06:52
    End   date: 2019-08-03 06:06:52
  Key Type: RSA(1023 bit)
  Usage: General
  Fingerprint(sm3):18d39e4c50c9ad8b11446ac7ac1736f853ac92e769994b98233b48787562429c
  Fingerprint(sha1):ab3559e26384539ffcac3c76b5a5e7a1f7073dfb
  Associated Identity: test
       index: 3

My Certificate:
  Status: Valid
  Serial Number: 109eedc1b977a43973273f7d0c538a3b
  Subject: C=CN, ST=beijing, L=dongcheng, O=ciecc, OU=gfa, E=test@ec.com.cn, CN=rsa2
  Issuer : C=CN, ST=BEIJING, O=CIECC, OU=GFA CA, CN=MiniCA FreBSD Root Cert
  Validity
    Start date: 2012-06-26 05:01:23
    End   date: 2032-06-26 05:01:23
  Key Type: RSA(1024 bit)
  Usage: General
  Fingerprint(sm3):504599a2f170c51b62b2f8b0850f33a5595bc9e592d14eae9c90b1e59de35a89
  Fingerprint(sha1):080614a82cc4f3786458c585f9a58edf19da19bd
  Associated Identity: test
       index: 4
```

Step 4: FTP client uploads files to and downloads files from the FTP server.

FTP client uploads files to the FTP server:

```
Device#filesystem
Device1(config-fs)#copy file-system startup ftps 2.0.0.1 a a startup VerifyType peer

Copying!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!!
Total 103440 bytes copying completed.
```

FTP client downloads files from the FTP server:

```
Device(config-fs)#ftpscopy 2.0.0.1 a a test.doc test.doc VerifyType peer

Downloading##########################################################################################
```

```
##################################################################################################
################################################################################ OK!
```

Step 5: Check the result.

#After the file download process is completed, view the file in the file system of Device.

```
Device(config-fs)#dir
  size          date          time       name
------------   ------        ------    --------
10189           NOV-04-2015  20:27:03   history
436578          NOV-04-2015  20:33:08   test.doc
```

5 File System Management

5.1 Overview

The following lists the storage medium of the device and their functions:

- SDRAM: Synchronous Dynamic Random Access Memory (SDRAM) provides the space for executing application programs of the device.
- FLASH: Stores application programs, configuration files, and the BootROM programs, and so on.
- EEPROM: Electrically Erasable and Programmable Read-Only Memory, stores system configuration files and user information which is frequently changed.
- USB: Used to store user data.

The device manages the following types of files:

- BootROM files: Store basic data for system initialization.
- Device application programs: Implement tasks such as route forwarding, file management, and system management.
- Configuration files: Store the system parameters that are configured by the users.
- Log files: Stores system log information.

Note:

- The filesystem command is used to access the file system and can be run on both Master and Slave.

5.2 File System Management Function Configuration

Table 5-1 File System Management Function Configuration List

Configuration Task	
Manage storage devices.	Display the information about a storage device.
	Format a storage device.
Manage file directories.	Display the information about a file directory.
	Display the current working path.
	Change the current working path.
	Create a directory.
	Delete a directory.
Manage file operations	Copy a file.
	Rename a file.
	Display the content of a file.
	Delete a file.
Execute a configuration file manually.	Execute a configuration file manually.
Configure startup parameters.	Configure startup parameters.

5.2.1 Manage storage devices.

Configuration Condition

Before performing operations on storage devices, ensure that:

- The system has started normally.

Display the information about a storage device.

By displaying the information about a storage device, you can view the features of the storage device and the size of the remaining space.

Table 5-2 Displaying the Information about a Storage Device

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Display the information about a storage device.	**volume**	Mandatory

Format a storage device.

If the space of a storage device is unavailable, you can use the format command to format the storage device.

Table 5-3 Formatting a Storage Device

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Format a storage device.	**format** { **/flash | /syslog** | **/usb** }	Optional

Caution:

- Exercise caution in formatting a storage device, because the operation may cause permanent loss of all files on the storage device, and the files cannot be recovered.

5.2.2 Manage file directories.

Configuration Condition

Before performing operations on file directories, ensure that:

- The system has started normally.

Display the information about a file directory.

By displaying the information about a file directory, you can view the details of the files in the specified directory.

Table 5-4 Displaying File Directory Information

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Display the information about a directory.	**dir** [*path*]	Mandatory

Display the current working path.

By displaying the current working path, you can view the details of the current path.

Table 5-5 Displaying the Current Working Path

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Display the current working path.	**pwd**	Mandatory

Change the current working path.

By changing the current working path, you can switch over a user to the specified directory.

Table 5-6 Changing the Current Working Path

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Change the current working path.	**cd** *path*	Mandatory

Create a directory.

If you want to create a directory in the file system, perform this operation.

Table 5-7 Creating a Directory

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Create a directory.	**mkdir** *directory*	Mandatory

Delete a directory.

If you delete a directory through this operation, all sub-directories and files in the directory are deleted.

Table 5-8 Deleting a Directory

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Delete a directory.	**rmdir** *directory*	Mandatory

Note:

- Exercise caution when deleting a directory, because the operation of deleting the directory may permanently delete all sub-directories and files in the directory, and the files cannot be recovered.

5.2.3 Manage file operations

Configuration Condition

Before performing operations on files, ensure that:

- The system has started normally.

Copy a file.

In the file system, you can copy a file to the specified directory.

Table 5-9 Copying a File

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Copy a file.	**copy** *src-parameter dest-parameter*	Mandatory

Note:

- The copy command can be used to copy file between the file system, the FTP server, and the TFTP server. For details, refers to the section on copy command in the User Manual.

Rename a file.

In the file system, you can change the name of a file into a specified name.

Table 5-10 Renaming a File

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Rename a file.	**rename** *src-filename dest-filename*	Mandatory

Display the content of a file.

In the file system, you can view the content of a file.

Table 5-11 Displaying the Content of a File

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Display the content of a file.	**type** *path/filename*	Mandatory

Delete a file.

In the file system, you can delete a file that is no longer in need.

Table 5-12 Deleting a File

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Delete a file.	**delete** *path/filename*	Mandatory

Note:

- Exercise caution when you use the delete command because it permanently deletes a file, and the file cannot be recovered.

5.2.4 Download a File from FTP

Configuration Condition

Before manually downloading the file from the FTP, first complete the following tasks:

- The system has started normally.
- Ensure that the route between the FTP server and the device interface is reachable and the route can be pinged through.

Download a File from the FTP Server

Use a command for downloading the file from the FTP and you can download the related file on the FTP server to the file system

Table 5-13 Downloading a File from the FTP server

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-

Step	Command	Description
Download a File from the FTP Server	**{ftpcopy** | ftpscopy}[**vrf** *vrf-name*] *host-ip-address usrname password src-filename* { **/flash** | **/syslog | usb** | *dest-filename* }	Optional

Note:

- The ftpcopy command can be used to download the file from the FTP server to the file system. For details about the operation, refer to the section on ftpcopy command and ftpscopy command in the User Manual.

5.2.5 Configure startup parameters.

Configuration Condition

Before configuring startup parameters, ensure that:

- The system has started normally.

Configure startup parameters.

\In configuring startup parameters, you can configure the application program file that is to be used in the next startup.

Table 5-14 Configuring Startup Parameters

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Configure startup parameters.	**boot-loader** *path/filename* [*bootline-number*]	Mandatory

5.2.6 File System Managing, Monitoring, and Maintaining

Table 5-15 File System Managing, Monitoring, and Maintaining

Command	Description
clear boot-loader [*bootline-number*]	Clear the startup parameters with the specified index.
show filesystem	Display the information about the file system.
show file descriptor	Display the location of the system file in the file system and the descriptor.
show boot-loader	Display the system startup parameters.

5.3 Typical Configuration Example of File System Management

5.3.1 Configure startup parameters.

Network Requirements

None

Network Topology

None

Configuration Steps

Step 1: Enter the file system configuration mode.

Step 2: Configure system startup options.

#View the system startup parameters.

```
Device#filesystem
Device(config-fs)#show boot-loader
The app to boot at the next time is: flash0: /flash/sp26-g-9.5.0.2(20)(R).pck
The app to boot at the this time is: flash0: /flash/sp26-g-9.5.0.2(20)(R).pck
Boot-loader0: flash0: /flash/sp26-g-9.5.0.2(20)(R).pck

Device(config-fs)#exit
```

#Copy the file sp26-g-9.5.0.2(20)(R).pck to flash via ftp, and then modify the sp26-g-9.5.0.2(20)(R).pck file in flash to be the next system startup option, and set the priority to 0.

```
Device#filesystem
Device(config-fs)#boot-loader /flash/sp26-g-9.5.0.2(20)(R).pck

Boot-loader0 set OK
Device(config-fs)#exit
```

#View the configuraiton result.

```
Device(config-fs)#show boot-loader
The app to boot at the next time is: flash0: /flash/sp26-g-9.5.0.2(20)(R).pck
The app to boot at the this time is: flash0: /flash/sp26-g-9.5.0.2(20)(R).pck

Boot-loader0: flash0: /flash/sp26-g-9.5.0.2(20)(R).pck
Boot-loader4: backup0: sp26-g-9.5.0.2(20)(R).pck
Device(config-fs)#exit
```

6 Configuration File Management

6.1 Overview

Configuration file management is a function that is used to manage device configuration files. Through the command line interface provided by the device, users can easily manage configuration files. If the device needs to automatically load the current configuration of users after restart, the current configuration commands must be saved into the configuration file before the device restarts. Users can upload configuration files to or download configuration files from another device through FTP or TFTP, realizing batch device configuration. The device configuration is categorized into the following two types:

Startup configuration:

When the device starts, it loads the startup configuration file with the name "startup" by default, and it completes the initialization configuration of the device. This configuration is called startup configuration. Here the device has two startup configuration files, one is the default startup configuration file, and the other is the backup startup configuration file. When the device starts, if the default startup configuration file does not exists, the system copies the backup startup configuration file to the location of the default startup configuration file and loads this startup configuration file.

Current configuration:

Current configuration is a set of commands that take effect currently. It consists of startup configuration and the configuration that is added or modified by the user after startup. The current configuration is saved in the memory database. If the current configuration is not saved into the startup configuration file, the configuration information gets lost after the device restarts.

The following describes the contents and formats of the configuration files:

- Configuration files are saved in the file system in the form of text files.
- The contents of the configuration files are saved in the form of configuration commands, and only non-default configuration is saved.
- Configuration files are organized based on command modes. All commands in one command mode are organized together to form a paragraph.
- Paragraphs are organized according to a certain rule: system configuration mode, interface configuration mode, and configuration modes of different protocols.

- Commands are organized according to their relations. The related commands form a group, and different groups are separated by blank lines.

6.2 Configuration File Management Function Configuration

Table 6-1 Configure File Management List

Configuration Task	
Save the current configuration.	Save the current configuration.
Back up device configuration.	Back up the current configuration.
	Back up the startup configuration.
Restore the startup configuration.	Restore the startup configuration.

6.2.1 Save the current configuration.

Configuration Condition

None

Save the current configuration.

If the current configuration of the user can take effect only after the device starts, you need to save the current configuration into the startup configuration file.

Table 6-2 Saving the Current Configuration

Step	Command	Description
Save the current configuration to the startup configuration file.	**write**	Mandatory

Note:

- If the device is restarted or powered off while the configuration file is being saved, configuration information may get lost.
- Saving the current configuration not only saves the configuration to the startup

configuration file, but also saves the configuration to the backup startup configuration file.

6.2.2 Configure the Backup System

Configuration Condition

Before configuring the backup system parameters, ensure that:

- The route between the device and the server is reachable.
- The configuration file to be backed up exists; otherwise, backup fails.

Back up the current configuration.

In backing up the current configuration, you can use a command to back up the current configuration to the FTP server.

Table 6-3 Backing Up the Current Configuration

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Back up the current configuration to a remote host through the FTP protocol.	**copy running-config** { **file-system** *dest-filename* | **ftp** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *username password dest-filename* | **startup-config** | **tftp** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *dest-filename* **ftps** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *username password dest-filename* **VerifyType { none | peer }** }	Mandatory

Back up the startup configuration.

In backing up the startup configuration, you can use a command to back up the startup configuration to the FTP server.

Table 6-4 Backing Up the Startup Configuration

Step	Command	Description
Enter the file system configuration mode.	**enable**	-
Save the startup configuration to a remote host through the FTP protocol.	**copy startup-config** { **file-system** *dest-filename* | **ftp** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *username password dest-filename* | **ftps** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *username password dest-filename* **VerifyType { none | peer }**| **tftp** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *dest-filename* }	Mandatory

6.2.3 Restore the startup configuration.

Configuration Condition

Before restoring the startup configuration, ensure that:

- The route between the device and the server is reachable.
- The configuration file that is to be restored exists.

Restore the startup configuration.

In restoring the startup configuration, you can use a command to download the startup configuration file from the FTP server and set it as the startup configuration file that is used after restart. In this way, after the device is restarted, the device can load the startup configuration file.

Table 6-5 Restoring the Startup Configuration

Step	Command	Description
Enter the file system configuration mode.	**filesystem**	-
Restore the startup configuration.	**copy** { **file-system** *src-filename* **| ftp** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *username password src-filename* | **ftps** [**vrf** *vrf-name*] { *hostname* | *ip-address* }	Mandatory

Step	Command	Description
	username password src-filename | **tftp** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *src-filename* } { **file-system** *dest-filename* **| startup-config** }	

Note:

- Before overwriting the local startup configuration, ensure that the configuration file matches the device type and matches the current system version.
- After performing the operation of restoring the startup configuration, the current configuration is not changed. After the device is restarted, the startup configuration is restored.

6.2.4 Configuration File Managing, Monitoring, and Maintaining

Table 6-6 Configuring File Management, Monitoring and Maintaining

Command	Description
show running-config [**after-interface** | **before-interface | interface** [*interface-name*] | [*configuration*]] [| { { **begin** | **exclude | include** } *expression* | **redirect** { **file** *file-name* | **ftp** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *user-name password file-name* } } | **ftps** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *user-name password file-name* } }]	Display the current configuration information.
show startup-config [*file-number* | { **|** { { **begin** | **exclude** | **include** [**context**] } *expression* | **redirect** { **file** *filename* | **ftp** { [**vrf** *vrf-name*] { *hostname* **|** *ip-address* } *user-name password file-name* } | | **ftps** { [**vrf** *vrf-name*] { *hostname* **|** *ip-address* } *user-name password file-name* } } }]	Display the startup configuration information.

6.2.5 Configuration File Encryption

Configuration Condition

- Configuration file encryption requires a USB device to be plugged in.

Configure Encryption of Configuration Files

Configuration file encryption is to encrypt the configuration file using the SM4 algorithm, the key is specified by the user, when the user specifies the key, it will encrypt the configuration file when the next write action is executed.

Operation record encryption refers to encrypting the configuration file using the State Secrets SM4 algorithm, the key is specified by the user, and when the user specifies the key, the encryption starts for the subsequent operation records.

Table 6-7 Configuration File Encryption and Operation Record Encryption

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configuration File Encryption	**service encryption startup algorithms SM4 key** *password*	Configuration file encryption, and the user specifies the key.
Operation record encryption	**service encryption history algorithms SM4 key** *password*	Operation record encryption, and the user specifies the key.

Note:

- Encryption of the configuration file takes effect at the next write action executed after the encryption function is configured. Encryption of operation record takes effect immediately after the encryption function is configured.
- An external USB device must be plugged in to configure the encryption function. The operation record encryption function does not require a USB device.

7 System Management

7.1 Overview

Through system management, users can view the current working status of the system, configure the basic functional parameters of the device, and perform basic maintenance and management of the device. System management provides the following functions: configure the device name, configure the system time and time zone, configure the login welcome message, configure the system exception processing mode, configure to restart the device, configure the password encryption service, configure the history command saving function, configure the login security service, configure monitor CPU, configure display of properties in pages.

7.2 System Management Function Configuration

Table 7-1 System Management Function Configuration List

Configuration Task	
Configure the device name.	Configure the device name.
Configure the system time and time zone.	Configure the system time and time zone.
Configure the login welcome message.	Configure the login welcome message.
Configure the system exception processing mode.	Configure the system exception processing mode.
Configure to restart the device.	Configure to restart the device.
Configure the encryption service.	Configure the encryption service.
Configure the history command saving function.	Configure the history command saving function.
Configure the login security service.	Configure the login security service.

Configuration Task	
Configure CPU monitoring.	Configure CPU monitoring.
Configure display of properties in pages.	Configure display of properties in pages.
Configure system security mode.	Configure system security mode.

7.2.1 Configure the device name.

Configuration Condition

None

Configure the device name.

A device name is used to identify a device. A user can change the device name according to the actual requirement. The modification takes effect immediately, that is, the new device name is displayed in the next system prompt.

Table 7-2 Configure the Device Name

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the device name.	**hostname** *host-name*	Mandatory

7.2.2 Configure the system time and time zone.

Configuration Condition

None

Configure the system time and time zone.

The system time and time zone is the time displayed in the timestamp of system information. The time is determined by the configured time and time zone. You can run the **show clock** command to view the time information of the system. To make the device work normally with other devices, the system time and time zone must be accurate.

Table 7-3 Configuring the System Time and Time Zone

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the system time.	**clock timezone** *timezone-name-string hour-offset-number* [*minute -offset-number*]	Mandatory The default is Universal Time Coordinated (UTC).
Enter the privileged user mode.	**exit**	-
Configure the system time.	**clock** *year-number* [*month-number* [*day-number* [*hour-number* [*minute-number* [*second-number*]]]]]	Mandatory

7.2.3 Configure the login welcome message.

Configuration Condition

None

Configure the login welcome message.

When a user logs in to the device for login authentication, the login welcome message is displayed. The welcome message can be configured according to the requirement.

Table 7-4 Configuring the Login Welcome Message

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the login welcome message.	**banner motd** *banner-line*	Mandatory

7.2.4 Configure the system exception processing mode.

Configuration Condition

None

Configure the system exception processing mode.

When a system exception occurs, the system directly restarts to restore the system. The system exception processing mode is configured in three aspects: The first is enabling periodical exception detection. The system periodically detects the task status, code segment, and semaphore dead lock with a cycle of 10s, 10s, and 30s respectively. Secondly, an exception level is configured. If exceptions of the level and higher levels occur, the device restarts. Exception levels include: alert, critical, emergency, error, and warn. You can also configure the health monitoring exception processing mode, which includes the ignore mode and the reload mode.

Table 7-5 Configuring the System Exception Processing Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure exception processing mode.	**exception** { **period-detect enable** | **reboot** [**level** { **alert** | **critical** | **emergency** | **error** | **warn** }] | **detect-health {ignore | reload}** }	Mandatory By default, Periodic exception detection is enabled, When an exception occurs, the exception level for device restart is **critical**; By default, the health monitoring is enabled, and the processing mode by default is Ignore when an exception is detected by health monitoring.
Configure exception processing mode in stacking mode.	**exception** { **period-detect enable** | **reboot** {**device** *device-num* | **level device** *device-num* { **alert** | **critical** | **emergency** | **error | warn** } } **| detect-health** *device-num* **{ignore | reload}** }	Mandatory By default, Periodic exception detection is enabled, When an exception occurs, the exception level for device restart is **critical**; By default, the health monitoring is enabled, and the processing mode by default is Ignore when

Step	Command	Description
		an exception is detected by health monitoring.

Note:

- If the device is configured to restart at a certain exception level, then an exception of the level and above occurs, the device will restart.
- The exception levels in descending order are: emergency, alert, critical, error and warn.

7.2.5 Configure to restart the device.

Configuration Condition

None

Restart a Device

When a device fault occurs, you can choose to restart the device according to the actual situation so as to eliminate the fault. The device restart modes include cold restart and hot restart. In a cold restart, the user can directly power off the device and power on the device again. In a hot restart, the user restarts the device by using a restart command. During the hot restart process, the device is not powered off.

Table 7-6 Restarting a Device

Step	Command	Description
Restart a device using the command or restart all active virtual switch member devices in the stacking domain using the command in stacking mode.	**reload**	Mandatory

Note:

- If you forcibly power off and restart a device that is in the operating status, hardware damage or data loss may be caused. Therefore, this restart mode is usually not

recommended.

- If you use the reload command to restart the device, all the services of the device are interrupted. Exercise caution when performing this operation.

7.2.6 Configure the history command saving function.

Configuration Condition

None

Configure the history command saving function.

With the history command saving function, you can query and collect the history commands that have been executed. Before the history command saving function is configured, history commands are saved in the memory file system. After the function is configured, the system automatically saves history commands in the flash file system.

Table 7-7 Configuring the History Command Saving Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to save history commands.	**shell-history save**	Mandatory By default, the history command saving function is enabled.

7.2.7 Configure the login security service.

Configuration Condition

None

Enable the System Login Security Service

To enhance the system security, the device provides the system login security service function. The functions include:

- Prevents brute force cracking of user login passwords.
- Prevents the fast connection function.

The function of brute force cracking prevention prevents malicious illegal users from forcedly cracking the user name and password for logging in to the device. If the system finds that the number of continuous login authentication failures of a user reaches the number specified by the system, the system rejects the login request from the IP address within the specified period of time.

The function of preventing fast connections prevents illegal users from initiating a large number of login requests within a short period time because this may occupy a lot of system and network resources. If the number of repeated login connections from a user reached a specified number, the system rejects the login connection requests from the IP address within the specified period of time.

Table 7-8 Enabling the System Login Security Service

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the system login security service.	**service login-secure { telnet | ssh | ftp | snmp}**	Mandatory By default, the system login security service is disabled.

Configure the Parameters of the System Login Security Service

Table 7-9 Configuring the Parameters of the System Login Security Service

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the duration for Telnet module to forbid logins from an offending IP address.	**login-secure** telnet ip-addr **forbid-time** *forbid-time-number*	Mandatory By default, the duration is 10 minutes.
Configure the maximum number of continuous login authentication failures of an offending IP address forbidden by the Telnet module.	**login-secure** telnet ip-addr **max-try-time** *max-try-time-number*	Mandatory By default, the number is 5.
Configure the aging time for the Telnet module to forbid an offending IP	**login-secure** telnet ip-addr **record-aging-time** *record-aging-time-number*	Mandatory By default, the aging time is 15 minutes.

Step	Command	Description
address from recording information.		

7.2.8 Configure CPU monitoring.

Configuration Condition

None

Configure CPU monitoring.

Through CPU monitoring, the system monitors the CPU occupancy to learn the current operation status of the CPU. The following shows the contents of CPU monitoring:

- Monitor the CPU occupancy of each process in the system, and you can view the relevant information after configuration by entering the **show cpu** command.Enable the CPU occupancy history statistics function, and you can view the relevant information after configuration by using the **show cpu monitor** command.

Table 10-11 Configuring CPU Monitoring

Step	Command	Description
Enter the global configuration mode.	**enable**	-
Enable monitoring of CPU occupancy of each process.	**spy cpu**	Mandatory By default, the CPU occupancy monitoring function is not enabled.
Enable the CPU occupancy historical statistics function.	**monitor cpu**	Mandatory By default, the CPU occupancy historical statistics function is enabled.

7.2.9 Configure display of properties in pages.

Configuration Condition

None

Configure Display of Properties in Pages

System information can be displayed in pages, making it easy for users to view the information. Users can set to display device information in pages according to the actual requirement.

Table 7-12 Configuring Display of Properties in Pages

Step	Command	Description
Enter the global configuration mode.	**enable**	-
Configure Display of Properties in Pages	**more** { **on** | **off** | **displine** [*num*] }	Mandatory By default, the function of display in pages is enabled. By default, 24 lines are displayed in **displine**.

7.2.10 Operation record file management

Configuration Condition

None

Configure Operation Record File

Operation records are saved in flash by default, and operation record file management is mainly to change the location where operation records are saved.

Table 7-13 Configuring File Encryption and Operation Record Encryption

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Operation record file management	**shell-history location** *device-name*	User-specified location for saving operation records.
Operation record file size specification.	**shell-history file max-size** *num*	Users specify the size of the operation record file.

7.2.11 Configure system security mode.

Configuration Condition

None

Configure system security mode.

Table 7-14 Configuring System Security Mode

Step	Command	Description
Enter the global configuration mode.	**config terminal**	
Configure system security mode.	**ssac mode** *{strict | loose}*	The system security mode can be configured as strict mode or loose mode.

7.2.12 System Managing, Monitoring, and Maintaining

Table 7-15 System Managing, Monitoring, and Maintaining

Command	Description
show clock	Display system clock information.
show cpu	Display CPU occupancy information.
show device	Display system device information.
show environment	Display board temperature information.
show history | { **begin** *expression* | **exclude** *expression* **| include** *expression* | **redirect** { **file** *file-name* | **ftp** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *user-name password file-name* | **ftps** [**vrf** *vrf-name*] { *hostname* | *ip-address* } *user-name password file-name* } }	Display history command information.
show language	Display system language version information.

Command	Description
show login-secure {telnet | ssh | ftp | snmp}{ip-addr | user | quick-connect}	Display system login security service Information.
show login-secure quick-connect	Display quick connection information for system login security.
show mbuf allocated [*pool-name*]	Display mbuf information.
show memory	Display memory information.
show pool [**detail** | **information**]	Display system memory pool information.
show process [*task-name*]	Display the main tasks in the system and their running status.
show semaphore { *sem-name* | **all** | **binary** | **counting** | **list** | **mutex** } [**any** | **pended** | **unpended**]	Display system semaphore information.
show spy	Display monitoring switch status.
show stack	Display the usage of each task stack in the system.
show system fan [**brief**]	Display system fan information.
show system lpu [*lpu-num* | **brief**]	Display system LPU information.
show system module brief	Display summary information for all module components of the device.
show system mpu [brief |*mpu-num* **]**	Display system MPU information.
show system power [*power-num* | **brief**]	Display system power information.
show tech-support { sys-base [detail] | drv-base [detail] | l2-base [detail] | l3-base [detail] | all } [**page** | **to-memory** | **to-flash**]	Display technical support information.
show version [**detail**]	Display system version information.

7.2.13 Configure the flexible table entry mode.

Configuration Condition

None

Configure the flexible table entry mode.

Flexible table entry mode is configured to adjust some of the device's table entry specifications, such as MAC address table, routing table, etc., for different scenarios.

Table 16-17 Configuring the Flexible Table Entry Mode

Step	Command	Description
Configure the flexible table entry mode.	**flexible-table mode** { **BALANCE | LARGE_L2 | LARGE_ROUTE | MAC_ROUTE | ENHANCED** }	By default, the flexible table entry mode is BALANCE.

7.3 Typical Configuration Example of System Management

7.3.1 Configure user- and IP-based login restrictions

Network Requirements

- PC1 and PC2, as local terminals, can log in to Device via Telnet and ssh.
- Device can restrict login to PC1 and PC2 by user and IP.

Network Topology

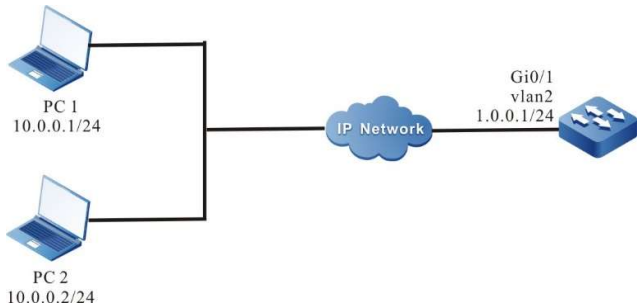


Figure 7-1 Network Topology for Configuring User- and IP-based Login Restrictions

Configuration Steps

Step 1: Configure the IP address of each interface and configure the routing protocol to enable intercommunication between PC1, PC2 and Device. (Omitted)

Step 2: Configure the user- and IP-based login restriction function.

#Enable telnet, ssh login security function.

```
Device#configure terminal
Device(config)#service login-secure telnet
Device(config)#service login-secure ssh
```

#Configure the maximum number of retries to 5 for telnet and ssh IP addresses and 5 for users, respectively.

```
Device(config)#login-secure telnet ip-addr max-try-time 5
Device(config)#login-secure telnet user max-try-time 5
Device(config)#login-secure ssh ip-addr max-try-time 5
Device(config)#login-secure ssh user max-try-time 5
```

Step 3: Enable the ssh service of Device, configure the username and password, and set up local login authentication.

```
Device(config)#ip ssh server
Device(config)#local-user user1 class manager
Device(config-user-manager-user1)#service-type ssh
Device(config-user-manager-user1)#password 0 admin
Device(config-user-manager-user1)#exit
Device(config)#line vty 0 15
Device(config-line)#login aaa
Device(config-line)#exit
```

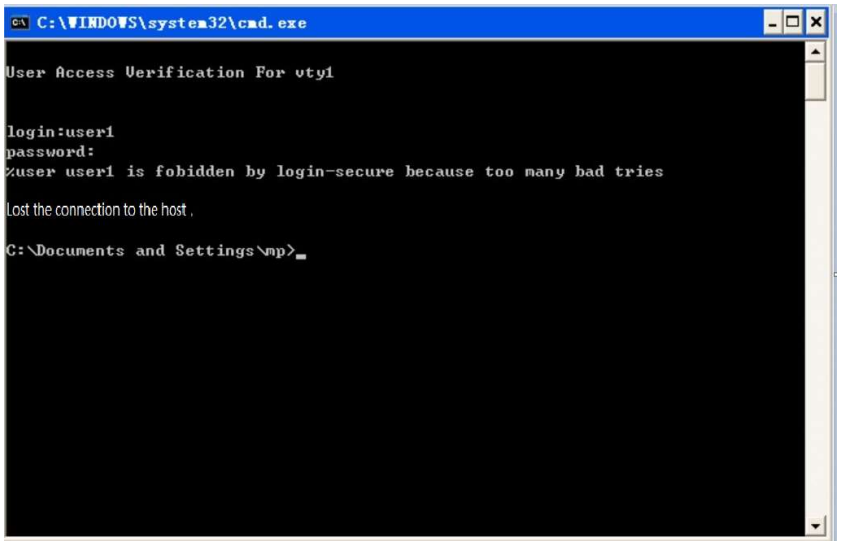
Step 4: Check the result.

#PC1 attempts to log in to Device via telnet with username user1, and after entering the wrong password 6 times in a row, the user information of the telnet login security statistics is displayed on Device:

```
Device#show login-secure telnet user
telnet module forbidden user information:
user        try-time  forbid-time     number     record-time
---------   --------  -----------     ------     -----------
user1         6       00:09:00          0        00:01:00
```

You can see that user1 is considered as a login attack user and is not allowed to login to the device via telnet for 10 minutes.

PC1 uses user1 to log in to Device via telnet for the second time, the system prompts that login is rejected.



#PC2 attempts to log in to Device via ssh, using unconfigured username of Device, and after logging in 6 times in a row, the ip information in the ssh login security statistics is displayed:

```
Device#show login-secure ssh ip-addr
ssh module forbidden login address:
client address  try-time  forbid-time    type     number  record-time
--------------  --------  -----------  ------   ------  -----------
10.0.0.2        6         00:09:00       login    0       00:01:00
```

You can see that PC2's IP address is considered to be a login attack address, and PC2 is not allowed to log in to the device via ssh for 10 minutes.

At this point, PC2 logs in to Device via ssh again and will be prompted that login is rejected.

Note:

- When the number of logins exceeds the configured maximum number of retries, it will be considered a login attack and rejected of login; logins equal to the configured maximum will not be forbidden.
- Some ssh clients on the PC will retry internally when login fails, and the device will still record this as multiple logins.
- By default, the telnet and ssh login security functions of the device are enabled.

7.3.2 Configure quick login restrictions

Network Requirements

- PC1 and PC2, as local terminals, can log in to Device via Telnet.
- PC1 is restricted from logging in after repeated quick logins to Device, while PC2 is not affected.

Network Topology

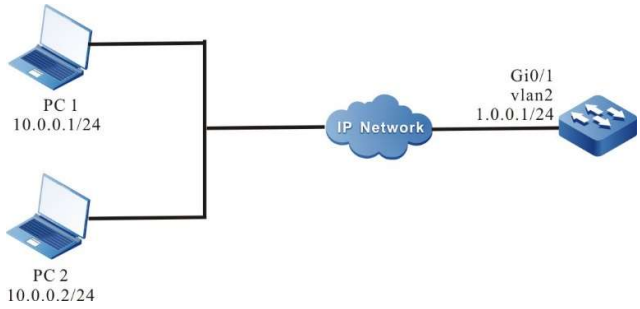


Figure 2-7 Network Topology for Configuring Quick Login Restriction

Configuration Steps

Step 1: Configure the IP address of each interface and configure the routing protocol to enable intercommunication between PC1, PC2 and Device. (Omitted)

Step 2: Configure telnet quick login restriction function.

#Enable telnet login security function and configure the maximum number of quick logins to 20 and forbid time to 10.

```
Device#configure terminal
Device(config)#service login-secure telnet
Device(config)#login-secure telnet quick-connect max-times 20
Device(config)#login-secure telnet quick-connect forbid-time 10
```

Step 3: Configure the login username and password of Device , and set it to use local authentication to log in.

```
Device(config)#local-user user1 class manager
Device(config-user-manager-user1)#service-type ssh
Device(config-user-manager-user1)#password 0 admin
Device(config-user-manager-user1)#privilegeprivilege  15
Device(config)#line vty 0 15
Device(config-line)#login aaa
Device(config-line)#exit
```

Step 4: Check the result.

#PC1 logs in and out via telnet for 21 times repeatedly using user1, with no more than 30 seconds between each login, the quick connection information in the telnet login security statistics is displayed:

```
Device#show login-secure telnet quick-connect
telnet module quick connect info:
connect ip     connect times  last connect time          forbid-time    record-time
----------     -------------  -----------------          -----------    -----------
10.0.0.1       21             TUE AUG 11 20:22:38 2015   00:09:00       00:01:00
```

You can see that PC1 is considered as a login attack address and is not allowed to login to the device via telnet for 10 minutes.

PC2 can successfully log in to Device via telnet.

8System Alarm

8.1 Overview

With the system alarm function, if an exception occurs, the system sends an alarm prompt message so that the user can pay attention to the exception of the device and take the corresponding measures to ensure stable operation of the device. System alarms include temperature alarms, power supply abnormality alarms, and fan abnormality alarms. For the system temperature alarms, if the CPU or environment temperature reaches the threshold, abnormal system alarm log information is generated. By default, the CPU temperature alarm threshold is 110°C and the environment temperature alarm threshold is 110°C. Power supply and fan exceptions also generate abnormal system alarm log information.

8.2 System Alarm Function Configuration

Table 8-1 System Alarm Function Configuration List

Configuration Task	
Configure System Temperature Alarms	Configure System Temperature Alarms
Configure System CPU Alarms	Configure System CPU Alarms
Configure System Memory Alarms	Configure System Memory Alarms
Configure System Power Supply Alarms	Configure System Power Supply Alarms
Configure System Fan Alarms	Configure System Fan Alarms

8.2.1 Configure System Temperature Alarms

Configuration Condition

Before configuring system alarms, ensure that:

- After the system is started and operates stably, all boards are loaded successfully.
- After the system is started and operates stably, the power supply and fans operate normally.

Configure System Temperature Alarms

Configure the system temperature alarms is to configure the system switch chip, CPU and motherboard alarm temperature, when the switch chip, CPU or motherboard temperature reaches a certain threshold value, the system alarm log message will be generated.

Table 8-2 Configuring System Temperature Alarms

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure switch chip, CPU or motherboard temperature alarm thresholds	**alarm temperature mpu** { **switch** | **cpu** } *temperature*	Mandatory
Configure the temperature alarm threshold of an active virtual switch member device's switch chip, CPU or motherboard in a stacked environment.	**alarm temperature device** *device-num* **mpu** { **switch**| **cpu** } *temperature*	Mandatory

8.2.2 Configure System CPU Alarms

Configuration Condition

Before configuring system alarms, ensure that:

- After the system is started and operates stably, all boards are loaded successfully.

Configure System CPU Alarms

Configure system CPU alarms is the function that sends an CPU utilization exception alarm when the monitoring threshold is exceeded after the threshold of CPU utilization monitoring is configured.

Table 8-3 Configuring System CPU Alarms

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the system CPU utilization alarm threshold	**cpu utilization warner-threashold** [*rate-value*]	Optional

8.2.3 Configure the low threshold of memory usage

Configuration Condition

Before configuring the system threshold alarms, first complete the following tasks:

- After the system is started and operates stably, all boards are loaded successfully.

Configure the Low Threshold of Memory Usage

Configure the low threshold of system memory usage refers to the function that sends the system into a state of memory shortage when the system memory falls below the low threshold after the low threshold of system memory usage is configured.

Table 4-8 Configuring System Memory Threshold Alarms

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure system memory threshold alarms.	**memory threshold low** *low-value*	Optional By default, the low threshold of system memory is 32M.

8.2.4 Configure System Memory Alarms

Configuration Condition

Before configuring system alarms, ensure that:

- After the system is started and operates stably, all boards are loaded successfully.

Configure System Memory Alarms

Configuring system memory alarms is a function that alerts you of system memory utilization exception when the monitoring threshold is exceeded after the system memory utilization monitoring threshold is configured.

Table 8-5 Configuring System Memory Alarms

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the system memory utilization alarm threshold	**memory utilization warner-threashold** [*rate-value*]	Optional By default, the system memory utilization alarm threshold is 95%.

8.2.5 Configure System Power Supply Alarms

Configuration Condition

None

Configure System Power Supply Alarms

If a power supply fault or exception occurs, the system immediately generates log information about system power supply alarms. This helps the user to pay attention to the exception of the device power supply and take the corresponding measures to get rid of the fault and ensure stable operation of the device. By default, the system power supply alarm function is enabled.

8.2.6 Configure System Fan Alarms

Configuration Condition

None

Configure System Fan Alarms

If a system fan fault or exception occurs, the system immediately generates log information about the system fan alarm. This helps the user to pay attention to the exception of the device fans and take the corresponding measures to get rid of the fault and ensure stable operation of the device. By default, the system fan alarm function is enabled.

9System Log Configuration

9.1 Overview

System log information is categorized into eight levels, including: **emergencies**, **alerts**, **critical**, **errors**, **warnings**, **notifications**, **informational**, and **debugging**. Here levels 0-6 are log information and level 2 is debugging information. For details, refer to the following table.

Table9-1 Description of the System Log Level Fields

Field	Level	Description
emergencies	0	Fatal fault. The system is unavailable, the device stops and it needs to be restarted.
alerts	1	Serious error. Functions of a certain type become unavailable, and the services are stopped.
critical	2	Critical error. Irreversible problems occur on the functions of a certain type, and some functions are affected.
errors	3	Error Message
warnings	4	Warning message.
notifications	5	Event notification message.
informational	6	Message prompt and notification.
debugging	7	Debugging message.

System log information is outputted to five directions: control console (Console terminal), monitor console (Telnet or SSH terminal), log server, log files (memory log files and flash log files) and email. The output to the five directions is controlled by respective configuration commands. The debugging information is outputted to two directions, control console and monitor console. In some special cases, the debugging information can also be configured to output to the log server or log files.

Table 9-2 Directions for Log Output

Log Output Direction	Description
Control console	System log information is outputted to the Console terminal.
Monitor console	System log information is outputted to the Telnet or SSH terminal.
Log server	System log information is outputted to the log server. By default, logs of levels 0-5 are outputted to the log server.
Log files	System log information is outputted to the system memory or flash memory. By default, log information of levels 0-5 is outputted to the system memory, and log information of levels 0-5 is outputted to the flash memory.
email	System log information is outputted to the log email. By default, logs of level 0~4 are outputted to the log email.

The log module runs in a separate syslog process. The main thread of the syslog process receives the log information sent from the system, first processes the log data and allocates cache space, and then mounts it to the cache queue corresponding to each output terminal according to the configured output action. Since the cache queue has a length limit, there is a situation that logs are lost when a large number of logs are outputted. In such case, the log module will count the lost logs. There are two threads for log scheduling output (log information output to console, monitor, log server and log file run in the same sub-thread, and log information output to email runs in another sub-thread), and a timer is enabled in the scheduling thread for each output direction, and the timer gets log data from the queue corresponding to the terminal after each response and outputs it to the corresponding terminal as configured by the user.

9.2 System Log Function Configuration

Table 9-3 Log Function Configuration List

Configuration Task	
Configure Log Output Functions	Configure Log Output to the Control Console
	Configure Log Output to the Monitor Console
	Configure Log Output to the Server
	Configure Log Output to Files
	Configure log output to email
Configure the Timestamp for Logs	Configure the Timestamp for Logs
Configure operation log output to the log server	Configure operation log output to the log server
Configure log duplicate suppression function	Configure log suppression
Configure log files capacity	Configure log files capacity
Configure log files encryption function	Configure log files encryption
Configure log display color	Configure log display color
Configure log filtering function	Configure log filtering function
Configure the origin-id of a device	Configure the origin-id of a device

9.2.1 Configure Log Output Functions

Configuration Condition

None

Configure Log Output to the Control Console

The control console refers to a Console terminal. It is a channel through which the system output log information to the control console.

Table 9-4 Configuring Log Output to the Control Console

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the log output function.	**logging enable**	Optional By default, the log output function is enabled.
Enable log display on the control console.	**logging source** { *module-name* | **default** } **console** { **level** *severity* | **deny** }	Optional By default, log display on the control console is enabled.

Configure Log Output to the Monitor Console

The monitor console refers to the Telnet or SSH terminal, which is used for managing remote devices. When configuring to display log output to the monitor console, the log display on the current terminal shall be enabled.

Table 9-4 Configuring Log Output to the Monitor Console

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the log output function.	**logging enable**	Optional By default, the log output function is enabled.
Enable log display on the monitor console.	**logging source** { *module-name* | **default** } **monitor** { **level** *severity* | **deny** }	Optional By default, log display function of the global control console is enabled.
Enable log display on the current monitor console.	**terminal monitor**	Mandatory By default, log display function of the current control console is not enabled.

Configure Log Output to the Server

In order to record log information more comprehensively, you can configure log output to the log server for easy maintenance and management of the system. When configuring log output to the log server, the host address or domain name of the log server shall be configured.

Table 9-5 Configuring Log Output to the Log Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the log output function.	**logging enable**	Optional By default, the log output function is enabled.
Configure Log Output to the Log Server	**logging server** *server-name* [**vrf** *vrf-name*] { **ip** *ip-address* | **ipv6** *ipv6-address* | **hostname** *host-name*} [**port** *port-num*] [**facility** *facility-name*] **[level** *severity***]**	Mandatory By default, log output to the log server is not enabled.
Configure Log Output to Source IP Address.	**logging server source** { **ip** *ip-address* | **ipv6** *ipv6-address* | **interface** *interface-name* }	Optional By default, the outgoing interface for sending log information will be determined based on the route, and the primary IP address of the outgoing interface will be used as the source IP address for the log output.
Configure a Specified Level of Log Output to the Log Server	**logging source** { *module-name* | **default** } **server** [*server-name &<1-8>*] { **level** *severity* | **deny** }	Optional By default, logs of level 0-5 are outputted to the log host.

Configure Log Output to Files

Log files can be stored either in memory or in Flash storage. For log information stored in memory, only the content from after the syslog is started until before the system or the syslog process is restarted is kept. By default, log information at level 5 (**notifications**) and above is kept. The log information stored in Flash memory is saved as level 5 (**notifications**) and above by default, please refer to the detailed definition in Table 9-1 for log levels. When the log file size reaches the configured maximum capacity, the oldest log file will be deleted first when adding a new log (log information is recorded by multiple log files), and then a new log file will be created and the new log information will be recorded into the new log file.

Table 9-6 Configuring Log Output to Files

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the log output function.	**logging enable**	Optional By default, the log output function is enabled.
Configure Log Saved to Flash	**logging source** { *module-name* | **default** } **file** { **level** *severity* | **deny** }	Optional By default, logs of level 0-5 are saved to Flash.
Configure Log Saved to Memory	**logging source** { *module-name* | **default** } **buffer** { **level** *severity* | **deny** }	Optional By default, logs of level 0-5 are saved to memory.
Configure Log Files Capacity Alarms	**logging** *{* **buffer** / file *}* warning *warning-value recover-value*	Optional By default, the log information alarm threshold is at 90% and the recovery threshold is at 70%.
Configure Log Files Compression	**logging compress [gunzip]** **logging compress max-num** *value*	Optional By default, log compression function is not enabled.

Configure Log Output to Email

In order to record log information more comprehensively, you can configure log information to be outputted to the corresponding recipient and copy-to email address via email.

Table 9-7 Configuring Log Output to Email

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the log output function.	**logging enable**	Optional By default, the log output function is enabled.
Configure Email Template	***logging email*** *email-profile*	Mandatory By default, the template for log output to the email is not configured.
Configure the email address of the recipient receiving the log information.	**mail recipient** *mail-address*	Mandatory By default, the email address of the recipient receiving the log information is not configured.
Configure the copy-to email address receiving the log information.	**mail copyto** *mail-address*	Optional By default, no copy-to email address receiving the log information is configured.
Configure the email address of the sender of the log information.	***mail sender*** *mail-address*	Mandatory By default, not email address of the sender of the log information is configured.
Configure the email password of the	**mail sender password** *password-string*	Mandatory By default, no email password of the

Step	Command	Description
sender of the log information.		sender of the log information is configured.
Configure the email domain address of the recipient receiving the log information.	**mail server** *server-name*	Optional By default, the characters after the @ character in the sender's email address are used as the sender's domain address.
Configure the email subject of the sender of the log information.	***mail subject*** *subject-name*	Optional By default, no email subject of the sender of the log information is configured.
Configure a specified level of log information to be outputted to the corresponding recipient and copy-to email address via email.	**logging source** { *module-name* | **default** } **email** { **level** *severity* | **deny** }	Optional By default, logs of level 0-4 are outputted to email.

9.2.2 Configure the Timestamp for Logs

Configuration Condition

None

Configure the Timestamp for Logs

Timestamp for logs provides a detailed record of when the log was generated. By default, the log timestamp takes the form of absolute time, but it also supports the form of Uptime (relative time). When configuring absolute time, you can specify the year of logging and log with millisecond precision, with detailed log time output.

Table 9-8 Configuring Timestamp for Logs

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Type of Timestamp for Logs	**logging timestamps uptime**	Optional By default, the log information uses the absolute timestamp.
Configure the Type of Timestamp for Logs	**logging timestamp-format { msec | timezone | year }**	Optional By default, log information is displayed in a timestamped format with the year of logging.

9.2.3 Configure Operation Log Output to the Log Host

Configuration Condition

Configure log output to the log host first.

Configure operation log output to the log server

When the operation log is configured to be sent to the log server, you can view the user-generated operation log on the log server.

Table 9-9 Configuring Log Output to the Log Host

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the log output function.	**logging enable**	Optional By default, the log output function is enabled.
Configure Log Host	**logging server** *server-name* [**vrf** *vrf-name*] { **ip** *ip-address* | **ipv6** *ipv6-address |*	Mandatory By default, the function of sending logs to the

Step	Command	Description
	hostname *host-name* } [**port** *port-num*] [**facility** *facility-name*] **[level** *severity***]**	log server is not enabled.
Configure operation log output to the log server	**logging operation to-server**	Mandatory By default, the function of sending operation logs to the log server is not enabled.

9.2.4 Configure log suppression

Configuration Condition

None

Configure Log Duplicate Suppression

Since in some cases the module may keep outputting the same logs over and over again, affecting the observation of other logs, this can be avoided by enabling the log duplicate suppression function. Repeated log information are outputted once within each suppression cycle, and the number of times this log was suppressed during the suppression cycle is outputted at the end of the suppression cycle.

Table 9-11 Configuring Log Duplicate Suppression

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the function of log duplicate suppression.	**logging suppress duplicates interval** *interval-num*	Mandatory By default, the function of log suppression is enabled.

9.2.5 Configure log files capacity

Configuration Condition

None

Configure log files capacity

Due to the limitation of Flash memory capacity, the log file capacity can be configured in the range of 1M to 32M. When the log information storage exceeds the configured maximum capacity limit, new logs will overwrite the old log information (overwrite the old log information file in file units).

Table 9-10 Configuring Log Files Capacity

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure log files capacity	**logging file size** *file-max-size*	Optional By default, the log files capacity is 1M bytes.

9.2.6 Configure log files encryption

Configuration Condition

None

Configure log files capacity

Considering the security of log information, the log files stored in flash can be encrypted. When the log files encryption function is configured, the logs generated subsequently will be stored in the form of cipher text in the log files. If the password of the log files is changed, logs previously stored in the form of cipher text will not be displayed in plain text. The log information will be displayed in plain text only when the password is reconfigured to the password used to generate the logs.

Table 9-11 Configuring Log Files Encryption

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure log files encryption	***logging file encryption alogrithms SMV4 key*** *password*	Optional By default, no encryption is configured for the log files in Flash.

9.2.7 Configure log display color

Configuration Condition

None

Configure log display color

When displaying log information, different levels of log information can be configured to display different colors in order to highlight the importance of the information. By default, the function of log display color is enabled and different log levels correspond to default log display colors, please refer to the following table:

Table 9-12 Log Colors Description

Field	Description
emergencies	Red
alerts	Purple
alerts	Blue
errors	Brown
warnings	Cyan
notifications	White
informational	Green
debugging	Green

Table 9-13 Configuring Log Display Color

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure log display colors corresponding to log levels	**logging color** [*logging-level logging-color*]	Optional By default, each log level has its default log display color.

Note:

- When the control or monitoring console needs to output the color of log information, the color option of the display terminal shall be configured, otherwise, the color of the log information cannot be displayed.

9.2.8 Configure log filtering function

Configuration Condition

None

Configure log filtering function

When configuring log filtering, you can specify to display not only log information containing the filter string, but also log information without the filter string and the log information level range. When this command is used, the filter string needs to be used together with the log level range.

Table 9-14 Configuring the Log Filtering Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure log filtering function	**logging filter** { **exclude** *exclude-string* | **include** *include-string* | **level** *high-level low-level* }	Optional By default, the log filtering function is not enabled.

9.2.9 Configure the origin-id of a device

Configuration Condition

None

Configure the origin-id of a device

When configuring the origin-id of a device, a maximum 63 characters can be configured. After configuring, the hostname field of the logs sent to the log server will be replaced by the origin-id string.

Table 9-17 Configuring the Origin-id of a Device

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the origin-id of a device	**logging origin-id string** *origin-id*	Optional By default, the origin-id of a device is not configured.

9.2.10 Log Monitoring and Maintaining

Table 9-18 Log Monitoring and Maintaining

Command	Description
clear logging [**buffer** | **file**]	Clear log information stored in memory or Flash.
show logging [**buffer** | **file**]	Display log information stored in memory or Flash.
show logging { **file** | **buffer** } **desc**	Reverse display of log information stored in memory or Flash.
show logging filter	Display log filtering configuration information.
show logging operation	Display log information stored in the operation log files.
show logging [{ **file** | **buffer** } [**begin-level** *level-value* **/** [**start-time** *stime* [**end-time** *etime*]] [**detail**]]]	Display log information stored in the operation log files, and with the filtering option of time and level to display filtered log information.
show logging { file | buffer } message-counter	Display the size of the log files and the number of log entries stored in Flash or memory of the device.

10 Software Upgrade

10.1 Overview

Software upgrade provides a more stable software version and more abundant software features for the user.

Upgraded programs are stored in the storage mediums of the device in the form of files or data blocks. The software modules with different functions cooperate to keep the device in the stable working state and support the hardware features of the device and application services of users.

Users can upgrade software through the TFTP/FTP network transmission mode or the Ymodem transmission mode of the Console port. In upgrading software of different types, users must carefully read the operation steps and notes and cautions described in the manuals related to the software upgrade.

In upgrading software, you usually need to upgrade software of each type. If the software of a type is not updated during the upgrade process, you need not upgrade the software again. Usually, you can restart the device only after the all software versions are upgraded.

The following types of software are available:

- **Image package**: A MPU package with the .pck suffix contains a collection of programs (operating system, applications, etc.) for the normal operation of the system.
- **FPGA (Field Programmade Gate Array) program**: The program with the suffix .bin is mainly used to implement the logic control of the device and the sending and receiving of service data.
- **Bootloader program**: A program with the suffix .bin or .pck. MPU bootloader program is cured in the ROM of the MPU and SPU, and is the first to be executed after the device is powered on. This program initializes the base system and its main function, and is mainly used to guide the operating system to load.
- **CPLD (Complex Programmable Logic Device)** programs, with the suffix .pck, are digital integrated circuits that construct logic functions.
- **Devinfo:** OEM program containing information such as model ID and function ID of various devices and boards. It is mainly used for upgrading when the equipment is retrofitted.

- **Patch:** Patch is a fast, low-cost way to fix defects in product software versions. The main advantage of patching over upgrading software versions is that it does not disrupt the business that the device is currently running, i.e., defects in the current software version of the device can be fixed without rebooting the device.
- **Package packager:** A package file containing image, bootloader, cmm programs, which allows for upgrade of multiple types of software programs at once, convenient and time-saving.

The correspondence between the above-mentioned types of upgrade software and types of board is shown in the table:

Table 10-1 Correspondence between Upgrade Software and Different Types of Boards

	image Package	fpga Procedures	bootloader Procedures	cpld Procedures	devinfo DOCUMENTATION	patch DOCUMENTATION	package Package file
Main Processing Unit (MPU)	√	√	√	√	√	√	√

Note:

- WAN business board daughter cards like CPOS, POS, etc. have FPGA program, while Ethernet business board daughter cards does not have FPGA program.

10.2 Software Upgrade Function Configuration

Table 10-2 Software Upgrade Function Configuration List

Configuration Task	
Upgrade the image Program Package	Upgrade MPU iamge package via TFTP/FTP
FPGA program upgrade	Upgrade FPGA program via TFTP/FTP
bootloader Program Upgrade	Upgrade bootloader program via TFTP/FTP
CPLD program upgrade	Upgrade CPLD program via TFTP/FTP
Devinfo file upgrade	Upgrade devinfo file package via TFTP/FTP
Patch file upgrade	Patch upgrade via TFTP/FTP
Package packager upgrade	Upgrade package packager via TFTP/FTP

10.2.1 Upgrade the image Program Package

The image package is suitable for MPU upgrade.

Configuration Preparation

Before upgrading the image program package, ensure that:

- Ensure that the route between the TFTP/FTP server and the device interface is reachable and the route can be pinged through.
- The TFTP/FTP server configuration is correct, and the image program is stored in the specified directory of the TFTP/FTP server.
- Ensure the remaining flash space is sufficient. If the space is insufficient, manually delete files on flash that are not in use.
- The configuration files have been backed up.

Upgrade the image Program Package in TFTP/FTP Mode

Enter the privileged user mode, ensure that the device can obtain the upgrade program through the external TFTP/FTP server, and then use the sysupdate image command to upgrade the program package.

Table 10-3 Upgrading the image Program Package in TFTP/FTP Mode

Step	Command	Description
Enter the privileged user mode.	None	Mandatory
Upgrade the image program package.	**sysupdate image** [**device** { *memberId* **| all }**] **mpu** [**vrf** *vrf-name*] {*dest-ip-address* **|** *dest-ipv6-address*} *filename* [**ftp** *ftp-username ftp-password*] [**reload**]	Mandatory If the FTP option is not specified, TFTP is used for upgrade by default.

For example: In standalone mode, upgrade the MPU image program via the FTP server 130.255.168.45.

```
Hostname#sysupdate image mpu 130.255.168.45 sp7-g-9.7.1.1(74)(R).pck ftp a a

#The device will prompt the following:

checking "sp7-g-9.7.1.1(74)(R).pck" : ...OK
The file sp7-g-9.7.1.1(74)(R).pck already exists on Mpu 0, overwrite it?(Yes|No):y
downloading "sp7-g-9.7.1.1(74)(R).pck" :
##########################################################################################################OK
Download "sp7-g-9.7.1.1(74)(R).pck" (95678892 Bytes) successfully.
Verify the image...
Apr 16 2021 03:11:33 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 download file successfully!valid
Writing file to
filesystem.....
.....OK!
Start backup ios to raw flash...
Apr 16 2021 03:12:08 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 write file to file-system
successfully!.....
.....OK
 %Sysupdate image is in process, please wait...
Apr 16 2021 03:12:28 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 write file to backup file-system
successfully!
Apr 16 2021 03:12:28 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 upgrade successfully!
 %Sysupdate image finished.

      sysupdate image result information list:
-------------------------------------------------------------
      Card      result information
-------------------------------------------------------------
      Mpu 0     upgrade successfully!
```

Apr 16 2021 03:12:30 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:Upgrade image to sp7-g-9.7.1.1(74)(R).pck from ftp: 130.255.168.45 successfully !

The above message indicates that the image program of the active/standby MPU in position has been successfully upgraded.

Note:

- If the command option reload is added, the system prompts whether to save the configuration and

whether to restart the device. However, usually the device is started after all programs are upgraded. Therefore, the reload option is not recommended.

- Before the upgrade, ensure that there is sufficient space in the flash. If the space is insufficient, the upgrade fails. In this case, you can manually delete files that are not in need from the flash memory to obtain more space for upgrading application programs.
- When the active/standby MPU flash space is insufficient, it will prompt whether to delete the extra image file, if the space remains insufficient after deleting, the upgrade fails.
- It takes a long time to upgrade the image program package. A smaller remaining space in the flash memory results in longer upgrade time.
- After the upgrade is completed, to run the new image program, restart the device.
- If there are two MPUs in the device, you need to upgrade the them synchronously. If the versions of the two MPUs are inconsistent, it may lead to abnormal startup and operation.
- When upgrading the active/standby MPU at the same time, the upgrade fails if one of them does not meet the upgrade conditions.
- When upgrading the active/standby MPU simultaneously, the upgrade will continue when the standby MPU is not in position.
- If the device fails to start normally, open the monitor screen, modify the startup mode to network startup. After the device is started successfully, start the upgrade. For the method, refer to the related section in the monitor configuration manual and command manual.

Warning:

- During the upgrade process, ensure the device cannot be powered off, and avoid unplugging of the MPU or rebooting operation; otherwise, the system may not boot up and the flash file system of the MPU may be damaged.

10.2.2 Patch program upgrade.

Configuration Condition

Before upgrading the patch program, the following tasks shall be completed:

- The route between the TFTP/FTP server and the device interface is reachable, and the TFTP/FTP server and the device can ping each other successfully.
- The TFTP/FTP server configuration is correct, and the patch program is stored in the specified directory of the TFTP/FTP server.
- The configuration files have been backed up.

Patch upgrade via TFTP/FTP

Enter the privileged user mode, ensure that the device can obtain the upgrade program through the external TFTP/FTP server, and then use the sysupdate patch command to upgrade the program package.

Table 10-4 Upgrading the Patch Program Package in TFTP/FTP Mode

Step	Command	Description
Enter the privileged user mode.	None	Mandatory
Upgrade patch program.	**sysupdate patch [device {***memberId* **| all}] mpu** [**vrf** *vrf-name*] *dest-ip-address filename* [**ftp** *ftp-username ftp-password*]	Mandatory If the FTP option is not specified, TFTP is used for upgrade by default.

Upgrade the patch program with the file name sp7-g-9.7.1.1.HP001.pat from the device interface via FTP server 130.255.168.45.

```
Hostname#sysupdate patch mpu 130.255.168.45 sp7-g-9.7.1.1.HP001.pat ftp a a

        #The device will prompt the following:
        checking " sp7-g-9.7.1.1.HP001.pat" : ...OK
        downloading "sp7-g-9.7.1.1.HP001.pat" : #OK
        ..... ..... ..... .....(Omitted).....
        %Sysupdate patch finished.

            sysupdate patch result information list:
----------------------------------------------------------------------
            Card       result information
----------------------------------------------------------------------
            Mpu 0      upgrade successfully!
        sysupdate patch to sp7-g-9.7.1.1.HP001.pat from ftp: 130.255.168.45 successfully !
```

#The above information indicates that the patch program of the device has been successfully upgraded, and the report and log information of the upgrade result will be outputted after the upgrade is completed.

10.2.3 bootloader Program Upgrade

The bootloader program is suitable for upgrading the MPU, forwarding board, SPU mother card and SPU daughter card.

Configuration Preparation

Before upgrading the bootloader program, you need to complete the following tasks:

- Ensure that the route between the TFTP/FTP server and the device interface is reachable and the route can be pinged through.
- The TFTP/FTP server is correctly configured and the bootloader program is correctly stored in the specified TFTP/FTP directory.

- The configuration files have been backed up.

Upgrade bootloader program via TFTP/FTP

Enter privileged user mode, ensure the device can get the upgrade program from external TFTP/FTP server, and then upgrade the program via sysupdate bootloader command.

Table 10-5 Upgrading the bootloader Program in TFTP/FTP Mode

Step	Command	Description
Enter the privileged user mode.	None	Mandatory
Upgrade bootloader program.	**sysupdate bootloader** [**device** { *memberId* **| all }**] **mpu** [**vrf** *vrf-name*] {*dest-ip-address dest-ipv6-address*} *filename* [**ftp** *ftp-username ftp-password*] [**reload**]	Mandatory If the FTP option is not specified, TFTP is used for upgrade by default.

For example: In standalone mode, upgrade the bootloader program on the MPU via the FTP server 130.255.168.45.

```
Hostname#sysupdate bootloader mpu 130.255.168.45 sz01-bootloader-nl02-9.6.0.3ft15-1.1.18.pck ftp a a
#The device will prompt the following:
checking " sz01-bootloader-nl02-9.6.0.3ft15-1.1.18.pck " : ...OK
downloading " sz01-bootloader-nl02-9.6.0.3ft15-1.1.18.pck " : ####OK
Download " sz01-bootloader-nl02-9.6.0.3ft15-1.1.18.pck " (3637108 Bytes) successfully.
Update bootloader start.
.....OK.

 %Sysupdate bootloader is in process, please wait...
 %Sysupdate bootloader finished.

      sysupdate bootloader result information list:
-------------------------------------------------------------------
      Card      result information
-------------------------------------------------------------------
      Mpu 0     upgrade successfully!
```

#The above information indicates that the bootloader program of the active MPU has been successfully upgraded.

Note:

- When upgrading, please select the correct bootloader version, and upgrade the bootloader of all service boards on the device synchronously to avoid occurence of exceptions.
- If the command option reload is added, the system prompts whether to save the configuration and whether to restart the device. However, usually the device is started after all programs are

upgraded. Therefore, the reload option is not recommended.

- After the upgrade is complete, in order to run the new bootloader program, you need to reboot the board or the device.
- The bootloader program of all device MPUs need to be upgraded simultaneously to avoid the occurrence of exceptions.
- Please select the correct bootloader version for the upgrade to avoid the occurrence of exceptions.

Warning:

- During the upgrade process, ensure that the device cannot be powered off, and avoid unplugging of the MPU or rebooting operation; otherwise, the system may not boot up and the bootloader file of the MPU may be damaged.

Upgrade bootloader Program via Console

Ensure that the HyperTerminal can access the device through the Console port, enter the bootloader mode, adjust the baud rate, and upgrade through the ymodem of the HyperTerminal. If there are two MPUs on the device, they need to upgraded separately.

For detailed descriptions of the commands, please refer to the relevant sections of the "bootloader" command manual.

Table 10-6 Upgrading the bootloader Program via the Console Port

Step	Command	Description
Set up the HyperTerminal.	None	Mandatory Run the HyperTerminal program and select the corresponding serial port (e.g. com1), set up its properties, that is, baud rate is 9600 bps, soft flow control, 8 data bits, no parity check, 1 stop bit.
Enter the bootloader mode	None	Mandatory When the device reboots, press CTRL+C to enter the bootloader mode.
Modify the baud rate of the Console port and the	**srate** { *speed* }	Optional

Step	Command	Description
HyperTerminal to speed up the upgrade		Modify the baud rate of the device Console port to 115200bps, then disconnect the HyperTerminal, modify the baud rate of the HyperTerminal to 115200bps, and reconnect.
Upgrade bootloader program.	**mupdate bootloader**	Mandatory Enter the mupdate bootloader command in bootloader mode, then select the ymodem protocol in HyperTerminal, select the bootloader program and start sending.

For example: Upgrade the bootloader program of the active MPU through the Console port.

```
#The device will prompt the following:
bootloader# mupdate bootloader
Download bootloader start...
run command=loady
## Ready for binary (ymodem) download to 0x20000000 at 115200 bps...
C
Starting ymodem transfer.  Press Ctrl+C to cancel.
Transferring sz02sz01-bootloader-nl02-9.6.0.3ft15-1.1.18.pck...
  100%    1760 KB       4 KB/sec    00:07:03       0 Errors

## Total Size      = 0x001b83d8 = 1803224 Bytes
Download bootloader OK.
bootloader image check:
..... done
Un-Protected 16 sectors

..... done
Erased 16 sectors
run command=cp.b 200000f0 0x1bc00000 0xc3ea0
Copy to Flash... done
..... done
Protected 16 sectors
```

Update bootloader OK #**The above information indicates that the bootloader program of the active MPU has been successfully upgraded**.

Note:

- Upgrade the bootloader program of the standby MPU through the Console port, the operation process is the same as the active MPU.
- When upgrading the bootloader program, make sure the speed rate of the HyperTerminal and the

speed rate of the device Console port are in consistency.

- When upgrading the bootloader program, it is recommended to set the transfer rate to 115200bps, so as to shorten the upgrade transfer time.
- When upgrading the bootloader program, if the default rate of the Console port is modified, when loading the image package, the Console port rate of the device is automatically restored to 9600bps, and the rate of the HyperTerminal needs to be modified as well.
- It is recommended to try upgrading the bootloader program via TFTP/FTP, and use the Console port to upgrade the bootloader program only when the conditions for the former are not met.

Warning:

- During the upgrade process, ensure that the device cannot be powered off, and avoid the unplugging of the MPU or rebooting operation; otherwise, the system may not boot up and the bootloader file of the MPU may be damaged.

10.2.4 Devinfo file upgrade

The devinfo file is used for MPU upgrade.

Configuration Preparation

The following tasks need to be completed before the devinfo file can be upgraded:

- Ensure that the route between the TFTP/FTP server and the device interface is reachable and the route can be pinged through.
- The TFTP/FTP server is correctly configured and the devinfo file is correctly stored in the specified TFTP/FTP directory.
- The configuration files have been backed up.

Upgrade Devinfo Files via TFTP/FTP

Enter the privileged user mode to ensure the device can get the upgrade program from external TFTP/FTP server, and can be upgraded through sysupdate devinfo command.

Table 10-7 Upgrading Devinfo File via TFTP/FTP

Step	Command	Description
Enter the privileged user mode.	None	Mandatory
Devinfo file upgrade	**sysupdate devinfo** [**device** { *memberId* **| all }**] **mpu** [**vrf** *vrf-*	Mandatory

Step	Command	Description
	name] {*dest-ip-address* **|** *dest-ipv6-address*} *filename* [**ftp** *ftp-username ftp-password*] [**reload**]	If the FTP option is not specified, TFTP is used for upgrade by default.

For example: In standalone mode, upgrade the devinfo file on the MPU via the FTP server 130.255.168.45.

```
Hostname#sysupdate devinfo mpu  130.255.168.45 devInfo_sw_HIT_V2.125 ftp a a
#The device will prompt the following:
checking "devInfo_sw_HIT_V2.125" : ...OK
downloading "devInfo_sw_HIT_V2.125" : #OK
Download "devInfo_sw_HIT_V2.125" (6275 Bytes) successfully.
Writing file to filesystem....OK!

 %Sysupdate devinfo is in process, please wait...
 %Sysupdate devinfo finished.

      sysupdate devinfo result information list:
---------------------------------------------------------------------
      Card      result information
---------------------------------------------------------------------
      Mpu 0     upgrade successfully!
```

#The above information indicates that the devinfo file of the active/standby MPU in position has been successfully upgraded.

Note:

- If the command option reload is added, the system prompts whether to save the configuration and whether to restart the device. However, usually the device is started after all programs are upgraded. Therefore, the reload option is not recommended.
- After the upgrade is complete, in order to run the devinfo file, you need to reboot the board or the device.
- The devinfo files of all active/standby MPUs on the device need to be upgraded in synchronization to avoid anomalies.
- Please select the correct devinfo file version for the upgrade to avoid the occurrence of exceptions.

Warning:

- During the upgrade process, ensure that the device cannot be powered off, and avoid the unplugging of MPU or rebooting operation; otherwise, the system may not boot up properly and the devinfo file may be damaged.

10.2.5 Package file upgrade

The package file contains image, bootloader, and devinfo file, which can be upgraded all at once through the package file.

Configuration Preparation

The following tasks need to be completed before the package file can be upgraded:

- Ensure that the route between the TFTP/FTP server and the device interface is reachable and the route can be pinged through.
- The TFTP/FTP server is correctly configured and the package file is correctly stored in the specified TFTP/FTP directory.
- The configuration files have been backed up.

Upgrade Package Files via TFTP/FTP

Enter privileged user mode, ensure the device can get the upgrade program from external TFTP/FTP server, and then upgrade the program via sysupdate package command.

Table 10-8 Upgrading Package File via TFTP/FTP

Step	Command	Description
Enter the privileged user mode.	None	Mandatory
Upgrade Package File	**sysupdate package** [**device** { *memberId* **| all }**] **[vrf** *vrf-name***]** {*dest-ip-address* **|** *dest-ipv6-address*} *filename*[**ftp** *ftp-username ftp-password* **] [no-comparision]** **[reload]**	Mandatory If the FTP option is not specified, TFTP is used for upgrade by default.

For example: In standalone mode, package and upgrade programs of all active boards via the FTP server 130.255.168.45.

```
Hostname#sysupdate package 130.255.168.45 sp7-g-9.7.1.1(74)(R)-001.pkg FTP a a

#The device will prompt the following:

Downloading "sp7-g-9.7.1.1(74)(R)-001.pkg" header...OK!
Checking "sp7-g-9.7.1.1(74)(R)-001.pkg" header...OK!
```

```
Downloading "sp7-g-9.7.1.1(74)(R)-001.pkg" :
##################################################################################################OK!
Download "sp7-g-9.7.1.1(74)(R)-001.pkg" (96507023 Bytes) successfully!
Checking package file...OK!
Verify the image...valid
Writing file to
filesystem.....
.....OK!
Start backup ios to raw flash.....
Apr 16 2021 02:46:51 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 write file to file-system
successfully!.....
.....OK
 %Sysupdate image is in process, please wait...
Apr 16 2021 02:47:10 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 write file to backup file-system
successfully!
Apr 16 2021 02:47:10 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 upgrade successfully!
 %Sysupdate image finished.
Update bootloader start.
.....OK.

 %Sysupdate bootloader is in process, please wait...
Apr 16 2021 02:47:15 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:bootloader : Mpu 0 upgrade successfully!
 %Sysupdate bootloader finished.
Writing file to filesystem...OK!
.
 %Sysupdate devinfo is in process, please wait...
Apr 16 2021 02:47:16 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:devinfo : Mpu 0 upgrade successfully!
 %Sysupdate devinfo finished..
 %Sysupdate pkgInfo is in process, please wait...
Apr 16 2021 02:47:17 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:pkgInfo : Mpu 0 upgrade successfully!
 %Sysupdate pkgInfo finished.

      package sysupdate result information list:
---------------------------------------------------------------

sp7-g-9.7.1.1(74)(R).pck sysupdate result information list:
---------------------------------------------------------------
      Mpu 0   -  upgrade successfully!

sz03-bootloader-cn61-1.0.35.pck sysupdate result information list:
---------------------------------------------------------------
      Mpu 0   -  upgrade successfully!

devInfo_sw_HIT_V2.122 sysupdate result information list:
---------------------------------------------------------------
      Mpu 0   -  upgrade successfully!

pkg_info.txt sysupdate result information list:
---------------------------------------------------------------
      Mpu 0   -  upgrade successfully!
BCM_hezi-ss69#

Apr 16 2021 02:47:19 BCM_hezi-ss69 MPU0 %SYS_UPDATE-RESULT-5:Sysupdate package to sp7-g-9.7.1.1(74)(R)-
001.pkg from ftp: 130.255.168.45 successfully !
```

#The above information indicates that the package files of all types of active boards have been successfully upgraded.

Note:

- For business board daughter card, it is only shown when the upgrade fails.
- If the command option reload is added, the system prompts whether to save the configuration and whether to restart the device. However, usually the device is started after all programs are

upgraded. Therefore, the reload option is not recommended.

Warning:

- During the upgrade process, ensure that the device cannot be powered off, and avoid the unplugging of boards or rebooting operation; otherwise, the system may not boot up properly and files may be damaged.

10.3 Example of typical configuration for software upgrade

10.3.1 Upgrade Package File

Network Requirements

- A PC acts as an FTP server, and Device acts as an FTP client. The network between the server and the device is normal.
- On the FTP server, set the user name of the device for logging in to the FTP server as admin and the password is admin; place the packaged program for upgrade under the FTP server directory to upgrade all software versions that the device supports for packaged upgrade.

Network Topology

Figure 10-1 Network Topology for Packaged Upgrading of All Supported Software Versions

Configuration Steps

Step 1: Configure the FTP server and place the packaged program for upgrade in the directory of the FTP server. (Omitted)

Step 2: Back up the device configuration file. (Omitted)

Step 3: Configure the IP address of the interface to connect the device to the FTP server network. (Omitted)

Step 4: Upgrade the packaged program.

#Use sysupdate to upgrade the packaged program.

```
Device#sysupdate package 2.0.1.1 sp28sp28-g-9.66.0.11(R)-001.pkg  ftp admin admin no-comparision
```

After the upgrade is completed, a list of upgrade results is printed out for the user to determine the upgrade results of all upgrade programs included in the packaged upgrade file on the device.

```
%Sysupdate pkgInfo finished.

      package sysupdate result information list:
---------------------------------------------------------------------

sp7-g-9.7.1.1(74)(R).pck sysupdate result information list:
---------------------------------------------------------------------
      Mpu 0   -  upgrade successfully!

sz03-bootloader-cn61-1.0.35.pck sysupdate result information list:
---------------------------------------------------------------------
      Mpu 0   -  upgrade successfully!

devInfo_sw_HIT_V2.122 sysupdate result information list:
---------------------------------------------------------------------
      Mpu 0   -  upgrade successfully!

pkg_info.txt sysupdate result information list:
---------------------------------------------------------------------
```

Mpu 0 - upgrade successfully!

Caution:

- Please ensure that all boards are in position with their status in Start OK before packaged upgrade. Please do not unplug any board during the upgrade process to avoid upgrade abnormalities affecting the subsequent start-up of the board.

Note:

If you select the "no-comparision" parameter, the program will be upgraded directly using the version in the program without comparing the image versions. If this parameter is not selected, the image version will be compared, and if the image version in the packaged upgrade program is lower than or the same as the running version of the device, the device will prompt the user and wait for the user to confirm whether to upgrade the image program in the upgrade package. Whether the user chooses to upgrade the program or not, it will not affect the upgrade of other upgrade files in the upgrade package. If the image file is the only file included in the upgrade package, the package upgrade ends if the user chooses not to upgrade.

- This command also allows you to add the "reload" parameter, which can reboot the device directly after the upgrade is completed.

Step 5: Command to reboot the device

#Use the reload command to reboot the device.

```
Device#reload
Save current configuration to startup-config(Yes|No)?y
Please confirm system to reload(Yes|No)?y
```

It is up to the user to decide whether to save the configuration before rebooting.

Note:

- If the "reload" parameter is included in the upgrade command, this step is omitted.

Step 6: Check the result.

#After the upgrade is completed and the device is rebooted, check the version information of the upgraded file in the packaged upgrade program via the show package version command.

```
Device#show package version

package        :sp7-g-9.7.1.1(74)(R)-001.pkg
image          :sp7-g-9.7.1.1(74)(R).pck
bootloader     :sz03-bootloader-cn61-1.0.35.pck
```

devinfo :devInfo_sw_HIT_V2.122

#To verify if the update is successful, check the version number of each program via the show system verison brief command.

```
Device#show system version  brief

version information display:

Module    Online State    Name                BootLoader  IOS                CMM     PCB   CPLD   FPGA
-------------------------------------------------------------------------------------------------------------------------
Mpu 0     online Start Ok   HIT SW          1.0.36     9.7.1.1(74)(integrity) /      001   105    /
```

Caution:

- The version of the upgrade file in the packaged upgrade program can be viewed via the show package version command, and the final upgrade result can be viewed via the show system verison brief command.

10.3.2 Full Upgrade of All Software Versions

Network Requirements

- A PC acts as an FTP server, and the device Device acts as an FTP client. The network between the server and the device is normal.
- On the FTP server, set the user name of the device for logging in to the FTP server as admin and the password is admin; place the image program and bootloader program for upgrade under the FTP server directory to upgrade all software versions of the device.

Network Topology

Figure 10-2 Network Topology for Upgrading of All Software Versions

Configuration Steps

Step 1: Configure the FTP server and place the image program and bootloader program for upgrade in the directory of the FTP server. (Omitted)

Step 2: Back up the device configuration file. (Omitted)

Step 3: Configure the IP address of the interface to connect the device to the FTP server network. (Omitted)

Step 4: Upgrade the image program.

#Check if there is enough space left in the file system before upgrading the image program.

```
Device#filesystem
Device(config-fs)#volume
```

#Use sysupdate to upgrade the image program of the MPU.

```
Device#sysupdate image mpu 2.0.0.1  sp7-g-9.7.1.1(74)(R).pck ftp admin admin
```

For information on image program upgrade process and whether the upgrade was successful, please refer to the relevant section on "Image Program Package Upgrade" in "Software Upgrade Configuration".

Step 5: Upgrade bootloader program.

#Use sysupdate to upgrade the bootloader program of the MPU.

```
Device#sysupdate bootloader mpu all 2.0.0.1 sz03-bootloader-cn61-1.0.35.pck ftp admin admin
```

For information on bootloader program upgrade process and whether the upgrade was successful, please refer to the relevant section on "Bootloader Upgrade" in "Software Upgrade Configuration".

Step 6: Upgrade FPGA program.

#Upgrade the FPGA program of the active/standby MPUs, CPOS, POS, E1 and other WAN daughter cards as needed, as shown in the following example: Use sysupdate to upgrade the FPGA program of all CPOS daughter cards on the device.

```
Device#sysupdate  fpga mpu 2.0.0.1 pb035mpuc_fpv001_101.bin ftp  admin admin
```

The upgrade command for the active/standby MPUs, POS, E1 and other WAN daughter cards shall follow suit, and only the file name needs to be changed. For information on FPGA program upgrade process and whether the upgrade was successful, please refer to the relevant section on "FPGA Upgrade" in "Software Upgrade Configuration".

Note:

- When upgrading FPGA, if the board type is not specified, the corresponding board will be searched automatically according to the FPGA program type for upgrading.
- In general, FPGA program's update frequency is relatively low, so please confirm the upgrade version is higher than the current running version of the system before upgrade. If the FPGA version is not updated, then the upgrade is not necessary. Please refer to step 10 below to check the current FPGA version of the system.

Step 7: Upgrade CPLD files

#Use sysupdate to upgrade the CPLD program on board.

```
Device#sysupdate cpld mpu 2.0.0.1          pb011_s5830_cpld_clv009.pck ftp admin admin
```

For information on CPLD program upgrade process and whether the upgrade was successful, please refer to the relevant section on "CPLD Program Package Upgrade" in "Software Upgrade Configuration".

Step 8: Upgrade devinfo program

#Use sysupdate to upgrade the devinfo program of the MPU.

Device#sysupdate devinfo mpu 2.0.0.1 devInfo(v2.2) ftp admin admin

For information on devinfo program upgrade process and whether the upgrade was successful, please refer to the relevant section on "Devinfo Upgrade" in "Software Upgrade Configuration".

Step 9: Command to reboot the device.

#Use the **reload** command to reboot the device.

```
Device#reload
Save current configuration to startup-config(Yes|No)?y
Please confirm system to reload(Yes|No)?y
```

It is up to the user to decide whether to save the configuration before rebooting.

Step 10: Check the result.

After the upgrade is complete and the device is rebooted, verify that all versions have been updated by checking the version numbers of various programs.

#Verify that the image and bootloader programs of the active/standby MPU have been upgraded successfully.

```
Device#show  system  mpu
System Card Information(Mpu 0 - ONLINE)
 ---------------------------------------------------------------------
                 Type:   HIT SW
               Status:   Start Ok
           Last-Alarm:   Normal
         Card-Port-Num:   54
       Card-SubSlot-Num:   0
      Power-INTF-Status:   Normal
      Power-Card-Status:   On
           Serial No.:   mpu30--;kljhsadi$^#&-[;'
          Description:
   Hardware-Information:
                  PCB-Version: 001
                CPLD-Version: 105
    Software-Information:
             Bootloader-Version: 1.0.36
              Software-Version: 9.7.1.1(74)(integrity)
 Temperature-Information:
               Temperature-State:
                           Switch-Temperature = 63 C
                           Last-Alarm = Normal.
 CPU-On-Card-Information:   < 1 CPUs>
                     CPU-Idx:  00
                      Status:  Normal
                    Core-Num:  0002
                   Core-State:
                    Core-Idx-00
                         Core-Status:  0000
                       Core-Utilization:  18%
                    Core-Idx-01
                         Core-Status:  0000
                       Core-Utilization:  0%
                  Temperature:
                    Temperature-State:
                              Temperature = 48 C
                               Last-Alarm = Normal.
 MEM-On-Card-Information:  <1 MEMs>
                     MEM-Idx:  00
                    MEM-State:
                          BytesFree = 3301539840 bytes
                         BytesAlloc =  859258880 bytes
                         BlocksFree =          5 blocks
                        BlocksAlloc =        364 blocks
                       MaxBlockSizeFree =   58720256 bytes
                            SizeTotal = 4160798720 bytes
 DISK-On-Card-Information:  <3 DISKs>
                     DISK-Idx:  00
                        Type:  Flash
                      Status:  Online
                    DISK-State:
                         SizeTotal = 3964465152 bytes
                          SizeFree = 3333177344 bytes
 CPLD-On-Card-Information:  <2 CPLDs>
                     CPLD-Idx:  00
                    Info-Struct:
                             version = 105
                      CPLD-Idx:  01
                    Info-Struct:
                             version = 105
 ---------------------------------------------------------------------
 STATISTICS:         1 IN, 0 OUT, 0 IERR, 0 OERR
```

```
Device#show devInfo
vendor        : HIT
product Type  : SWITCH
devInfo version: V2.122
```

Note:

- The interface of the device that can reach the FTP server by routing can be either a dc0 out-of-band management interface or a service interface.
- There is no strict order for upgrading image and bootloader programs as mentioned above, but remember, you need to upgrade all programs before rebooting the whole device.
- Before upgrading, you should ensure that there is enough space left in the flash file system of the active/standby MPU for saving the upgraded image files. If the remaining space on the device is insufficient, delete redundant files in the file system of the device; it is recommended to ensure that the remaining space of flash of the active/standby MPU is more than 170M before upgrading, otherwise the upgrade time may be extended.
- If some programs have not been modified in the new released version, the unmodified programs can be left unupgraded.
- If an exception occurs during the upgrade process, resulting in the unsuccessful upgrade of some boards, you can upgrade this part of the board separately later on.

10.3.3 Upgrade bootloader using Console port.

Network Requirements

- A PC is directly connected to the device Console port.
- Use the Console port to upgrade the bootloader program of the active/standby MPU.

Network Topology

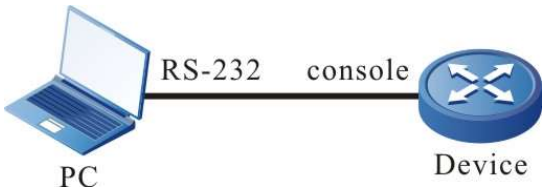


Figure 10-3 Using the Console Port to Upgrade the bootloader Program

Configuration Steps

Step 1: A PC is properly connected to the Console port of the device. (Omitted)

Step 2: Open the bootloader screen.

Press and hold "ctrl+c" to open the bootloader screen when the device has just booted up and printed "Press ctrl+c to enter bootloader mode: 0".

Step 3: Set the transfer rate to 115200bps to speed up the upgrade.

```
bootloader#srate 115200
```

#After setting the transfer rate of Console port under bootloader, the transfer rate of HyperTerminal should be set to 115200bps as well.

Step 4: Upgrade the bootloader version in the bootloader environment.

```
bootloader#mupdate bootloader
```

#Enter the command "mupdate bootloader" to transfer the bootloader file saved on the PC using ymodem.

#Check the result.

#The following message will be printed on the bootloader screen after the upgrade is completed.

```
download bootloader via y modem protocol......CCCCC

Starting ymodem transfer.  Press Ctrl+C to cancel.

Transferring sz03-bootloader-cn61-1.0.34.pck...

 100%    1760 KB      4 KB/sec    00:07:03      1 Errors


## Total Size      = 0x001b83d8 = 1803224 Bytes

 success!

Update bootloader start...

Erase Master Flash OK ...

\Flash Program OK ...

Verifying flash data...

Verify OK ...

                Update bootloader OK.
```

Step 5: Check the result.

#Rebooting the device after the upgrade is complete, and the system will print that the system is loaded guided by the new bootloader.

```
Bootloader 1.0.34 (Build time: Apr 02 2021 - 08:38:15)


Warm boot from slave sector
```

Press ctrl+c to enter bootloader mode: 0

0

Note:

- Since upgrading the bootloader program via Console port is more complicated and time-consuming, it is usually recommended to use TFTP to upgrade the bootloader program, and use the Console port to upgrade the bootloader program only when the conditions of the former are not met.
- After the upgrade is complete, exit the bootloader with the "reset" command and let the new bootloader program guide the image program to load.
- When upgrading the bootloader program, if the default baud rate of the Console port is modified, the Console port rate of the device is automatically restored to 9600bps when loading the image package, and the rate of the HyperTerminal needs to be modified as well.

11 Bootloader

11.1 Overview

In embedded systems, the bootloader program runs before the OS kernel runs and is used to initialize hardware devices (including Console ports, Ethernet interfaces, flash, etc.), establish memory space mapping, thus bring the system's hardware and software environment to a suitable state in order to prepare the correct environment for the eventual boot of the OS kernel. In an embedded system, there is usually no firmware program like BIOS, and the loading and booting task of the whole system is done by bootloader.

The bootloader system mainly contains the following functions:

- Set startup parameters to load IOS via network device or internal flash memory device
- Upgrade bootloader program.
- Back up bootloader program.

11.2 bootloader Function Configuration

Table 11-1 bootloader Function Configuration List

Configuration Task	
Enter the bootloader configuration mode	Enter the bootloader configuration mode upon startup
Set bootloader startup parameters	Set bootloader startup parameters to boot the image program in flash.
Configure the bootloader to manage the Ethernet port IP address.	Configure the bootloader to manage the Ethernet port IP address.
Upgrade bootloader program.	Upgrade bootloader program.

11.2.1 Preparation for bootloader function configuration

Before starting the bootloader configuration, you need to set up the local configuration environment. Connect the serial port of the host (or terminal) to the Console port of the device through the configuration cable, and the configuration of the communication parameters of the host (or terminal) and the default configuration of the Console port of the device need to be consistent. The default configuration of the Console port on the device is:

- Transmission rate: 9600bps
- Flow control mode: None
- Calibration method: None
- Stop Bit: 1Bit
- Data bits: 8Bit

11.2.2 Enter the bootloader configuration mode

Configuration Condition

None

Enter the bootloader configuration mode

Table 11-2 Entering the bootloader Configuration Mode

Step	Command	Description
Enter the bootloader configuration mode	None	Mandatory After the device is powered on, press and hold "ctrl+c" to enter the bootloader configuration mode; after entering, the prompt message is: "bootloader#"

Note:

- After entering the bootloader configuration mode, you can perform the functions

provided by the bootloader mode.

11.2.3 Set bootloader startup parameters

Configuration Condition

None

Set Bootloader Startup Parameters

Table 11-3 Setting the bootloader Startup Parameters

Step	Command	Description
Enter the bootloader configuration mode	None	Mandatory After the device is powered on, press and hold "ctrl+c" to enter the bootloader configuration mode; after entering, the prompt message is: "bootloader#"
Set IOS startup parameters under bootloader	**change** *index[0~3]* **dc0** *filename local-ip-addr host-ip-addr [gatewayip] [netmask]* **change** *index[0~3]* **flash0** *filename*	Mandatory The first line of the command is the network startup configuration parameters, if you upgrade across network segments, you need to add the gateway and mask. The second line of the command is the startup configuration parameters for flash storage device.

Note:

- The bootloader program of the domestic switch currently can set startup parameters to boot the image program over network.

11.2.4 Upgrade bootloader program.

Configuration Condition

None

Upgrade bootloader program.

Table 11-4 Upgrade bootloader Program

Step	Command	Description
Enter the bootloader configuration mode	None	Mandatory After the device is powered on, press and hold "ctrl+c" to enter the bootloader configuration mode; after entering, the prompt message is: "bootloader#"
Start tftp server on the PC.		Mandatory Copy the new bootloader version used for the upgrade to the root directory of tftp for the device to download the version file via tftp.
Upgrade bootloader program.	**update bootloader***filename* **dc0** *local-ip-addr host-ip-addr [gatewayip] [netmask]*	Mandatory Upgrade the PCK file of bootloader via tftp server
Back up bootloader program.	**bootloaderbak**	Optional

Note:

- The bootloader system program adopts a dual bootloader backup mode, i.e. it has both the main bootloader program and the backup bootloader program, using the upgrade command can only upgrade the program version of the main bootloader, while the backup bootloader program will remain unchanged.
- After upgrading the bootloader system program, use the command **reset** or power off and reboot the device to use the latest bootloader system program.
- When the system is loaded successfully, you can upgrade it with the sysupdate command.

11.2.5 bootloader Monitoring and Maintaining

Table 11-5 bootloader Monitoring and Maintaining

Command	Description
version	Display the bootloader program version number.
print *index[0~4]*	Display startup parameters information specified by index.
boot index[0~4]	Load the startup parameters information specified by index.
clear index[0~3]	Clear the startup parameters information specified by index.
grate	Obtain data on the speed rate of the current serial port.
Srate ratenum	Obtain data on the speed rate of the current serial port, the value of which is taken as 9600 or 115200.

11.3 bootloader Typical Configuration Example

11.3.1 Configure the bootloader to start the Image program via the network.

Network Requirements

- A PC acts as a TFTP server, and Device acts as a TFTP client. The network between the server and the device is normal.
- On the TFTP server, place the image program and bootloader program that need to be upgraded in the TFTP server directory.

Network Topology

Figure 11-1 Configuring the bootloader to Boot the Image Program via the Network

Configuration Steps

Step 1: Configure TFTP server and place the image program in the directory of the TFTP server. (Omitted)

Step 2: After the device is powered on, press and hold "ctrl+c" to enter the bootloader configuration mode.

Step 3: Configure the startup line parameters to start the Image program via the network.

For instance,

```
bootloader # change  0  dc0        sp7-g-9.7.1.1(70)(T)(v3.9.0.255)-dbg.pck  1.1.1.3  1.1.1.1

bootloader # boot  0
```

Note:

- Connect the first port of the device to the tftp server.
- After setting the startup information, the device can communicate with the tftp server normally before performing boot.

12 PoE Management

12.1 Overview

The existing Ethernet, with its basic structure of Cat.5 cabling unchanged, not only transmits data signals for IP-based terminals (such as IP phones, WLAN access points, and network cameras), but also provides the DC power supply for the devices. This technology is called Power over Ethernet (PoE). The PoE technology ensures not only the security of existing structured cabling but also normal operation of the existing network, greatly reducing the cost.

PoE is also called Power over LAN (PoL) or Active Ethernet. It is the latest standard specification for making use of existing standard Ethernet transmission cable to transmit data and provide power. It is compatible with the existing Ethernet systems and users. IEEE 802.3af and IEEE802.3at are the technical standards that PoE must comply with. IEEE802.3af is the basic standard of the PoE technology. It is based on the IEEE 802.3, and the standards related to direct power supply through network cables are added. It is an extension of the existing Ethernet standards. IEEE802.3at is an extension based on the IEEE802.3af.

According to the definition of the IEEE802.3af standard, a complete PoE power supply system consists of two types of devices: Power Sourcing Equipment (PSE) and Power Device (PD).

- PSE: It provides power to other devices.

12.1.1 PD (Power Device): Devices that receive power. The power of the devices is usually not large.

PSE/PD Interface Specifications

For the 10BASE-T and 100BASE-TX networks, IEEE802.3af defines Power Interfaces (PIs), which are interfaces between PSE/PD and network cables. Currently, it has defined two power supply modes, Alternative A (xsignal wire pairs 1, 2, 3 and 6) and Alternative B (signal wire pairs 4, 5, 7, and 8). The following is a description of the two power supply modes:

1. Power supply through signal wire pairs (Alternative A)

As shown in the following figure, a PSE can supply power to a PD through signal wire pairs. Because DC and data frequency does not interfere with each other, electric current and data can be transmitted through the same wire pair. For electric cables, this is a kind of "multiplexing". Wires 1 and 2 are connected to form a positive (or negative) polarity, and wires 3 and 6 are connected to form a negative (or positive) polarity.

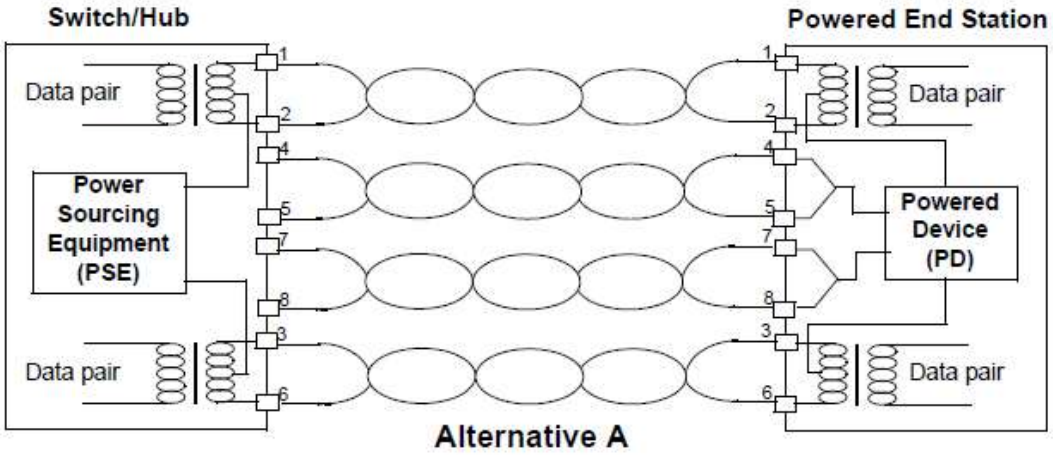


Figure 12-1 Alternative A Power Supply Mode with 10BASE-T and 100BASE-TX

2. Power supply through idle wire pairs (Alternative B)

As shown in the following figure, a PSE can supply power to a PD through idle wire pairs. Wires 4 and 5 are connected to form a positive polarity, and wires 7 and 8 are connected to form a negative polarity.

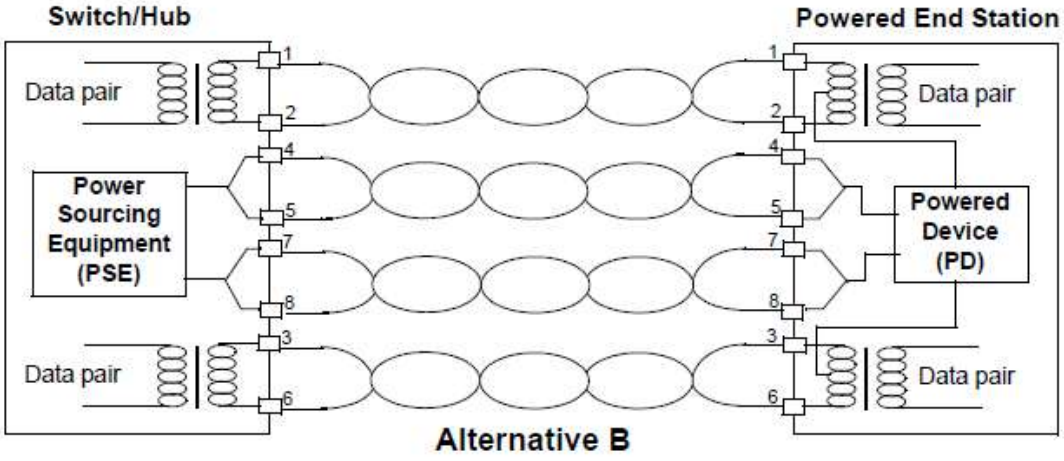


Figure 12-2 Alternative B Power Supply Mode with 10BASE-T and 100BASE-TX

According to IEEE802.3af, standard PDs must support both power supply through signal wire pairs and power supply through idle wire pairs, while PSEs need only support either of the two modes.

12.1.2 PoE Power Supply Process

If a PSE is installed in a network, the PoE Ethernet power supply process is as follows:

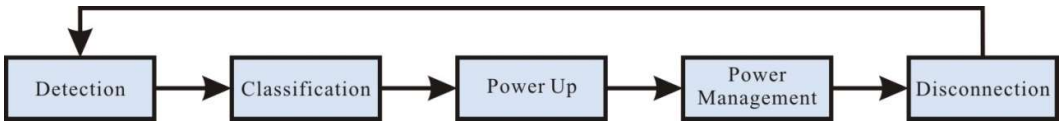


Figure 12-3 PSE Power Supply Process

- Detection: After a network device is connected to a PSE, the PSE first detects whether the device is a PD to ensure that the current is not supplied to non-PDs because supplying power to a device that is not a PD may damage the device. The PSE detects the resistance capacitance between the power output wire pairs to determine whether PDs exist. The PSE proceeds to the next step only after it detects PDs.
- Classification: After detecting PDs, the PSE classifies the PDs. It determines power grade of PDs by detecting power output current. During the power supply process, classification is optional.
- Power Up: Within a startup period which is configurable (usually less than 15 us), the PSE starts to provides low power voltage to PDs and gradually increases the power voltage to 48 V DC.
- Power Management: The PSE provides stable and reliable 48 V DC power for PDs. Once the PSE starts to supply power, it continuously detects PD current inputs. If the current consumption of a PD drops under the minimum value owing to various causes, such as the PD is disconnected, the PD encounters power consumption overload or short circuit, and the power load exceeds the PSE power supply load, the PSE regards the PD as not in position or abnormal. In this case, the PSE stops providing power to the PD.
- Disconnection: The PSE detects the current of PDs to determine whether PDs are disconnected. If a PD is disconnected, the PSE stop supplying power to the PD quickly (usually within 300 to 400 ms), and then the PSE returns to the Detection status.

12.2 PoE Function Configuration

Table 12-1 PoE Function Configuration List

Configuration Task	
PoE Basic Function Configuration	Enable the Global PoE Function
	Enable the Interface PoE Function
	Enable the Forced Power Supply Function of an Interface
	Enable the Auto Power Supply Function of an Interface
Configure the PoE Power	Configure the Total Power of PoE
	Configure the Protection Power of PoE

Configuration Task	
	Configure the Maximum Output Power Limit Mode of an Interface
	Configure the Maximum Output Power of an Interface
Configure Power Supply Priorities	Configure a PoE Power Management Mode
	Configure the Power Supply Priority of an Interface
Configure PD Power-up and Power-down Parameters	Configure Interface PD Detection Mode
	Configure Interface Classification Mode
	Configure Interface Power-up Inrush Current Mode
	Configure Interface Power Supply Wire Pairs
	Configure Interface Power Failure Detection Mode
Configure the Abnormality Recovery Function	Configure the Time for Recovery from a Power Supply Abnormality of an Interface
	Restart the PoE Power Supply
Configure PoE Power Alarm Function	Configure PoE Power Alarm Threshold

12.2.1 PoE Basic Function Configuration

The PoE function is controlled by configuring global PoE and interface PoE, that is, the PoE function can be used only when the global PoE and interface PoE are both enabled. If you run the command for disabling the global PoE, the PoE functions of all interfaces are disabled. If you run the command for disabling the interface PoE function, you can choose to disable the PoE function of some interfaces. The interface PoE function is a standard power supply mode, while the interface forced power supply function is a special power supply mode. You can select only one mode at a time. However, both of the two modes are valid only after the global PoE function is enabled.

Configuration Condition

None

Enable the Global PoE Function

Table 12-2 Enabling the Global PoE Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the Global PoE Function	**power enable**	Optional By default, the global PoE function is enabled.

Enable the Interface PoE Function

Table 12-3 Enabling the Interface PoE Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the Global PoE Function	**power enable**	Optional By default, the global PoE function is enabled.
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Enable the Interface PoE Function	**power enable**	Optional By default, the interface PoE function is enabled.

Enable the Forced Power Supply Function of an Interface

Table 12-4 Enabling the Forced Power Supply Function of an Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enable the Global PoE Function	**power enable**	Optional By default, the global PoE function is enabled.
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Enable the Forced Power Supply Function of an Interface	**power force** { **always** | **once** }	Mandatory By default, the forced power supply function of an interface is disabled.

Note:

Forced power supply is a special power supply mode, which does not require enabling the interface PoE function.

Enable the Auto Power Supply Function of an Interface

Table 12-5 Enabling the Auto Power Supply Function of an Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the Global PoE Function	**power enable**	Optional By default, the global PoE function is enabled.
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Enable the Auto Power Supply Function of an Interface	**power auto-enable**	Mandatory

Step	Command	Description
		By default, the auto power supply function of an interface is disabled.

Note:

The auto-power supply function of an interface works only in manual power management mode.

12.2.2 Configure the PoE Power

Configuration Condition

Before configuring the PoE power, ensure that:

- Enable the Global PoE Function.
- Enable the Interface PoE Function.

Configure the Total Power of PoE

By configuring the total power of PoE, you can limit maximum output power of the device. If the total power required by all PDs exceeds the configured total power, power supply to some PDs is stopped according to the current power supply priority mode.

Table 12-6 Configuring the Total Power of PoE

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Total Power of PoE	**power total-power** { **all** | *system-id* { **all** | *subsystem-id* } } *power-value*	Optional By default, the total power is the maximum total power that the device power supply can provide.

Configure the Protection Power of PoE

When a PD is normally powered, the consumed power fluctuates within a certain range. To prevent PD power-off owing to power fluctuation, part of power is reserved from the total power of the device to act as the protection power. When the consumed power of the PD increases, the increased part is allocated from the protection power.

Protection power may also be allocated as normal power supply. When the available power is insufficient for providing power to newly connected PDs, if the available power of the device and the protection power is equal to or larger than the maximum output power of the interface of the new PD, sufficient power is allocated from the protection power to the new PD.

Table 12-7 Configuring the Protection Power of PoE

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Protection Power of PoE	**power guard-band** { **all** | *system-id* { **all** | *subsystem-id* } } *guard-band-value*	Optional By default, the protection power of the power supply is 40.0 watt.

Configure the Maximum Output Power Limit Mode of an Interface

The maximum output power of an interface is determined by the PD classification type. You can also customize the maximum output power of an interface.

Table 12-8 Configuring the Maximum Output Power Limit Mode of an Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the Maximum Output Power Limit Mode of an Interface	**power threshold-mode** { **classification** | **user** }	Optional By default, the maximum output power limit mode is the user customization mode.

Configure the Maximum Output Power of an Interface

You can limit the maximum power that a PSE can supply to a PD through an interface. If the power required by a PD exceeds the maximum output power of the interface, the PSE stops power supply to it.

Table 12-9 Configuring the Maximum Output Power of an Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the maximum output power limit mode to the user customization mode.	**power threshold-mode user**	Mandatory By default, the maximum output power limit mode is the user customization mode.
Configure the Maximum Output Power of an Interface	**power port-max-power** *max-power-value*	Optional By default, the maximum output power is 30.0 watt.

12.2.3 Configure Power Supply Priorities

With the power supply priority function, if the total power of a PSE is insufficient for powering all PDs, key PDs have the priority to obtain power. Through this function, you can configure the mode in which key PDs are powered.

Configuration Condition

Before configuring power supply priorities, ensure that:

- Enable the Global PoE Function.
- Enable the Interface PoE Function.

Configure a PoE Power Management Mode

Table 12-10 Configuring a PoE Power Management Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure a PoE Power Management Mode	**power manage** { **all** | *system-id* { **all** | *subsystem-id* } } { **dynamic-fifs** | **dynamic-priority | static-fifs** | **static-priority** }	Optional The default power management mode is the dynamic First In First Served (FIFS).

Configure the Power Supply Priority of an Interface

If the PoE power management mode is dynamic priority mode, when the power supply of PSE is insufficient, the system will prioritize power supply to the PD with a higher interface power supply priority. If the interface power supply priority is the same, then priority is given to the PD with the smaller interface number.

Table 12-11 Configuration of Interface Power Supply Priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure a PoE Power Management Mode to Dynamic Priority Mode	**power manage** { **all** | *system-id* { **all** | *subsystem-id* } } **dynamic-priority**	Mandatory The default power management mode is the dynamic First In First Served (FIFS).
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the Power Supply Priority of an Interface	**power priority** { **critical** | **high** | **medium** | **low** }	Optional By default, the power supply priority is low.

12.2.4 Configure PD Power-up and Power-down Parameters

The PoE power-up process is divided into several steps:

1. Detection: PSE detects the presence of PD.
2. Classification: PSE classifies the PD and determines the PD power consumption. This step is optional.
3. Power-Up: PSE supplies power to PD.

The parameters of the above steps can be adjusted to power different types of PDs.

Configuration Condition

Before configuring the PD power-up parameters, first complete the following tasks:

- Enable the Global PoE Function.
- Enable the Interface PoE Function.

Configure Interface PD Detection Mode

When an interface PoE function is enabled, the PSE detects the resistance capacitance between the power output wire pairs to determine whether PDs exist. The standard detection mode can only detect PDs that comply with IEEE802.3af and IEEE802.3at standards. The standard defines PD and non-PD, however, there is another device with a resistance and capacitance value between PD and non-PD,and the compatibility mode is used to detect this type of device.

Table 12-12 Configuring Interface PD Detection Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Interface PD Detection Mode	**power detect-mode** { **compatible** | **standard** }	Optional By default, PD detection mode is standard mode.

Configure Interface Classification Mode

After an interface PoE function is enabled, the PSE determines the power level of the PD by detecting the power supply output current. Corresponding power is assigned to the PD according to the power level of the PD. PD classification is an optional step in the overall power-up process and can be configured to skip this step by going to unclassified mode.

Table 12-13 Configuring Interface Classification Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Interface Classification Mode	**power class-mode** { **standard** | **never** }	Optional By default, it is unclassified in the classification mode.

Note:

Some non-standard PDs may not support classification, in which case the default classification for the PD is class0 and the maximum output power of the interface is 15.4 Watts.

Configure Interface Power-up Inrush Current Mode

The PoE standard regulates the inrush current when powering up the PD. This parameter is related to the PSE, the (parasitic) capacitance of the PD, and the PD power. For some PDs that do or do not meet the specification, the required onrush current may vary and the appropriate onrush current mode needs to be configured for the different PDs.

Table 12-14 Configuring Interface Power-up Inrush Current Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Interface Power-up Inrush Current Mode	**power power-up-mode** { **802.3af** | **high** | **Pre-802.3at** | **802.3at** }	Optional By default, the power-on inrush current mode is high inrush current.

Configure Interface Power Supply Wire Pairs

The PoE standard regulates two power supply modes, idle wire pairs and data wire pairs. Standard PDs must support both power supply through signal wire pairs and power supply through idle wire pairs, while PSEs need only support either of the two modes.

Table 12-15Configuring the Interface Power Supply Wire Pairs Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Interface Power Supply Wire Pairs Mode	**power power-pair**{**pair-A** | **pair-B** }	Optional By default, the power supply wire pairs mode is data wire pairs.

Note:

PSE devices only support the data wire pairs power supply mode.

Configure Interface Power Failure Detection Mode

PSE switches can provide different power failure detection modes depending on the type of current supplied DC or AC.

Table 12-16 Configuring Interface Power Failure Detection Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Interface Power Failure Detection Mode	**power disconnect**{ **ac** | **dc** }	Optional By default, the power failure detection mode is AC.

Note:

The PoE function of the PSE device is integrated into the switch, and the interface power failure detection mode on the device is AC mode by default.

12.2.5 Configure the Abnormality Recovery Function

When there is a PoE power supply abnormality, the abnormality recovery function is supported, including automatic recovery and manual recovery.

Configuration Condition

Before configuring the abnormality recovery function, ensure that:

- Enable the Global PoE Function.
- Enable the Interface PoE Function.

Configure the Time for Recovery from a Power Supply Abnormality of an Interface

If a PSE detects abnormal power supply status of an interface while powering PDs, it automatically disables the PoE function of the interface. After the time for recovery from a power supply abnormality elapsed, it enables the PoE function again, and tries to supply power to the PD of the interface.

Table 12-17 Configuring the Time for Recovery from a Power Supply Abnormality of an Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the Time for Recovery from a Power Supply Abnormality of an Interface	**power recover-time** *time-value*	Optional By default, the recovery time for a power supply abnormality is 0 minutes, indicating immediate recovery after the abnormality.

Restart the PoE Power Supply

When a PoE power supply abnormality occurs or the PoE power supply is abnormal, you can manually hot restart the PoE power supply to try to recover from the abnormal status.

Table 12-18 Configuring the Time for Recovery from a Power Supply Abnormality of an Interface

Step	Command	Description
Restart the PoE Power Supply	**power reload** { **all** | *system-id* }	Mandatory

Note:

During the power reboot process, the module will be initialized. You should avoid repeatedly operating power reload and wait until the power reboot is completed before executing it.

12.2.6 Configure PoE Power Alarm Threshold

Configuration Condition

Before configuring the PoE power, ensure that:

- Enable the Global PoE Function.
- Enable the Interface PoE Function.

Configure PoE Power Alarm Threshold

When PoE power utilization reaches or falls below the set power threshold, Trap alarms are sent.

Table 12-19 Configuring PoE Power Alarm Threshold

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure PoE Power Alarm Threshold	**power alarm-threshold** { **all** | *system-id* { **all** | *subsystem-id* } } *threshold-value*	Optional By default, the alarm threshold for power supply is 99%.

12.2.7 PoE Monitoring and Maintaining

Table 12-20 PoE Monitoring and Maintaining

Command	Description
show power { **manage** | **summary** | **configure interface** *interface-name* | **detect interface** *interface-name* | **pd-status interface** *interface-name* | **system-to-port** [*system-id*] | **version** }	Display PoE configuration, power supply status and port correspondence information, and system-to-port is only available in VST mode.

13 PDI

13.1 Overview

PDI: PD Inspection, refers to a way to detect whether the PD terminal is active, if the PD is not detected, it is considered abnormal and the POE is notified to restart the power supply.

The PDI function is controlled by configuring interface PDI, that is, the PDI function can be used only when the interface PDI is enabled.

13.2 Configure PDI Basic Functions

Table 13-1 Enabling Interface PDI Function

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Enable interface PDI function.	**pdi enable**	Mandatory By default, the interface PDI function is not enabled.

13.3 Configure the ARP message delivery interval.

Table 13-2 Configuring the Interface ARP Message Delivery Interval

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the interface ARP message delivery interval.	**pdi inspection-interval**	Optional By default, the interface arp message delivery interval is 3s.

13.4 Configure the number of retries for ARP message delivery.

Table 13-3 Configuring the Number of Retries for ARP Message Delivery

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the number of retries for ARP message delivery of an interface.	**pdi inspection-retry**	Optional By default, the number of retries for ARP message delivery of an interface is 3.

13.5 Configuring IP Inspection Table Entries

Table 13-4 Configuring IP Inspection Table Entries

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure ip detection table entries for PD.	**pdi ip-address**	Optional

13.6 PDI monitoring and maintaining

Table 13-5 1PDI Monitoring and Maintaining

Command	Description
show pdi { | **brief** | **interface** *interface-name* | **ip-entry ip-entry interface** *interface-name* | **statistic statistic interface** *interface-name* }	Display PDI global structure, port summary information and detailed information, etc.

14 LUM

14.1 Overview

***LUM**: Local User Manager, is a local user database used to provide local authentication for aaa.*

***RBAC:** Role Based Access Control, enables privileges to be granted to roles by establishing the association "Permissions <-> Roles", and assigns roles to users by establishing the association "Roles <-> Users", so that users can obtain the privileges of the corresponding roles. The basic idea of RBAC is to assign roles to users that define which system functions and resource objects they are allowed to operate.*

Since permissions and users are separated, RBAC has the following advantages:

• Administrators do not need to specify permissions for users one by one, but only need to pre-define roles with corresponding permissions, and then assign the roles to users. Therefore, RBAC is more adaptable to user changes and increases the flexibility of user privilege assignment.

• Since the relationship between roles and users often changes, but the relationship between roles and permissions is relatively stable, using this stable association can reduce the complexity of user authorization management and reduce management overhead.

Role: A collection of rules.

Rule: permit/deny permissions for commands of specific feature or all features.

Feature: Module.

14.2 LUM Function Configuration

Table 14-1 LUM Function Configuration List

Configuration Task	
Configure user roles	Configure user roles
Configure administrator program	Configure administrator
	Configure administrator user group

Configuration Task	
Configure access user program	Configure access user
	Configure user group

14.2.1 Configure Access

By default, there are four types of roles: Security-admin, Network-admin, Audit-admin and Network-operator, and the permissions of these four roles cannot be modified.

Custom role permissions are a subset of the network administrator role permissions. Module permissions that have been assigned to the Security-admin, or the Audit-admin cannot be configured. Please see the following table for specific permissions.

Table 14-2 Permissions Corresponding to User Roles

	Logging	History	User management and user authentication	Other modules
Public Elective	NO	NO	Change your own password	Show running, exit, etc.
Security Administrator	View Operation log and related configuration commands	History configuration and operation	OK	lai module, line, service, AAA
Audit Administrator	View data log and configuration commands	NO	NO	NO
network administrator	All commands other than operation log and data log	Histroy configuration and operation	NO	OK
Network Operator	All show commands within the privileges of network operator	show command	NO	All show commands within the privileges of network operator

By default, the user does not have the role attributes configured. When the role attribute is in effect, the user level is no longer in effect, and the role replaces the user level as the basic criterion for command authorization: users have different command execution rights depending on their respective roles.

Configuration Condition

None

Configure user roles

Table 14-3 Configuring User Roles

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create user roles and enter user role mode at the same time	**role** *role-name*	Mandatory By default, there are four types of roles: Security-admin, Network-admin, Audit-admin and Network-operator, and the permissions of these four roles cannot be modified.
Create a rule for the user role	**rule** *number* **{ deny | permit }** **feature {all** | *feature-name* }	By default, no rules are defined for newly created user roles, i.e., the current user role does not have any privileges. The rule modification does not take effect for users who are currently online, but for users who log in later to use the rule for that role. Rules with smaller rule IDs have higher priority.

14.2.2 Configure local users

Local users are those stored on the device: including local administrators and local access users. It only takes effect when local authentication mode is used. A local user is specified as an administrator or an access user when it is created.

Configuration Condition

None

Configure Local Administrator User

Table 14-4 Configuring Administrator

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create an user administrator and enter the user administrator mode	**local-user** *user-name* class manager	Mandatory. By default, no administrator user is configured.

Configure Local Access User

Table 14-5 Configuring Access User

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create access user and enter access user mode at the same time.	**local-user** *user-name* class network	Mandatory. By default, no access user is configured.

14.2.3 Configure administrator user attributes

An administrator is the user who logs into the device.

The following configuration restrictions and guidelines apply when configuring the attributes of local administrator user:

• If the user authorizes the role upon login through AAA, whether the user can execute commands after logging in to the device is determined by the role, and if the role is not authorized by AAA when the user logs in, whether the user can execute commands after logging in to the device is determined by the user level.

• For SSH users, when using public key authentication, if the authentication method for logging in to the device is not configured in the user line view, the commands available to them are based on the user role or user level (user role has higher priority than user level) set in the local administrator user view with the same name as the SSH user. For more information about user roles, please refer to "Configuring Roles" in the "LUM Configuration Guide".

• The attribute regarding the maximum number of password attempts for users can be configured in both local administrator user view and administrator user group view, and the order of priority for configuration is: local administrator user view -> administrator user group view, in descending order.

• The user password lifetime attribute can be configured in local administrator user view, administrator user group view and global view, and the order of priority for configuration is: local administrator user view --> administrator user group view --> global view, in descending order.

Configuration Condition

None

Configure administrator user attributes

Table 14-6 Configuring Administrator

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create an user administrator and enter the user administrator mode	**local-user** *user-name* class manager	Mandatory. By default, no administrator user is created.
Configure the administrator user password.	**password 0** *password*	Mandatory. By default, a user does not have a password.
Set the types of servers that users can use.	**service-type { ssh | telnet | console | ftp | web}**	Mandatory.

Step	Command	Description
		By default, a user does not support any service-type.
Set the user role for the local user.	**user-rol** *role-name*	Optional. **By default, no administrator role is configured .** The administrator role has higher priority over the administrator level, that is, when the role for the administrator user is configured, the administrator privileges are subject to the administrator role.
Set the user group for the administrator user.	**group** *group-name*	Optional. By default, no user group is configured.
Configure the authorized level of login user.	**privilege** *privilege-level-number*	Optional. By default, the authorized level is 1.
Configure the commands to be executed automatically by the user.	**autocommand** *command-line*	Optional. **By default, users do not have commands that are configured to be executed automatically.**
Configure options for users to automatically execute commands.	**autocommand-option** { **nohangup** [**delay** *delay-time-number*] |**delay** *delay-time-number* [**nohangup**] }	Optional. By default, the connection is disabled after executing the command automatically, and the delay time for executing the command automatically is 0.

Step	Command	Description
Configure user livetime	**password-control livetime** *user-live-time*	Optional. By default, user livetime is not restricted.
Configure the maximum number of consecutive login authentication failures for administrator users	**password-control max-try-time** ***max-try-time-number***	Optional. By default, user management does not set limits on the maximum number of attempts.
Configure the maximum number of online sessions for the same user.	**max-online-num** *user-number*	Optional. By default, there is no limit to the maximum number of online sessions for the same user.
Configure the file permissions available to the user.	**filesys-control{read | write | execute | none}**	Optional. By default, the user has permissions to read, write, and execute.
Configure the directories provided by the device that can be accessed or managed by the administrator	**work-directory** *directory*	Optional. The default, it is the /flash directory. This attribute currently only serves to configure the file directory of the ftp user login device.
Configure user status	**stat { active / block }**	Optional. By default, the user status is active.

14.2.4 Configure access user attributes

An access user is a user who accesses the network through a device.

Configuration Condition

None

Configure access user

Table 14-7 Configuring Access Users

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	
Create access user and enter access user mode at the same time.	**local-user** *user-name* class network	Mandatory. By default, no access user is configured.
Configure access user password	**password 0** *password*	Mandatory. By default, users do not have a password, which may prevent them from logging in to the device.
Set the type of server that access users can use.	**service-type** { **xauth** }	Mandatory. By default, a user does not support any service-type.
Set the user group to which the access user belongs.	**group** *group-name*	Optional. By default, the user group to which the access user belongs is not configured.
Configure user status	**stat** { **active** / **block** }	Optional. By default, the user status is active.

14.2.5 Configure local user groups

Local users are divided into the administrator user group and the access user group.

The administrator user group is a collection of administrator user attributes that support the configuration of password lifetime and the maximum number of consecutive login authentication failures.

The access user group manages access users, with hierarchical nesting, which more graphically reflects the organizational structure of the company or department relationship. No access user attributes are supported under the access user group at this time.

Configuration Condition

None

Configure administrator user group

Table 14-8 Configuring the Administrator User Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create the administrator user group and enter the administrator user group mode	**manager-group** *group-name*	Mandatory. By default, no administrator user group is configured.
Configure the user password lifetime under the administrator user group	**password-control livetime** *user-live-time*	Optional. By default, there is no limits set on the lifetime of administrator users under this user group, i.e., the password lifetime is subject to the one configured in the administrator user view.
Configure the maximum number of consecutive login authentication failures for users under the administrator user group.	**password-control max-try-time** ***max-try-time-number***	Optional. By default, there is no limit to the number of consecutive login authentication failures for users under the administrator user group, that is, the maximum number of consecutive login authentication failures is subject to the one configured under the administrator user view.

Configure Access User Groups

Table 14-9 Configuring access user groups

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	
Create the access user group and enter the access user group mode.	**user-group** *group-name*	Mandatory. By default, no access user group is configured.
Configure the parent group of the access user group.	**parent** *group-name*	Optional. By default, the parent group is seen as the parent path in the group name path.

14.2.6 Configure password policies

Our system has a strong password security policy. Password security is guaranteed from three aspects: password complexity, mandatory password change on first login, and a maximum number of password attempts. The password security policy is only valid for local administrator users.

Password Complexity:

(1) Password has a minimum length requirement, and the administrator can set limits to the minimum length of the administrator user password. When setting a user password, if the length of the entered password is less than the minimum length set, the system will not allow the password to be set, and prompts "Bad password: It must contain at least 2 character(s)."

(2) Password combination detection function where the administrator can set the type of combination of the elements that make up the user's password. The constituent elements of a password include the following four types:

• Uppercase letters: [A to Z]

• Lowercase letters: [a~z]

• Decimal numbers: [0 to 9]

• 31 special characters (`~! @$%^&*()_+-={}[]|\:;"'<>,. /')

There are 4 kinds of combinations of cryptographic elements, the specific meaning of each is as follows:

• Combination type 1 indicates that the password contains at least 1 element.

• Combination type 2 indicates that the password contains at least 2 elements.

• Combination type 3 indicates that the password contains at least 3 elements.

• Combination type 4 indicates that the password must contains all 4 elements.

When the user sets a password, the system checks whether the set password meets the configuration requirements, and only the password that meets the requirements can be set successfully.

(3) The password cannot be the same as the user name. When setting the administrator user password, if the password entered is the same as the user name, the system will not allow the password to be created.

Mandatory Password Change at First Login:

When the function of "User must change password when logging in for the first time" is enabled, the system will prompt the corresponding message upon the first login and ask the user to change the password, otherwise the user is not allowed to log in to the device. When the administrator user name is "admin", the user will be asked to change the password upon the first login, regardless of whether the "Mandatory password change on first login" function is enabled or not.

Password lifetime:

The password lifetime is used to limit the length of time a user's password can be used. When the password has been in use for longer than the password lifetime, the user is required to change the password. When a user logs in, if the user enters a password that has expired, the system will prompt that the password has expired and it must be reset before the local login can continue. If the password entered does not meet the requirements, or if the new password entered twice in a row does not match, the system will reject this login. For login in non-interactive mode, such as FTP user, after the password expires, the password of FTP user can only be changed by the administrator; however, if the password happens to expire during the login time period, it will not affect the login, however, the next FTP command will trigger offline. In particular, if the first login asks for a password change and the password has in fact reached its expiration time, the user will only be asked to change password once upon login.

Maximum Number of Password Attempts:

Setting limit on the maximum number of user attempts can be used to prevent malicious parties from decrypting passwords through multiple attempts. After the failed password attempt exceeds the maximum number of attempts, the system will add the user to the blacklist of the login-secure module, and the user account will be locked for a period of time.

Configuration Condition

None

Configuration Condition

Table 14-10 Configuring the Password Policy

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure password complexity	**password-control complexity** {**min-length** *len*| **with user-name-check** | **composition type-number** *type-number* }	Optional. By default, the minimum length of user password is 6, and there are 2 types of password element combination. User name and password are not allowed to be the same.
Configure users to mandatory password change on first login	**password-control firstmodify enable**	Optional. By default, users are not required to change their passwords for the first login. Users with the administrator username "admin" will be required to change their password when they log in for the first time even if the command is not enabled.
Configure user livetime	**password-control livetime** *user-live-time*	Optional. By default, no limit is set on user lifetime.
Configure the maximum number of consecutive login authentication failures for administrator users	**password-control max-try-time** ***max-try-time-number***	Optional. This command is configured in the administrator user group view and the administrator user view. By default, the maximum number of consecutive login authentication failures for users under the administrator user group is not configured, i.e., the maximum number of consecutive login authentication failures is

Step	Command	Description
		subject to the one configured under the administrator user view.

14.2.7 LUM Monitoring and Maintaining

Table 14-11 LUM Monitoring and Maintaining

Command	Description
debug user { manager | network}	Enable debug information for user management.
show users class { manager | network } [*username* **]**	Display user configuration information.
show role [*rolename* **]**	Display configuration information for all or specified roles.

14.3 Typical LUM Configuration Example

14.3.1 Configure network administrator users

Network Requirements

- Configure the network administrator user and verify user's network administrator privileges.

Network Topology

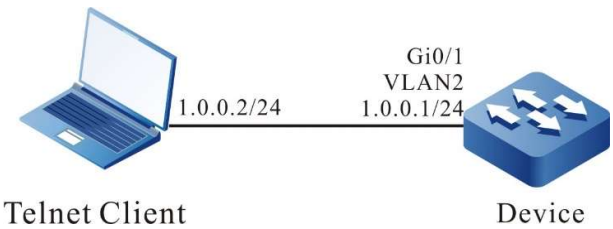


Figure 14-1 Network Topology for Configuring the Network Administrator User Group

Configuration Steps

Step 1: Configures IP addresses for the ports. (Omitted)

Step 2: Configure administrator attributes.

#Configure user admin, the password is admin.

```
Device#configure terminal
Device(config)#local-user admin class manager
Device(config-user-manager-admin)#password 0 admin
```

#Configuration service type

```
Device(config-user-manager-admin)#service-type telnet ftp web console ssh
```

#Configure the user role to which the local user belongs as network administrator.

```
Device(config-user-manager-admin)#user-role network-admin
```

#Configure local authorization to make the role effective

```
Device(config-user-manager-admin)#exit
Device(config)#domain system
Device(config-isp-system)#aaa authentication login local
Device(config-isp-system)#aaa authorization login local
Device(config-isp-system)#exit
```

#Configure login aaa authentication for line vty

```
Device(config)#line vty 0 15
Device(config-line)#login aaa
```

Step 3: Enters the username admin and password admin in the Telnet client to successfully log in to the device.

#Verify that the admin user can execute the admin command show logging to view the logs

```
Device#show logging
Logging source configurations
  console is enabled,level: 7(debugging)
  monitor is enabled,level: 7(debugging)
  buffer is enabled,level: 5(notifications)
  file is enabled,level: 7(debugging)
The Context of logging file:
```

#Verify that the network administrator cannot execute other administrator commands

```
Device#show role
You may not be authorized to perform this operation,please check.
```

Note:

- The default roles for administrators are security-admin, network-operator, audit-admin, and network-admin. You can set your administrator role as needed, or you can use custom roles.

15 ZTP

15.1 Overview

ZTP (Zero Touch Provisioning) is a feature that automatically loads version files (including system software, configuration files, license files, patch files, custom files) when a newly shipped or unconfigured device is powered on.

It is designed to solve the problem that when deploying network device, after the hardware installation of the device is completed, the administrator needs to go to the installation site to debug the software of the device. When the devices are large in number and widely distributed, administrators manually configuring each device affects the efficiency of deployment and labor costs in an bad way. The device runs ZTP function, which can get the version file from the USB disk or the file server and load it automatically to realize the field-free configuration and deployment of the device, thus reducing the labor cost and improving the deployment efficiency.

ZTP is not a standard protocol, it is a device zero-configuration deployment solution proposed by various vendors according to market demand, and there are differences in the details of implementation, but the basic process is the same. ZTP can be deployed in a number of ways, and we currently supports DHCP zero-configuration deployment, USB zero-configuration deployment and mail deployment. The process is to automatically enter the ZTP process by booting the device with empty configuration, first try to complete the automatic deployment through the inserted USB disk, and then try to complete the automatic deployment through DHCP if the USB disk deployment fails.

Network topology of a typical DHCP zero-configuration deployment is shown in Figure 15-1. When an empty-configuration device enters the DHCP zero-configuration deployment process, it will first broadcast DHCP discovery messages through the DHCP client. If the DHCP server is not in the same network segment with the zero-configuration device ready for employment, you need to configure a DHCP relay to send DHCP discovery messages across the network segments. When the DHCP server receives the DHCP discovery messages, it will assign temporary IP address, default gateway and other information for it, and return the intermediate file server address at the same time. The DHCP client receives the answering message from the DHCP server, parses out the intermediate file server address and other information, downloads the intermediate file via FTP/TFTP/SFTP. In the end, it will parse the intermediate file, and download the corresponding version and configuration files from the intermediate file server according to the SN of this device (Serial Number device serial number). Reboot the device to take effect.

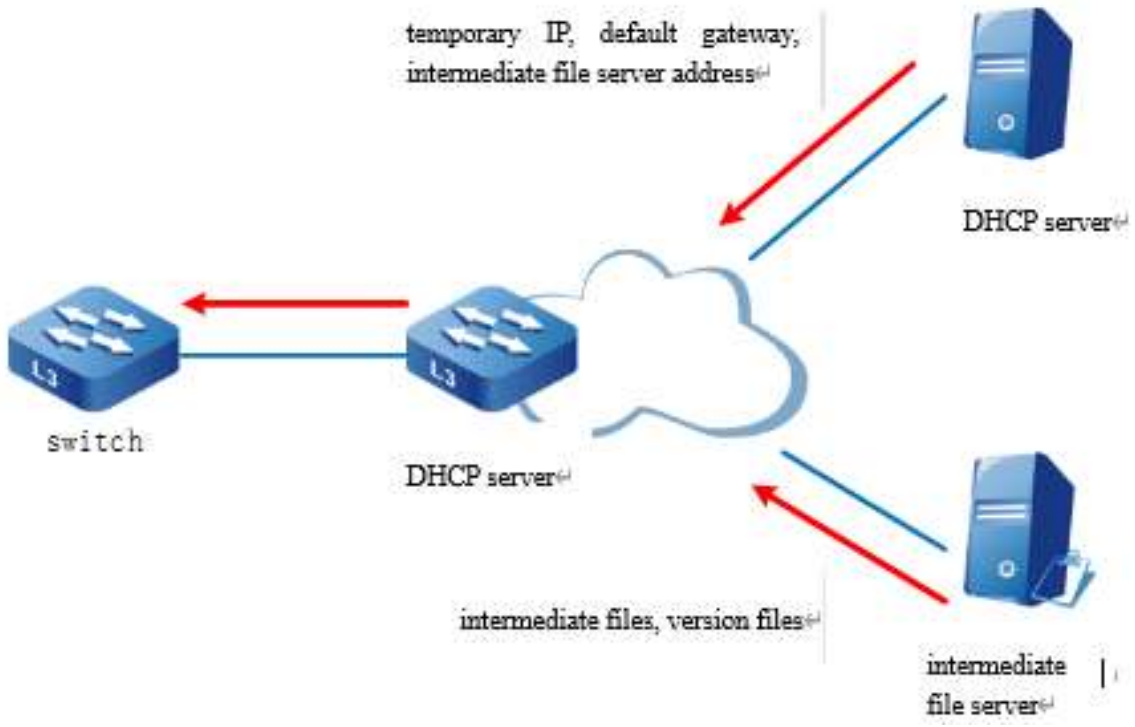


Figure 15-1 Typical Network Topology for DHCP

DHCP server: Used to assign temporary management IP address, default gateway, intermediate file server address and other information for the device executing ZTP.

DHCP relay: When the device executing ZTP and the DHCP server are in different network segments, it needs to forward the DHCP interaction messages through the DHCP relay.

Intermediate file server: Used to store intermediate files (intermediate file type is XML format), version files, configuration files, etc. needed by the device during the ZTP process. By parsing the intermediate file, the device executing ZTP can obtain information such as the file server address, the version file corresponding to this device, and the configuration file storage path. The intermediate file server supports TFTP, FTP, and SFTP types.

Version file server: Used to store the version files needed by the device, such as system software and configuration files. The version file server can be deployed on the same file server as the intermediate file server. It supports TFTP, FTP, and SFTP types.

In USB zero-configuration deployment process, the user edits the intermediate file, system version and configuration file and other information in advance and saves them in the USB. Then the USB is inserted into the device ready for zero-configuration deployment. When the device is powered on and detects the inserted USB with the intermediate file that meets the deployment requirements, it will enter the USB zero-configuration deployment process, compile the intermediate file according to the device SN, copy the corresponding system version and configuration files from the USB, and then reboot the device to take effect.

15.2 ZTP Function Configuration

15.2.1 Enable or Disable ZTP Function

Table 15-1 Enabling or Disabling the ZTP Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the ZTP function	**ztp enable**	By default, ZTP function is enabled on the device.
Disable the ZTP function.	**no ztp enable**	-

Note:

- When ZTP is enabled or disabled, configuration is not displayed with the show running-config command. However, the configuration will take effect after rebooting.

15.2.2 ZTP Monitoring and Maintaining

Table 15-2ZTP Monitoring and Maintaining

Command	Description
show ztp	Display ZTP information
[no] debug ztp	Enable or disable ZTP debugging

15.3 ZTP Typical Configuration Example

15.3.1 Configure ZTP to use common intermediate files for zero-configuration deployment via DHCP

Network Requirements

- A PC is used as the Console control end to monitor the device ZTP start-up process.
- Device2 acts as the DHCP server and provides DHCP service for ZTP boot process.
- Server1 acts as the file server and provides the FTP service (or TFTP service) needed for the ZTP startup process.
- Server2 acts as the log server and receives log information generated by the ZTP startup process.

Network Topology

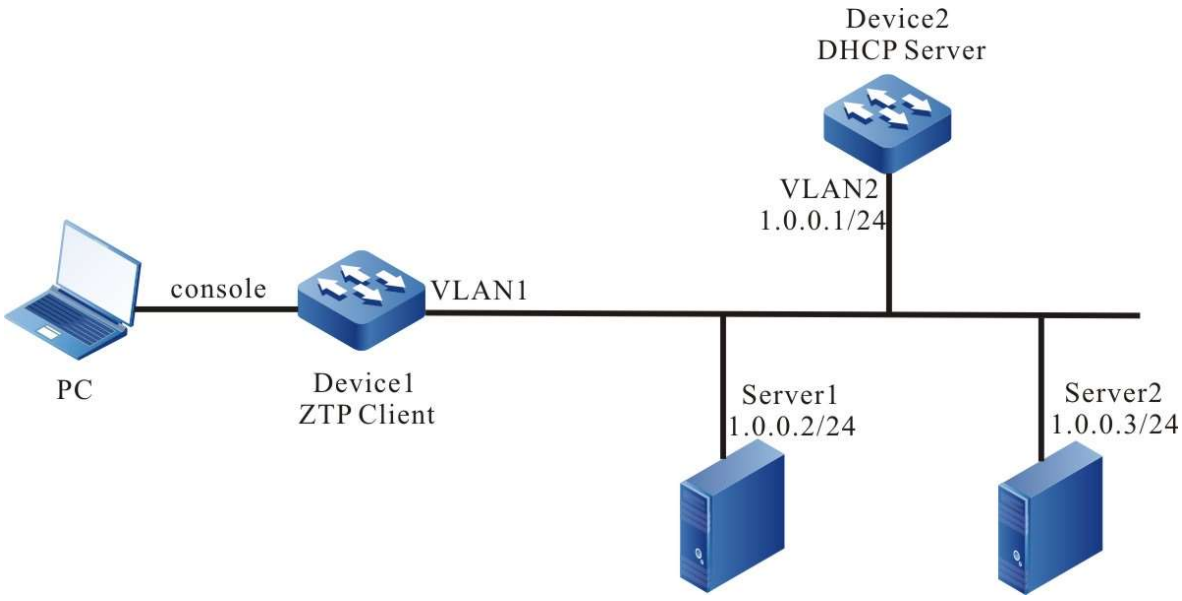


Figure 15-2 Network Topology of Device Using Common Intermediate Files for Zero-configuration Deployment via DHCP

Configuration Steps

Step 1: Configure the FTP server and place the intermediate files (e.g. ztp.xml), version files and device configuration files downloaded into the the FTP server directory. (Omitted)

#Edit the common intermediate file as follows:

Right mouse click to open it in Excel and edit

Opening and Editing XML File in Excel

Determined as XML table and click OK.

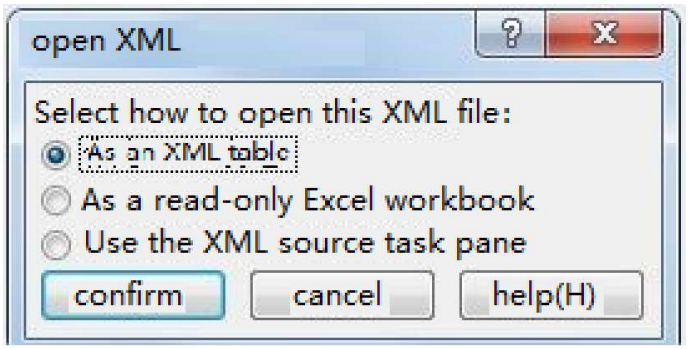


Figure 15-3 Determined as XML Table

Edit in Excel, here fill in the device serial number, version file name, version file name MD5 checksum value, configuration file name, configuration file MD5 checksum and description information, and finally save it, note that the it is saved in XML format.

	A	B	C	D	E	F
1	Serial-Number	Image-File	Image-File-MD5	Config-File	Config-File-MD5	Description
2	example_1:123456789	xxx.pck	xxx	startup	xxx	
3	example_1:123456789			startup		

Figure 15-4Editing the Name of the Version and Configuration Files in the XML File

Step 2: Configure DHCP service for Device2.

```
Device2#configure terminal
Device2(config)#ip dhcp pool ztp
Device2(dhcp-config)#range 1.0.0.4 1.0.0.10 255.255.255.0
```

#Configure intermediate file name options

```
Device2(dhcp-config)#option 67 ascii ztp.xml
```

#Configuration file download method and server address, username and password options

```
Device2 (dhcp-config)#option 66 ascii ftp://[a[:a]@]1.0.0.2
```

#Configure log server address options

```
Device2(dhcp-config)#option 7 ip 1.0.0.3
Device2(dhcp-config)#exit
```

#Enable DHCP service on server

```
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ip address 1.0.0.1/24
Device2(config-if-vlan2)#ip dhcp server
Device2(config-if-vlan2)#end
```

Step 3: Device1 boots with an empty configuration and enters the ZTP process to download the version upgrade and load the configuration file.

#See that the device enters the ZTP process through logs and sends DHCP requests

```
May  6 2020 15:04:19 Device1 MPU0 %ZTP-5:Now starting DHCP upgrade...
May  6 2020 15:04:19 Device1 MPU0 %ZTP-5:DHCP discovery phase started...
```

#During the ZTP request, you can exit the ZTP process with ctrl+c, thus starting with an empty configuration, or if you don't use ctrl+c, you can continue with the ZTP process.

```
May  6 2020 15:04:23 Device1MPU0 %ZTP-5:Press (ctrl + c) to abort Dhcp Upgrade
```

#Get the address successfully, download the common intermediate files

```
May  6 2020 15:06:29 Device1 MPU0 %DHCP-ASSIGNED_EXT-5:Interface vlan1 assigned DHCP address 1.0.0.4, mask 255.255.255.0.
May  6 2020 15:06:31 Device1 MPU0 %ZTP-5:Dhcp Upgrade DHCP discovery phase success
May  6 2020 15:06:31 Device1 MPU0 %ZTP-5:Start to download temp file ztp.xml
```

#Parse intermediate files and download version information

```
May  6 2020 15:06:56 Device1 MPU0 %ZTP-5:Download temp file ztp.xml is success
May  6 2020 15:06:56 Device1 MPU0 %ZTP-5:Start to parse temp file...
May  6 2020 15:06:56 Device1 MPU0 %ZTP-5:parse temp file is success
May  6 2020 15:06:56 Device1 MPU0 %ZTP-5:Start to download the Image file ztp.pck
```

#Download version and configuration file successfully, reboot the device automatically via ZTP

```
May  6 2020 15:14:09 Device1 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 upgrade successfully!
May  6 2020 15:14:11 Device1 MPU0 %ZTP-5:Download the Image file is success
May  6 2020 15:14:11 Device1 MPU0 %ZTP-5:Start to download the config file startup_ztp...
May  6 2020 15:14:12 Device1 MPU0 %ZTP-5:Download the config file is success
May  6 2020 15:14:12 Device1 MPU0 %ZTP-5:DHCP upgrade is success
May  6 2020 15:14:12 Device1 MPU0 %ZTP-5:System will rebooted by DHCP upgrade
```

Step 4: Check the result.

Check the ZTP status with the show ztp command, and view whether the configuration and version are in with show running-config and show version.

```
Device1#show ztp

Last ztp method: DHCP upgrade method
   Ztp state: ZTP DHCP upgrade success
   Ztp important inforamtion:
      FTP server IP: 1.0.0.2
      Temporary file name: ztp.xml
      Startup file name:startup_ztp
      Image file name:ztp.pck

Current ztp method: None upgrade method
```

Note:

- The device obtains the file download mode through option66 of DHCP protocol. It supports FTP and TFTP, you can choose any download mode when during configuration.
- If the version information of common intermediate file is empty, then the device

ZTP process will not engage in version upgrade, only configuration loading to continue the ZTP process, however, the configuration file can not be empty.

- MD5 of version file and MD5 of configuration file are used for integrity check of version file and configuration file.
- In the case that no option66 option is issued, you can issue the TFTP server address directly through option 150. In such case, you can download intermediate files, version files, configuration files through the TFTP server.

15.3.2 Configure ZTP to use python intermediate files for zero-configuration deployment via DHCP

Network Requirements

- A PC is used as the Console control end to monitor the device ZTP start-up process.
- Device2 acts as the DHCP server and provides DHCP service for ZTP boot process.
- Server1 acts as the file server and provides the TFTP service (or FTP service) needed for the ZTP startup process.
- Server2 acts as the log server and receives log information generated by the ZTP startup process.

Network Topology

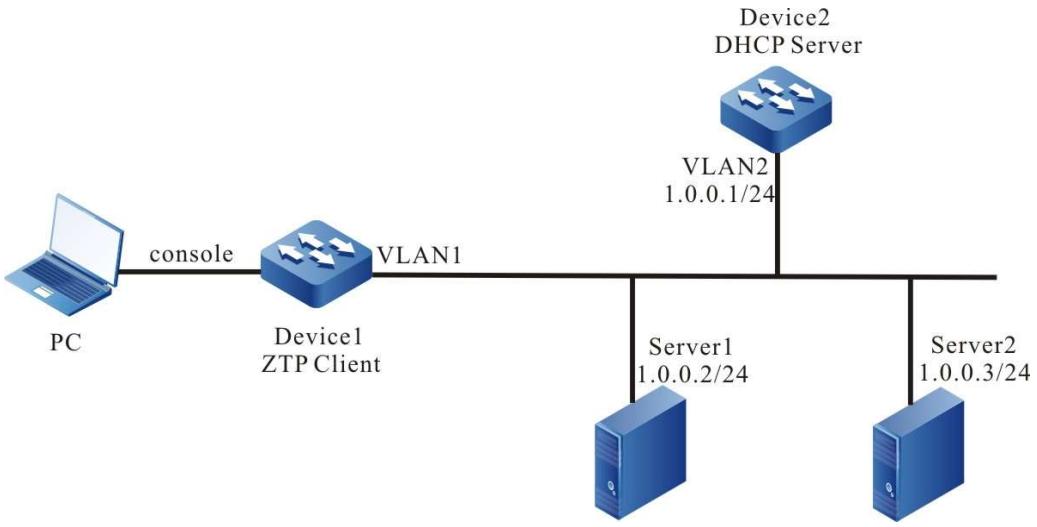


Figure 15- 5 Network Topology of Device Using Python Intermediate Files for Zero-configuration Deployment via DHCP

Configuration Steps

Step 1: Configure the FTP server and place the intermediate files (e.g. ztp.py), version files and device configuration files downloaded into the the FTP server directory. (Omitted)

#Normal python file editing can use any code editor

#Total file space required to configure ZTP

required_space = 100

#Configure file download method, and download timeout time

protocol = "tftp"

username = ""

password = ""

hostname = "1.0.0.2"

timeout = 1200

#Versions are found by version series, and version series can be found by shipping list

REMOTE_IMAGE_FILE = {

'NSS8900' : 'ztp.pck'

}

#Configure remote paths to make it easy to find them on the server when downloading files over TFTP

remote_config_path = "/flash"

remote_pck_path = ""

#Configure checksum MD5

remote_config_is_exist_md5 = False

remote_pck_is_exist_md5 = False

Step 2: Configure DHCP service for Device2.

```
Device2#configure terminal
Device2(config)# ip dhcp pool ztp
Device2(dhcp-config)#range 1.0.0.4 1.0.0.10 255.255.255.0
```

#Configure intermediate file name options

```
Device2(dhcp-config)#option 67 ascii ztp.py
```

#Configuration file download method and server address, username and password options

```
Device2(dhcp-config)#option 66 ascii tftp://1.0.0.2
```

#Configure log server address options

```
Device2(dhcp-config)#option 7 ip 1.0.0.3
Device2(dhcp-config)#exit
```

#Enable DHCP service on server

```
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ip address 1.0.0.1/24
Device2(config-if-vlan2)#ip dhcp server
Device2(config-if-vlan2)#end
```

Step 3: Device1 boots with an empty configuration and enters the ZTP process to download the version upgrade and load the configuration file.

#See that the device enters the ZTP process through logs and sends DHCP requests

```
May  6 2020 15:04:19 Device1MPU0 %ZTP-5:Now starting DHCP upgrade...
May  6 2020 15:04:19 Device1MPU0 %ZTP-5:DHCP discovery phase started...
```

#During the ZTP request, you can exit the ZTP process with ctrl+c, thus starting with an empty configuration, or if you don't use ctrl+c, you can continue with the ZTP process.

```
May  6 2020 15:04:23 Device1MPU0 %ZTP-5:Press (ctrl + c) to abort Dhcp Upgrade
```

#Get the address successfully, download the common intermediate files

```
May  6 2020 16:09:42 Device1 MPU0 %DHCP-ASSIGNED_EXT-5:Interface vlan1 assigned DHCP address 1.0.0.4, mask 255.255.255.0.
May  6 2020 16:09:56 Device1 MPU0 %ZTP-5:Dhcp Upgrade DHCP discovery phase success
May  6 2020 16:09:56 Device1 MPU0 %ZTP-5:Start to download temp file ztp.py...
May  6 2020 16:09:56 Device1 MPU0 %ZTP-5:Download temp file ztp.py is success
```

#Direct execution of python scripts

```
Execute python script start ...
/flash free space is 168(M).
Start to get remote and local file path.
remote config path is /flash/12345.cfg
Get remote and local file path is success.
remote PCK path is ztp.pck
Start to download image file ztp.pck...
Download image file is success
Start to set boot image file /flash/ztp.pck...
```

#Download version and configuration file successfully, reboot the device automatically via ZTP

```
May  6 2020 16:16:15  MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 upgrade successfully!
Set boot image file is success.
Start to download config file /flash/12345.cfg…
Download config file is success.
Start to parse config file /flash/startup...
Parse config file is success.
Execute python script success.

May  6 2020 16:16:18 Device1 MPU0 %ZTP-5:script execute success
May  6 2020 16:16:18 Device1 MPU0 %ZTP-5:System will rebooted by DHCP upgrade
```

Step 4: Check the result.

Check the ZTP status with the show ztp command, and view whether the configuration and version are in with show running-config and show version.

```
Device1#show ztp

Last ztp method: DHCP upgrade method
   Ztp state: ZTP DHCP upgrade success
```

```
Ztp important inforamtion:
  TFTP server IP: 1.0.0.2
  Temporary file name: ztp.py

Current ztp method: None upgrade method

Next ztp state: disable
```

Note:

- The device obtains the file download mode through option66 of DHCP protocol. It supports FTP and TFTP, you can choose any download mode when during configuration.
- The server download method issued by the DHCP server is used to download intermediate files, and the download method set in the python file is used to download version files and configuration files, which are not necessarily related.
- If the version information is not found through the device serial number, then the device ZTP process will not engage in version upgrade, only configuration loading to continue the ZTP process, however, the configuration file cannot be empty.
- If the file download method is TFTP, the username and password fields must be empty strings, and you cannot directly delete those two parameters.
- The name of the configuration file downloaded by the device is based on the serial number with the suffix .md5. For example, the device serial number is 12345, then the configuration file name is 12345.md5, and the MD5 checksum file is 12345.cfg.md5.
- After downloading the python file, the device executes the python file directly, so the python file must conform to the python syntax.

15.3.3 Configure ZTP to use common intermediate files for zero-configuration deployment via USB

Network Requirements

- A PC is used as the Console control end to monitor the device ZTP start-up process.
- Device1 is inserted with an USB device, which contains intermediate files, version files, and device configuration files.

Network Topology

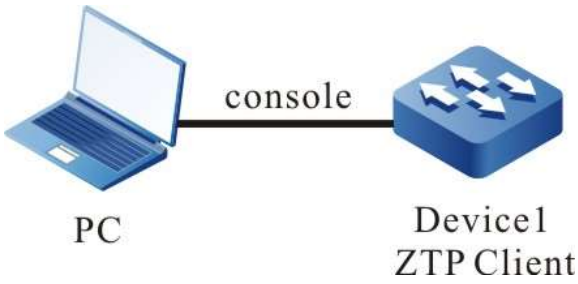


Figure 15-6 Network Topology of Device Using Common Intermediate Files for Zero-configuration Deployment via USB

Configuration Steps

Step 1: Place the intermediate file in the USB root directory and name it ztp_config.xml, i.e. /usb/ztp_config.xml.

#Edit the common intermediate file as follows:

Right mouse click to open it in Excel and edit

Opening and Editing XML File in Excel

Determined as XML table and click OK.

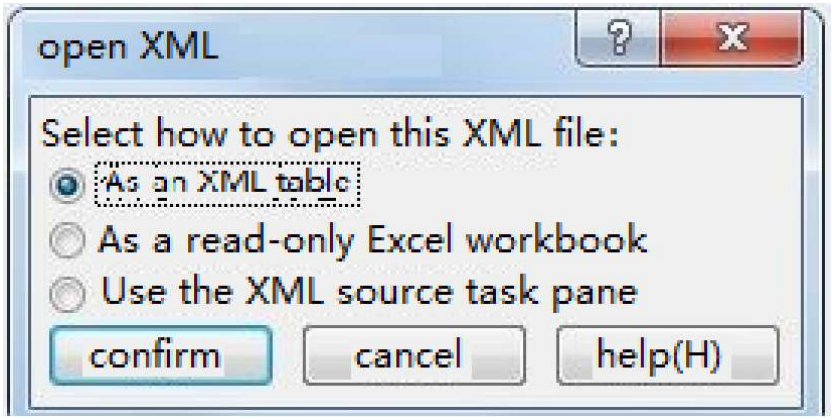
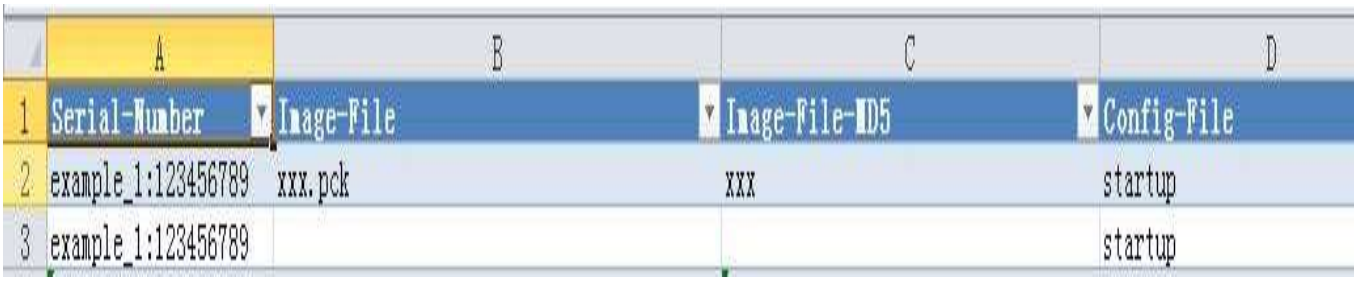


Figure 15-9 Determined as XML Table

Edit in Excel, here fill in the device serial number, version file name, version file name MD5 checksum value, configuration file name, configuration file MD5 checksum and description information, and finally save it, note that the it is saved in XML format.



	A	B	C	D
1	Serial-Number	Image-File	Image-File-MD5	Config-File
2	example_1:123456789	xxx.pck	xxx	startup
3	example_1:123456789			startup

Figure 15-7 Editing the Name of the Version and Configuration Files in the XML File

Note:

- XXX is the name of the corresponding IOS version in the USB.
- The XML intermediate file is obtained from the ZTP path of the software release notes.
- In the XML intermediate file, the required fields are serial number, version and configuration file. The serial number can be obtained from the device shipping list; the version file name and configuration file name filled in the xml intermediate file must be consistent with the IOS version file name and configuration file name in the USB, otherwise the deployment will fail.
- The version file MD5 code, configuration file MD5 code, and description information in the XML intermediate file are optional. If you need to fill in the MD5 code, it can be generated by a common MD5 code calculator.

Step 2: The version file and configuration file corresponding to the device serial number in the intermediate file are placed into the USB root directory, and named the same as described in the intermediate file. (Omitted)

Step 3: The device is powered on and enters the ztp process for deployment via USB.

#Device configuration is empty, enter USB deployment process

```
the current config file /flash/startup does not exist.
The backup file /backupramfs/startup is not exist.
The current config file /backup/startup does not exist.
May  6 2020 15:16:15 Device1MPU0 %ZTP-USB_UPGRADE-5:Now starting USB upgrade...
```

#Find and parse intermediate files

```
May  6 2020 15:16:15 Device1MPU0 %ZTP-USB_UPGRADE-5:Start to copy the temporary file /usb/ztp_config.xml...
May  6 2020 15:16:15 Device1MPU0 %ZTP-USB_UPGRADE-5:Copy the temporary file is success.
May  6 2020 15:16:15 Device1MPU0 %ZTP-USB_UPGRADE-5:Start to parse the temporary file /flash/ztp_config.xml
```

#Upgraded versions and configurations

```
May  6 2020 15:16:15 Device1MPU0 %ZTP-USB_UPGRADE-5:Parse temporary file is success
May  6 2020 15:19:53 Device1MPU0 %ZTP-USB_UPGRADE-5:Sysupdate image is success
May  6 2020 15:19:53 Device1 MPU0 %ZTP-USB_UPGRADE-5:Start to copy config...
```

```
May  6 2020 15:19:54 Device1  MPU0 %ZTP-USB_UPGRADE-5:Copy config is success
```

#Reboot after upgrade

```
May  6 2020 15:19:54 Device1 MPU0 %ZTP-USB_UPGRADE-4:System will be rebooted by USB Upgrade
```

Step 4: Check the results.

#Check the ZTP status with the show ztp command, and view whether the configuration and version are in with show running-config and show version.

```
Device1#show ztp

Last ztp method: USB upgrade method
  Ztp state: ZTP USB Upgrade success
  Ztp important information:
    Temporary file name:/usb/ztp_config.xml
    Startup file name:startup
    Image file name:ztp.pck

Current ztp method: None upgrade method

Next ztp state: disable
```

Note:

- If the version information of common intermediate file is empty, then the device ZTP process will not engage in version upgrade, only configuration loading to continue the ZTP process, however, the configuration file can not be empty.
- The device will download the version and configuration file from the USB copy, so the version file and the configuration file need to be placed into the USB.
- The name of the common intermediate file in USB can only be ztp_config.xml.

15.3.4 Configure ZTP to use python intermediate files for zero-configuration deployment via USB

Network Requirements

- A PC is used as the Console control end to monitor the device ZTP start-up process.
- Device1 is inserted with an USB device, which contains intermediate files, version files, and device configuration files.

Network Topology

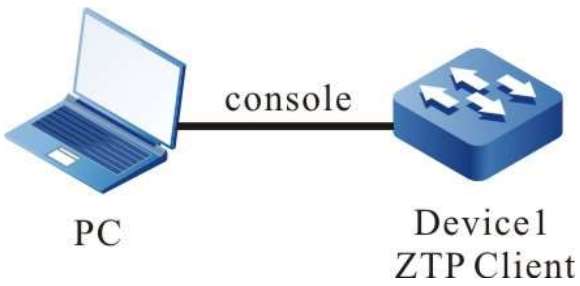


Figure 15-8 Network Topology of Device Using Python Intermediate Files for Zero-configuration Deployment via USB

Configuration Steps

Step 1: Place the intermediate file in the USB root directory and name it ztp_script.py, i.e. /usb/ztp_script.py.

```
#Normal python file editing can use any code editor

#Total file space required to configure ZTP (Unit: MB)

required_space = 100

#Versions are found by version series, and version series can be found by shipping list

REMOTE_IMAGE_FILE = {

'NSS8900' : 'ztp.pck'

}

#Configure the remote path and look for version files and configuration files in the /usb path

remote_config_path = "/usb"

remote_pck_path = "/usb"
```

Step 2: Copy the version file and the device configuration file to the USB root directory. The version name must be the same as the version file name corresponding to the device serial number in the intermediate file, and the configuration file name is consisting of the device serial number plus the .cfg suffix. For example, if the device serial number is 12345, then the configuration file name is 12345.cfg. (Omitted)

Step 3: The device is inserted with the USB and enters the ztp process for deployment via USB when powered on.

#Configuration file does not exist, the USB is plugged into the device, the device enters ZTP deployment process via USB.

```
The current config file /flash/startup does not exist.
The backup file /backupramfs/startup is not exist.
The current config file /backup/startup does not exist.
Apr 30 2020 11:10:12 Device1 MPU0 %ZTP-5:Now starting USB upgrade...
```

#Find and parse intermediate files

```
Apr 30 2020 11:10:12 Device1 MPU0 %ZTP-5:Start to copy the temporary file /usb/ztp_script.py...
Apr 30 2020 11:10:12 Device1 MPU0 %ZTP-5:Copy the temporary file is success.
Apr 30 2020 11:10:12 Device1 MPU0 %ZTP-5:Start to parse the temporary file /flash/ztp_script.py
```

#Invoke python to execute intermediate files

Execute python script start ...

#Check the remaining space

/flash free space is 159(M).

#Download configuration and version files

Start to get remote and local file path.
Get remote and local file path is success.
Start to set boot image file /usb/ztp.pck...
Apr 30 2020 11:13:51 Device1 MPU0 %SYS_UPDATE-RESULT-5:image : Mpu 0 upgrade successfully!Set boot image file is success.
Start to copy config file /usb/12345.cfg...
Copy config file is success.
Start to parse config file /flash/startup...
Parse config file is success.

#Download successfully, restart for the version and configuration to take effect.

Execute python script success, reboot device.
Apr 30 2020 11:13:54 Device1 MPU0 %ZTP-5:script execute success
Apr 30 2020 11:13:54 Device1 MPU0 %ZTP-4:System will be rebooted by USB Upgrade

Step 4: Check the results.

#Check the ZTP status with the show ztp command, and view whether the configuration and version are in with show running-config and show version.

Device1#show ztp

Last ztp method: USB upgrade method
  Ztp state: ZTP USB Upgrade success
  Ztp important information:
    Temporary file name:/usb/ztp_script.py
    Startup file name:startup
    Image file name:ztp.pck

Current ztp method: None upgrade method

Next ztp state: disable

Note:

- After downloading the python file, the device executes the python file directly, so the python file must conform to the python syntax.
- The device obtains the file download mode through option66 of DHCP protocol. It supports FTP and TFTP, you can choose any download mode when during configuration.
- If the version information is not found through the device serial number, then the device ZTP process will not engage in version upgrade, only configuration loading to continue the ZTP process, however, the configuration file cannot be empty.
- The name of the configuration file downloaded by the device is based on the serial number with the suffix .md5. For example, the device serial number is 12345, then the configuration file name is 12345.md5, and the MD5 checksum file is 12345.cfg.md5.
- The device will download the version and configuration file from the USB copy, so

the version file and the configuration file need to be placed into the USB.

- The name of the common intermediate file in USB can only be ztp_script.py.

15.3.5 Configure ZTP to automatically complete stacking using python intermediate files via DHCP

Network Requirements

- PC1 is used as the Console control end to monitor the device ZTP start-up process.
- Device3 acts as the DHCP server and provides DHCP service for ZTP boot process.
- Server1 acts as the file server and provides the FTP service (or FTP service) needed for the ZTP startup process.
- Server2 acts as the log server and receives log information generated by the ZTP startup process.
- Device1 and Device2 complete stacking through Te0/50 as a stacking link.

Network Topology

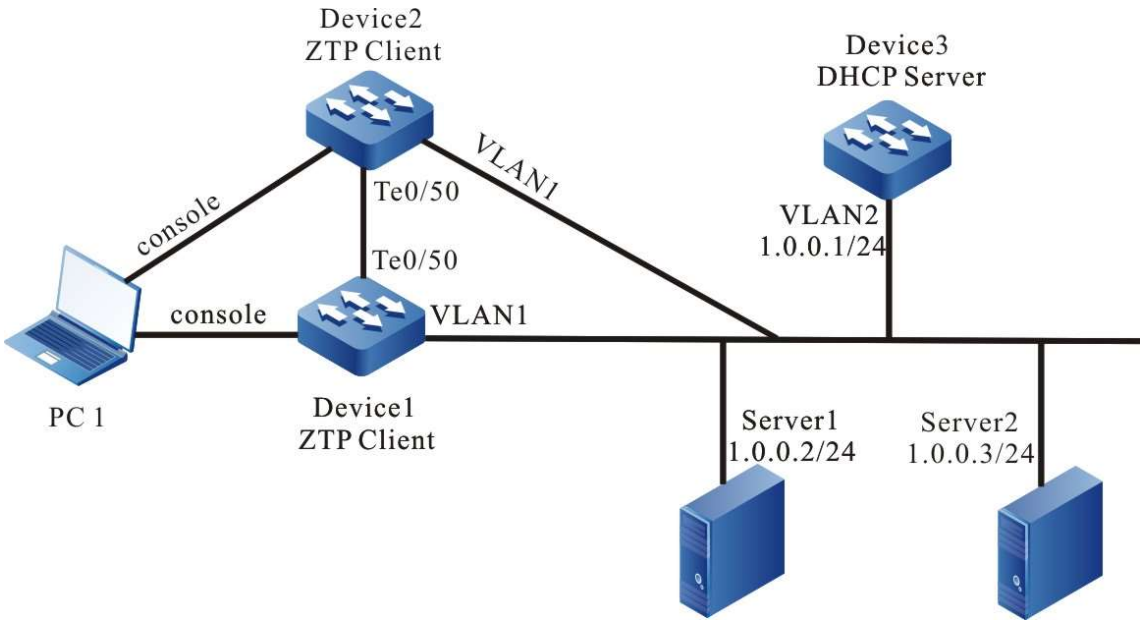


Figure 15-9 Network Topology of ZTP using python intermediate files to automatically complete stacking via DHCP

Configuration Steps

Step 1: Configure the FTP server, edit the intermediate files, and place the intermediate files (e.g. ztp.py) and the version file corresponding to the serial number in the FTP server directory. (Omitted)

```
#Normal python file editing can use any code editor
#Total file space required to configure ZTP
required_space = 100
#Configure file download method, and download timeout time
protocol = "ftp"
username = "a"
password = "a"
hostname = "1.0.0.2"
timeout = 1200
#Versions are found by version series, and version series can be found by shipping list
REMOTE_IMAGE_FILE = {
'NSS8900' : 'ztp.pck'
}
#Configure remote paths to make it easy to find them on the server when downloading files over FTP
remote_config_path = ""
remote_pck_path = ""
remote_stack_path = ""
#Configure checksum MD5
remote_config_is_exist_md5 = True
remote_pck_is_exist_md5 = True
remote_stack_is_exist_md5 = True
```

Step 2: Edit stack files and configuration files and upload them to the server for ZTP process download.

Here it is assumed that the device serial number of Device1 is 12345 and the device serial number of Device2 is 12340.

```
#Edit stack files
```

Stack file is named by adding .stack to the serial number. The name of Device1 stack file is 12345.stack, and the corresponding MD5 checksum file is 12345.stack.md5, while the name of Device2 stack file is 12340.stack, and the corresponding MD5 checksum file is 12340.cfg .md5.

Stack file content: It contains serial number, stacking domain number, and stacking device member.

The content of Device1's stack file includes

12345 101 1

The content of Device2's stack file includes

12340 101 0

#Edit the configuration file, the configuration file is named by adding the suffix .cfg to the device serial number, so the name of Device1 configuration file is 12345.cfg, and the corresponding MD5 checksum file is 12345.cfg.md5, while the name of Device2 configuration file is 12340.cfg, and the corresponding MD5 checksum file is 12340. cfg.md5.

The stacking section of the configuration file must be included with !VST_CONFIG_BEGIN and !VST_CONFIG_END, and the interface dimension set in the configuration file must be the stacked interface dimension, not the standalone dimension.

The configuration file of Device1 contains

!VST_CONFIG_BEGIN

!mode vsl information

vsl-channel 1/1

exit

!mode vsl end

!slot_0_NSS8900-08(V1)

!vsl mode

!slot 0/0

interface tengigabitethernet1/0/50

vsl-channel 1/1 mode on

exit

!end

!VST_CONFIG_END

The configuration file of Device2 contains

```
!VST_CONFIG_BEGIN

!mode vsl information

vsl-channel 0/1

 exit

!mode vsl end


!slot_0_ NSS8900-08(V1)

!vsl  mode

!slot 0/0

interface tengigabitethernet0/0/50

 vsl-channel 0/1 mode on

 exit

!end

!VST_CONFIG_END
```

After uploading the configuration file and stack files to the server, the following files 12345.cfg, 12340.cfg, 12345.cfg.md5, 12340.cfg.md5 exist on the server.

Step 3: Configure DHCP service for Device3.

```
Device3#configure terminal
Device3(config)# ip dhcp pool ztp
Device3(dhcp-config)#range 1.0.0.4 1.0.0.10 255.255.255.0
```

#Configure intermediate file name options

```
Device3(dhcp-config)#option 67 ascii ztp.py
```

#Configuration file download method and server address, username and password options

```
Device3(dhcp-config)#option 66 ascii ftp://[a[:a]@]1.0.0.2
```

#Configure log server address options

```
Device3(dhcp-config)#option 7 ip 1.0.0.3
Device3(dhcp-config)#exit
```

#Enable DHCP service on server

```
Device3(config)#interface vlan2
Device3(config-if-vlan2)#ip address 1.0.0.1/24
Device3(config-if-vlan2)#ip dhcp server
Device3(config-if-vlan2)#end
```

Step 4: Device1 and Device2 boot with an empty configuration and enters the ZTP process to download the version upgrade and load the configuration file.

Device1:

#See that the device enters the ZTP process through logs and sends DHCP requests

```
May  6 2020 15:04:19 Device1 MPU0 %ZTP-5:Now starting DHCP upgrade...
May  6 2020 15:04:19 Device1 MPU0 %ZTP-5:DHCP discovery phase started...
```

#During the ZTP request, you can exit the ZTP process with ctrl+c, thus starting with an empty configuration, or if you don't use ctrl+c, you can continue with the ZTP process.

```
May  6 2020 15:04:23 Device1MPU0 %ZTP-5:Press (ctrl + c) to abort Dhcp Upgrade
```

#Get the address successfully, download the common intermediate files

```
May  6 2020 16:09:42 Device1 MPU0 %DHCP-ASSIGNED_EXT-5:Interface vlan1 assigned DHCP address 1.0.0.4, mask 255.255.255.0.
May  6 2020 16:09:56 Device1 MPU0 %ZTP-5:Dhcp Upgrade DHCP discovery phase success
May  6 2020 16:09:56 Device1 MPU0 %ZTP-5:Start to download temp file ztp.py...
May  6 2020 16:09:56 Device1 MPU0 %ZTP-5:Download temp file ztp.py is success
```

#Direct execution of python scripts

```
/flash free space is 100(M).
Start to get remote and local file path.
Get remote and local file path is success.
```

#Download version

```
Start to download image file /flash/ztp.pck...
Download image file is success
Start to set boot image file /flash/ztp.pck....
```

#Download and parse stack file and configuration file

```
Start to download stack file /flash/12345.stack...
Download stack file is success.
Start to download config file /flash/12345.cfg…
Download config file is success.
Start to parse config file /flash/startup...
Parse config file is success.
Execute python script success.
```

#Download version and configuration file successfully, reboot the device automatically via ZTP

```
Apr 30 2020 09:45:32 Device1 MPU0 %ZTP-5:script execute success
Apr 30 2020 09:45:32 Device1 MPU0 %ZTP-5:System will rebooted by DHCP upgrade
```

The device Device2:

#See that the device enters the ZTP process through logs and sends DHCP requests

```
May  6 2020 15:04:19 Device2 MPU0 %ZTP-5:Now starting DHCP upgrade...
May  6 2020 15:04:19 Device2 MPU0 %ZTP-5:DHCP discovery phase started...
```

#During the ZTP request, you can exit the ZTP process with ctrl+c, thus starting with an empty configuration, or if you don't use ctrl+c, you can continue with the ZTP process.

```
May  6 2020 15:04:23 Device2 MPU0 %ZTP-5:Press (ctrl + c) to abort Dhcp Upgrade
```

#Get the address successfully, download the common intermediate files

```
May  6 2020 16:09:42 Device2 MPU0 %DHCP-ASSIGNED_EXT-5:Interface vlan1 assigned DHCP address 1.0.0.5, mask 255.255.255.0.
May  6 2020 16:09:56 Device2 MPU0 %ZTP-5:Dhcp Upgrade DHCP discovery phase success
May  6 2020 16:09:56 Device2 MPU0 %ZTP-5:Start to download temp file ztp.py...
May  6 2020 16:09:56 Device2 MPU0 %ZTP-5:Download temp file ztp.py is success
```

#Direct execution of python scripts

/flash free space is 101(M).
Start to get remote and local file path.
Get remote and local file path is success.

#Download version

Start to download image file /flash/ztp.pck...
Download image file is success
Start to set boot image file /flash/ztp.pck....

#Download and parse stack file and configuration file

Start to download stack file /flash/12340.stack...
Download stack file is success.
Start to download config file /flash/12340.cfg…
Download config file is success.
Start to parse config file /flash/startup...
Parse config file is success.
Execute python script success.

#Download version and configuration file successfully, reboot the device automatically via ZTP

Apr 30 2020 09:45:32 Device2 MPU0 %ZTP-5:script execute success
Apr 30 2020 09:45:32 Device2 MPU0 %ZTP-5:System will rebooted by DHCP upgrade

Step 5: Check the result.

Check the ZTP status with the show ztp command, view whether the configuration and version are in with show running-config and show version, and view that the stack has taken effect with show vst-config.

switch#show ztp

Last ztp method: DHCP upgrade method
  Ztp state: ZTP DHCP upgrade success
  Ztp important inforamtion:
    FTP server IP: 1.0.0.2
    Temporary file name: ztp.py

Current ztp method: None upgrade method

Next ztp state: Next ztp state: disable(Stack mode does not support ztp.)

switch X#show vst-config
Building Configuration...

!mode member information
switch mode virtual
switch virtual member 0
 domain 101
exit
switch virtual member 7
 domain 101
 exit
!mode member end

!mode vsl information
vsl-channel 0/1

```
 exit
vsl-channel 1/1
 exit
!mode vsl end


!slot_0_NSS8900-08(V1)
!vsl  mode
!slot 0/0
interface tengigabitethernet0/0/50
 vsl-channel 0/1 mode on
 exit
!end

!slot_14_NSS8900-08(V1)
!vsl  mode
!slot 7/0
interface tengigabitethernet1/0/50
 vsl-channel 1/1 mode on
 exit
!end
```

Note:

- The device obtains the file download mode through option66 of DHCP protocol. It supports FTP and TFTP, you can choose any download mode when during configuration.
- The MD5 of version files, configuration files, and stack files are stored separately, and they are named by adding the the suffix .md5. to their respective files names.
- The interface dimension in the configuration file for auto-stacking must be the stacked interface dimension, not the standalone interface dimension.
- After downloading the python file, the device executes the python file directly, so the python file must conform to the python syntax.
- If the version information is not found through the device serial number, then the device ZTP process will not engage in version upgrade, only configuration loading to continue the ZTP process, however, the configuration file cannot be empty.

16 Interface Basis

16.1 Overview

The interfaces supported by the device include physical interfaces and logical interfaces. The physical interfaces include L2 Ethernet interfaces and L3 Ethernet interfaces; the logical interfaces include aggregation group interfaces, VLAN interfaces, Loopback interfaces, Null interfaces, Tunnel interfaces, and so on.

Ethernet interface, also called L2 Ethernet interface or port, is one physical interface. It works in layer 2 in the OSI reference model-Data link layer and is mainly used for the data frame forwarding and MAC address learning.

L3 Ethernet interface is one physical interface. It works at layer 3 in the OSI reference model-network layer. Configurable with an IP address, it is mainly used for packet forwarding.

Aggregation group interface is one logical interface, formed by binding multiple physical links between two devices. It also works at the data link layer and is mainly used to expand the link bandwidth and improve the link reliability.

VLAN interface is one logical interface, used to be bound with VLAN and complete the packet forwarding between different VLANs.

Loopback interface, also called local loopback interface, is one logical interface. For packets sent to the Loopback interface, the device considers each packet to be sent to itself and will not forward the packet.

Null interface is one logical interface. Any packet sent to the Null interface will be dropped.

Tunnel interface is one logical interface that provides a transmission link for the point-to-point mode.

For different interfaces, there are corresponding configuration modes. The related configuration modes of the interfaces include:

- interface configuration mode, corresponding to the VLAN interface, the Loopback interface, the Null interface, and the Tunnel interface;
- L2 Ethernet interface configuration mode, corresponding to the L2 Ethernet interface;
- L3 Ethernet interface configuration mode, corresponding to the L3 Ethernet interface; and
- aggregation group configuration mode, corresponding to the aggregation group interface.

This chapter mainly describes the common function configuration of various interfaces. For the featured function configuration of various interfaces, refer to the corresponding interface chapter.

16.2 Basic Function Configuration of Interfaces

Table 1-1 Basic Function Configuration List of Interfaces

Configuration Task	
Configure the basic functions of the interfaces	Enable/disable interface
	Configure interface description
	Configure the statistics interval of the interface traffic
Configure the interface group function	Interface groups
Configure interface status SNMP agent care level	Configure interface status SNMP agent care level

16.2.1 Configure the Basic Functions of the Interfaces

Configuration Condition

None

Enable/Disable Interface

After Ethernet interface is disabled, it cannot receive or send packets. But after the Ethernet interface is enabled, whether it can receive and send packets also depends on other settings, such as whether the peer Ethernet interface is enabled, the rates of the local port and the peer port, and whether duplex mode matches with MDIX (Media Dependent Interface Crossover).

After the aggregation group interface is disabled, all member ports are disabled; after the aggregation group interface is enabled, you can disable or enable one member port separately.

Table 1-2 Turning on/Shutting down Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	The subsequent configuration takes effect only on the current interface after you enter the interface configuration mode, only on the aggregation group interface after you enter the aggregation group configuration mode, only on the current interface after you enter the L2/L3 Ethernet interface configuration mode, and only on the current virtual switch link interface after you enter the virtual switch link interface mode
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	
Enter virtual switch link interface configuration mode	**vsl-channel** *vsl-channel-id*	
Enable the interface	**no shutdown**	Mandatory By default, the interface is enabled
Disable the interface	**shutdown**	Mandatory By default, the interface is enabled

Note

- Configure the interface description function, which is not supported on Null interface.

Configure Interface Description

The interface description is used for naming different interfaces, helping the user distinguish different interface types and actual service functions. It is convenient for the user to manage various interfaces.

Table 1-3 Configuring Interface Description Information

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the interface configuration mode, only on the aggregation group interface after you enter the aggregation group configuration mode, only on the current interface after you enter the L2/L3 Ethernet interface configuration mode, and only on the current virtual switch link interface after you enter the virtual switch link interface mode
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	
Enter virtual switch link interface configuration mode	**vsl-channel** *vsl-channel-id*	
Configure interface description information	**description** *description-name*	Mandatory By default, the interface description information is not configured
	peer-description *description-name*	Mandatory By default, the peer interface description information is not configured

Note

- Configure the interface description function, which is not supported on Null interface.

Configure the Statistics Interval of the Interface Traffic

Different interfaces carry different service traffics. Adjusting the statistics interval of the interface traffic can help the user concern the history records of the interface traffic selectively, forecasting the future trend of the interface traffic more correctly. It is convenient for the user to analyze and adjust the bored services of the interface.

Table 1-4 Configuring Statistics Interval of Interface Traffic

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the interface configuration mode, only on the aggregation group interface after you enter the aggregation group configuration mode, only on the current port after you enter the L2 Ethernet interface configuration mode, and only on the current virtual switch link interface after you enter the virtual switch link interface mode
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	
Enter virtual switch link interface mode	**vsl-channel** *vsl-channel-id*	
Configure the statistics interval of the interface traffic	**load-interval** *load-interval-value*	Mandatory By default, the statistics interval of the interface traffic is 300 seconds.

Note

- Configure the interface description function, which is not supported on Null interface.

16.2.2 Configure the Interface Group Function

Bind multiple interfaces as one interface group. Configuring various interface commands on the interface group is equivalent to configuring on all interfaces of the interface group, while it is not necessary to configure on each interface repeatedly. Display the information of one interface group is to display the information of all interfaces in the interface group.

Configuration Condition

The interfaces covered by the interface group should already exist.

Interface Groups

Table 1-5 Configuring Interface Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create interface group in the list mode	**interface group** *group-id* **enum** *interface-name1 interface-name2 … interface-nameN* [**point-to-point** | **multipoint**]	Mandatory By default, the interface group is not created.
Enter the global configuration mode.	**configure terminal**	-
Create interface group by specifying range mode	**interface group** *group-id* **range** *start-interface-name end-interface-name* [**point-to-point** | **multipoint**]	Mandatory By default, the interface group is not created.

Note

- The interface types in the interface group should be the same. The user can configure multiple interface groups as desired.
- The user can configure the commands supported by all types of interfaces in the interface group, but if the interfaces covered by the interface group do not support, the commands do not take effect and there may be no error prompt. Please check whether the commands take effect by viewing the configuration.
- If the interface group covers the logical interface and when the logical interface is

deleted, the logical interface in the interface group is also deleted automatically.

16.2.3 Configure Interface Status SNMP Agent Care Level

There are actually two levels of interface UP/DOWN status in the system, one is the L2 link layer status, and the other is the L3 protocol layer (protocol) status, which can be seen with the command show ip interface brief. Generally, both statuses change with the physical interface UP/DOWN, but when keepalive gateway is configured on Ethernet Type interface, the L3 protocol layer status will be controlled by keepalive check status.

If SNMP agent function is enabled on the device, the network management server can obtain interface status information through public mib. Moreover, it can send interface status change information to the network management server when SNMP Trap is enabled.

By means of this function command, you can set the interface status level of SNMP agent care. By default, the interface status hierarchy of SNMP agent care is L2 link layer, but when keepalive gateway is configured on Ethernet Type interface, in order to ensure consistent linkage between the interface status presented by the network management server and the keepalive check status, you need to set the interface status level of SNMP agent care as L3 protocol layer. Therefore, in environments where keepalive check is enabled (e.g. MSTP WAN line environment), it is recommended to configure link-status-care l3.

Configuration Condition

None

Interface Groups

Table 16-6 Configuring Interface Status SNMP Proxy Care Level

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure interface status network management level	**link-status-care** { **l2** | **l3** }	Mandatory By default, the interface status SNMP agent care level is L2 link layer
Exit global configuration mode	**exit**	-

16.2.4 Basic Monitoring and Maintaining of Interfaces

Table 16-7 Interface Basics Monitoring and Maintaining

Command	Description
clear interface group *group-id*	Clear the statistics information of all interfaces in the interface group
interface group *group-id* **display**	Display all interfaces contained in the current interface group
show interface group *group-id*	Display the information of all interfaces in the interface group
show interface snmp ifindex	Display the corresponding SNMP network management index values of all interfaces in the interface

17 Ethernet Interface

17.1 Overview

Ethernet interface includes L2 Ethernet interface and L3 Ethernet interface.

Ethernet interface, also called L2 Ethernet interface or port, is one physical interface. It works at layer 2 in the OSI reference model-data link layer. It is mainly used to execute two basic operations:

Data frame forwarding: According to the MAC address (that is physical address) of the data frame, forward the data frame. Ethernet interface can only perform the L2 switching forwarding for the received packets, that is, can only receive and send the packets whose source IP and destination IP are at the same segment.

MAC address learning: Construct and maintain the MAC address table, used to support forwarding the data frames.

L3 Ethernet interface is one physical interface. It works at layer 3 in the OSI reference model-network layer. It is mainly used to execute following basic operations.

Packet forwarding: The packet is routed and forwarded according to the IP (Internet Protocol) address (ie, network address) of the packet. L3 Ethernet interface can only perform the L3 routing forwarding for the received packets, that is, can receive and send the packets whose source IP and destination IP are at the different segments.

According to the maximum rate supported by the port, the port type can be divided to the following four:

Fastethernet: 100M port, can be abbreviated as Fa, such as fastethernet0/1 or Fa0/1;

Gigabitethernet: 1000M port, can be abbreviated as Gi, such as gigabitethernet0/25 or Gi0/25;

Tengigabitethernet: 10 Gigabit port, can be abbreviated as Te, such as tengigabitethernet1/1 or Te1/1.

25ge: 25G Ethernet interface;

40ge: 40G Ethernet interface;

According to the media type of the port, the port type can be divided to copper (electrical port) and fiber (optical port).

17.2 Ethernet Interface Function Configuration

Table 2-1 Function Configuration List of Ethernet Interface

Configuration Task	
Configure Basic Functions of Port	Enter Ethernet interface configuration mode
	Enter Batch Configuration Mode of L2 Ethernet Interface
	Configure Port Rate and Duplex Mode
	Configure FEC
	Configure MDIX (Media Dependent Interface Crossover) mode
	Configure Port Media Type
	Configure MTU (Maximum Transmission Unit)
	Configure Port Flow Control
	Configure Delay Time
	Configure Port Auto Energy-Saving

Configuration Task	
	Configure Port Energy Efficient Ethernet Function
	Configure optical module type supported by the port
	Configure mandatory cancel of interface OMM-disabled status
Configure Port Detection Function	Configure Port Status Flap Detection
	Enable Port Loopback Test
Configure Storm Suppression	Configure Storm Suppression Parameters
	Configure the action executed after the storm suppression
Configure UNI/NNI attribute	Configure UNI/NNI attribute
	Configure Connectivity of uni Port
Configure basic functions of L3 Ethernet interface	Configure L3 Ethernet interface

17.2.1 Configure Basic Functions of Port

Configuration Condition

None

Enter Ethernet Interface Configuration Mode

To configure on the specified Ethernet interface, first enter the L2 Ethernet interface configuration mode of the Ethernet interface and then execute the corresponding configuration command.

Table 2- 2 Enter L2 Ethernet Interface Configuration Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the L2/L3 Ethernet interface configuration mode

Note

- The naming rule of the Ethernet interface number is U/S/P (Unit/Slot/Port). Unit indicates the device in stacking status, numbered from 0. When the device is initialized, it needs to be clear whether it is in the stacking status. If not, the device number defaults to 0 and is hidden. Slot indicates slots on the device, numbered from 0. If there is fixed Ethernet interface, slot 0 is reserved for the fixed Ethernet interface, while service slot is numbered from 1. Port indicates Ethernet interface on each device or interface card which is numbered from 1.
- The naming rule of Ethernet interface *interface-name* is Ethernet interface type + Ethernet interface number. For example, gigabitethernet0/1 represents the gigabit Ethernet interface numbered 1; tengigabitethernet1/2 represents the 10 gigabit Ethernet interface numbered 2 on the service slot numbered 1; in stacking mode, gigabitethernet0/1/2 represents that the member number is 0, with gigabit Ethernet interface numbered 2 on the service slot numbered 1.

Enter Batch Configuration Mode of L2 Ethernet Interface

When performing the same configuration on multiple ports, to improve the configuration efficiency and reduce the repeated steps, select to enter the batch configuration mode of the L2 Ethernet interface, including the following three cases: single port, such as gigabitethernet 0/1; successive ports, using "-" to indicate one section of successive ports, such as gigabitethernet 0/3-0/5, indicating port 0/3, 0/4, and 0/5; single port and successive ports, using comma to separate them. For example, "gigabitethernet 0/1, 0/3-0/4, and 0/6" represents ports 0/1, 0/3, 0/4, and 0/6.

Table 2- 3 Entering Batch Configuration Mode of L2 Ethernet Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter Batch Configuration Mode of L2 Ethernet Interface	**interface** *interface-list*	Mandatory

Note

- L3 Ethernet interface does not support the batch configuration mode.

Configure Port Rate and Duplex Mode

Setting the port rate includes two cases:

One is to set the fixed rate according to the port rate capability set. The optional parameters include **10** (10M), **100** (100M), **1000** (1000M), **10000** (10000M), 25000 (25000M) and 40000 (40000M);

The other is to set the rate as auto (auto-negotiation), specifying that the rate is negotiated by the local end and the peer port.

Similarly, setting the port duplex mode includes two cases:

One is to set the duplex mode according to the capability set of the port duplex mode. The optional parameters include full (full-duplex mode), indicating that the port can send packets when receiving the packets; half (half-duplex mode), indicating that the port can only receive or send packets at one moment, but cannot perform at the same time;

The other is to set the duplex mode as auto (auto-negotiation), indicating that the duplex mode is negotiated automatically by the local end and the peer port.

Table 2- 4 Configuring Port Rate and Duplex Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter

Step	Command	Description
		the L2/L3 Ethernet interface configuration mode
Configure the port rate	**speed** { **10** | **100** | **1000** | **10000** | |25000|40000|**auto** }	Mandatory
Configure the port duplex mode	**duplex** { **auto** | **full** | **half**}	Mandatory

Note

- When the port is the 100M optical port, the supported rate is 100M and auto, and the supported duplex mode is auto and full-duplex mode; when the port is 1000M optical port, the supported rate is 100M, 1000M and auto, the supported duplex mode is auto and full-duplex mode; when the port is the 10 gigabit optical port, the supported rate is 1000M, 10000M and auto, and the supported duplex mode is auto and full-duplex mode.

Configure FEC

FEC (Forward Error Correction) is one error correction method that adds error correction information to the data packet at the sending port, and uses the error correction information at the receiving end to correct the error produced upon transmission of the data packet in order to improve the signal quality, but at the same time it will also bring some delay to the signal. The user can choose to enable or disable this function according to the actual situation.

The FEC status of the port can be manually configured by the user, or be configured in an adaptive manner. If the user does not configure the supported optical module type on the port, the FEC will be configured adaptively according to the type and rate of the module inserted in the current port upon inserting of the module or configuring of the port rate. If there is user configuration on the port, the user configuration will prevail, and no adaptation will be done upon inserting of the module into the port or configuring of SPEED.

Table 1 Configuring Port FEC Status

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the L2/L3 Ethernet interface configuration mode
Configure port FEC status	**[no] fec mode {base-r {auto|manual} |rs { auto|manual }|none manual}**	Mandatory By default, FEC is not enabled on the port

Note

- When the rate is not 25G or 100G, it is not allowed to configure FEC. When the port has manual configuration of FEC, it is not allowed to switch the rate to other than 25G or 100G.
- This function is not allowed to be configured on VSL member port.
- The auto configuration is adaptively issued. Before restarting the device, the user needs to use the write command to save this configuration.
- Only 25GE and 100GE interfaces support this function. The fec configuration will take effect only when the actual rate is 25G or 100G.

Configure Port MDIX Mode

You can send and receive signals only after connecting the local end and the peer port. Therefore, the MDIX mode is used with connection cables.

The cables connecting ports are divided to two types: straight-through cable and crossover cable. To support the two types of cables, provide three kinds of MDIX modes: normal, cross and auto.

The optical port can only support straight-through cable. Therefore, MDIX mode can only be set as normal.

The electrical port is formed by eight pins. You can change the roles of the pins by setting the MDIX mode. When setting as normal, use pin 1 and 2 to send signals, and pin 3, 6 to receive signals; when setting as cross, use pin 1, 2 to receive signals, pin 3, 6 to send signals; when setting as auto, the local and peer electrical ports automatically negotiate the functions of the pins by connecting the cables.

When using the straight-through cable, the MDIX modes of the local and peer ports cannot be the same.

When using crossover cable, the MDIX modes of the local and peer ports should be the same or at least one is auto.

Table 2 Configuring MDIX Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the L2/L3 Ethernet interface configuration mode
Configure the mode of receiving and sending signals via network cable	**mdix** { **auto | cross | normal** }	Mandatory By default, the MDIX mode of the electrical port is auto and the MDIX mode of the optical port is normal.

Note

- The Optical port does not support this configuration.

Configure Port Media Type

Switch to use the optical port or electrical port on the Combo port by configuring the port media type. The optical port and the corresponding electrical port cannot work at the same time. When specifying one type of ports on Combo port, the other type of ports are automatically disabled.

Table 173 Configuring Media Type

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the L2/L3 Ethernet interface configuration mode
Configure Port Media Type	**media-type** { **auto** | **copper** | **fiber**}	Mandatory By default, the media type of the electrical port is copper; the media type of the optical port is fiber; the media type of the Combo port is copper.

Note

- When switching the optical port and electrical port on the Combo port, the port configuration after switching, such as rate, duplex mode, and MDIX mode, are initialized to the default values.

Configure Port MTU

The MTU configured on the port takes effect at the same time for the ingress and egress packets, and the set values are the same. When the length of the received and sent packets exceeds the set value, the packets are dropped directly.

In contrast, the MTU configured on L3 Ethernet interface only takes effect for the egress packets. When the length of the sent packet exceeds the set value, the packet first performs the IP fragmenting, making the length of the fragmented packet not exceed the set value, and then send it out.

Table 4 Configuring MTU

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the L2/L3 Ethernet interface configuration mode
Configure Port MTU	**mtu** *mtu-value*	Mandatory By default, the port MTU is 1824 bytes.

Configure Port Flow Control

When the sending or receiving buffer is full and if the duplex mode of the port is half-duplex, send the blocking signals back to the source end by the back pressure mode; if the duplex mode of the port is full-duplex mode, the port informs the source end to stop sending by the flow control mode.

Table 5 Configuring Flow Control

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Port Flow Control	**flowcontrol** { **on | off** }	Mandatory By default, the flow control function of the port is disabled.

Note

- Only when the flow control function is enabled on both the local port and the peer port, can the flow control on the local port be realized.
- The L3 Ethernet interface does not support flow control.

Configure Delay Time

When the port changes from Up to Down, first enter the set suppression time period and the switching of the port status is not felt by the system; and then after the set suppression time, report the port status change to the system. In this way, you can avoid the unnecessary running cost caused by the frequent switching of the ports status in short time.

Table 6 Configuring Delay Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Delay Time	**link-delay** *link-delay-value*	Mandatory By default, the delay report time of the port changing from Up to Down is 0, that is, disable the delay report function; when the port changes from Up to Down, report and process immediately.

Note

- L3 Ethernet interface does not support configuring the delay time.

Configure Port Auto Energy-Saving

When disabling or enabling port auto energy-saving, but not connecting cables, the port inside is always in the polling port state. To reduce the unnecessary energy consumption, automatically switch to the low energy consumption state when the port is idle by configuring the port auto energy-saving.

Table 7 Configuring Auto Power-down

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Port Auto Energy-Saving	**auto-power-down enable**	Mandatory By default, the auto energy-saving function of the port is disabled.

Note

- L3 Ethernet interface does not support configuring auto power-down.

Configure Port Energy Efficient Ethernet Function

When no data traffic passes, the inner port is always polling the port state. To reduce such unnecessary consumption, you can configure the interface energy efficient Ethernet function. When the interface is idle, it is automatically switched to the low energy state. When the data is normally transmitted, recover the power supply.

Table 8 Configuring Energy Efficient Ethernet Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect

Step	Command	Description
		only on the current interface after you enter the L2/L3 Ethernet interface configuration mode
Configure Port Energy Efficient Ethernet Function	**energy-efficient-ethernet enable**	Mandatory By default, the energy efficient Ethernet function of the interface is disabled.

Note

- After the interfaces on the both sides of the cable are enabled with the energy efficient Ethernet function, the function can take effect.
- The optical interface does not support such energy efficient Ethernet function.
- The interface with the rate as 10 Mbps and with the duplex mode as any mode and the interface with the rate as 100 Mbps and the duplex mode not as the automatic negotiation mode do not support the energy efficient Ethernet function.

Configure Optical Module Type Supported by the Port

The gigabit and 10 gigabit Ethernet optical interfaces are in OMM-disabled status when the optical module is not inserted in. This port can be enabled only when the type of the optical module inserted on the port is the same as the optical module type supported by the port configuration. Therefore, the optical module type supported by the port needs to be configured, which can be manually done by the user or done in an adaptive manner. If the user does not configure the supported optical module type on the port, the optical module type supported by the port will be adaptively configured according to the type of the module inserted on the port, so that the port can use the corresponding optical module normally. If there is user configuration on the port, the user configuration will prevail, and no adaptation will be done according to the type of the module inserted on the port.

The types of optical modules are divided into gigabit photoelectric modules, 10 gigabit photoelectric modules, ordinary optical modules, and unrecognizable-typed optical modules. Among them, the ordinary optical modules include gigabit optical modules, 10 gigabit optical modules, 10 gigabit high-speed cables, 40G optical modules, 40G high-speed cables and other optical modules. Unrecognizable optical modules offer no guarantee for normal use.

By default, the port supports ordinary optical modules.

Due to the different speed capability levels supported by different types of modules, the speed configuration of the port may be modified synchronously when the configuration port supports different optical module types (including user configuration and adaptive configuration).

Table 9 Configuring Optical Module Type Supported by the Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the L2/L3 Ethernet interface configuration mode
Configure photoelectric module supported by the port	**optical fiber-to-copper** { **get | xget** }	Mandatory By default, the port supports ordinary optical modules
Clear the configuration of the supported optical module type on the port	**no optical fiber-to-copper** { **get [**auto**] | xget [**auto**] | unknown-module auto** }	Mandatory The auto command is used to clear the adaptive configuration. It cannot clear the user configuration. After the adaptive configuration is cleared, the port supports ordinary optical modules by default. In this case, you need to unplug or plug the optical module or restart the device to trigger again the adaptation. The non-auto command is used to clear the user configuration. The optical module inserted on the port will be automatically

Step	Command	Description
		re-adapted according to the type of this optical module.

Note

- This function is only allowed to be configured on the Ethernet optical interface, and not allowed to be configured on the electrical port and the combo port.
- This function is not allowed to be configured on VSL member port.
- This function is not allowed to be configured on 40G and 100G ports.
- The auto configuration is adaptively issued. Before restarting the device, the user needs to use the write command to save this configuration.

Configure Mandatory Cancel of Interface OMM-disabled Status

If the optical module is not inserted on the Ethernet optical interface, the port will be in the OMM-disabled status and cannot receive and send packets. After inserting of the legal optical module, the OMM-disabled status of the Ethernet optical interface will be automatically canceled. But, sometimes the Ethernet port needs to be UP without the optical module inserted, such as enabling the loopback check function. In this case, you can configure to mandatorily cancel the OMM-disabled status of the Ethernet optical interface.

The Ethernet optical interface will be in the OMM-disabled status only when it has no optical module inserted. The electrical interface and Combo interface will not be set to the OMM-disabled status, and therefore, this function is not required.

Table 10 Enabling Mandatory Cancel of Interface OMM-disabled Status/Disabling Mandatory Cancel of Interface OMM-disabled Status

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter

Step	Command	Description
		the L2/L3 Ethernet interface configuration mode
Enable mandatory cancel of interface OMM-disabled status	**optical enable port manual**	Mandatory By default, this function is disabled
Disable mandatory cancel of interface OMM-disabled status	**no optical enable port manual**	Mandatory By default, this function is disabled

Note

- This function is only allowed to be configured on the Ethernet optical interface, and not allowed to be configured on the electrical port and the combo port.
- This function is not allowed to be configured on VSL member port.

Configure Port Traffic Ultra-Bandwidth Function

You need to configure snmp-server enable traps {in-usage-rate | out-usage-rate } first. This function is used to send an alarm trap when the bandwidth in-usage-rate/out-usage-rate of the port exceeds the max limit. When the bandwidth in-usage-rate/out-usage-rate of the port recovers from higher than the max limit to lower than the min limit, a recovered trap will be sent.

Table 11 Configuring Traffic Ultra-Bandwidth Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter L2 Ethernet interface configuration mode/aggregation group configuration mode	**interface** *interface-name*	Mandatory The subsequent configuration takes effect only on the current interface after you enter the L2 Ethernet interface configuration mode

Step	Command	Description
Configure traffic ultra-bandwidth trap function	**flow-warn { in-packet | out-packet } max-usage** *max-value* **min-usage** *min-value*	Mandatory By default, the traffic ultra-bandwidth trap sending function of the port is disabled. **in-packet** : Enable the trap function for the in-usage-rate of the port. **in-packet** : Enable the trap function for the out-usage-rate of the port. *max-value* : The max value of bandwidth usage rate. *min-value* : The min value of bandwidth usage rate.
Disable the traffic ultra-bandwidth trap function	**no flow-warn {in-packet | out-packet}**	Mandatory By default, this function is disabled

Note

- This function takes effect only on the L2 port

Configure Port Single-Fiber Function

Configure the single-fiber function of the Ethernet interface. This function configures the Ethernet interface to support both transmitting and receiving packets in the single-fiber mode.

Table 12 Configuring Port Single-Fiber Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter L2 Ethernet interface configuration mode/L3 Ethernet interface configuration mode	**interface** *interface-name*	Mandatory The subsequent configuration takes effect only on the current interface after you enter the L2 Ethernet interface configuration mode
Configure single-fiber function	**single-fiber mode**	Mandatory By default, the single-fiber function of the Ethernet interface is disabled. Enable both the single-fiber transmitting and receiving functions.
Disable the single-fiber function	**no single-fiber mode**	Mandatory By default, this function is disabled

Note

- This function takes effect only when the Ethernet interface is the optical interface

17.2.2 Configure Port Detection Function

Configure Port Status Flap Detection

When the port changes from Down to Up and if the port status flap detection is configured and it meets the detection condition, it is regarded that the status flap happens to the specified port or called Link-Flap and the port is automatically disabled and set as Error-Disabled.

Table 13 Configuring Status Flap Detection

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure port flap detection	**errdisable flap-setting cause link-flap max-flaps** *max-flaps-number* **time** *time-value*	Mandatory By default, the trigger condition of executing Link-Flap is: within 10s, the detected port becomes Up for at least 5 times.

Note

- When the port is disabled by the Link-Flap function and set as Error-Disabled and if it is necessary to recover automatically, you can configure the command **errdisable recovery cause** to set the above function.

Enable Port Loopback Test

When performing some troubleshooting, such as locating the port fault initially, you can enable the port loopback test function. The port enabled with the loopback test function cannot forward packets normally.

The port loopback test function includes internal loopback test and external loopback test.

During internal loopback test, change the internal receiving end and sending end of the specified port to make the packets sent by the port loopback in the device and received by the port. If the internal loopback test succeeds, it indicates that the port inside works normally. The Ethernet optical interface will be in the OMM-disabled status when the optical module is not inserted, and the internal loopback is configured not to be able to UP. In this case, you need to cancel the OMM-disabled status of the port first.

During the external loopback test, first insert one self-loop cable on the port and the packets sent by the specified port return to the port via the self-loop cable and received by the port. If the external loopback test succeeds, it indicates that the port works normally.

Table 14 Enabling Loopback Test

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the L2/L3 Ethernet interface configuration mode
Enable Port Loopback Test	**loopback** { **internal | external** }	Mandatory By default, the loopback test function for the Ethernet interface is not enabled

Note

- This device does not support the external loopback test function.

17.2.3 Configure Storm Suppression

Configure Storm Suppression Parameters

Limit the broadcast, multicast or unknown unicast traffic on the port by configuring the storm suppression parameters. When the broadcast, multicast or unknown unicast traffic on the port exceeds the set threshold, the system drops the excessive packets, so as to make the proportion of the broadcast, multicast or unknown unicast traffic on the port reduce to the limited range and ensure the normal running of the network services.

Table 15 Configuring Storm Suppression Parameters

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Storm Suppression Parameters	**storm-control** { **broadcast** | **multicast** | **unicast** } { *percent-value* | **kbps** *bps-value* | **pps** *pps-value* }	Mandatory By default, the storm suppression parameters of the port are not configured

Note

- The L3 Ethernet interface does not support the configuration of storm suppression.

Configure Action Executed after Storm Suppression

When the storm is detected on the specified port and the storm suppression is enabled, you can select three policies to process the storms on the port:

One is to make recording on the device and to print on the terminal and output the alarm information of detecting storm. In this mode, the port is enabled, so the port can receive the subsequent traffic and the storm on the port cannot be removed.

One is to disable the port, to make recording on the device and print on the terminal and output the alarm information of storm being detected, and to transmit the alarm information of the storm being detected and shutting down the port to the configured log server via trap. In this mode, the port is disabled, so the port cannot receive the subsequent traffic and the storm on the port is removed at once.

The other is to make recording on the device, to print on the terminal and output the alarm information of detecting storm, and to transmit the alarm information of detecting the storm to the configured log server via trap. In this mode, the port is enabled, so the port can receive the subsequent traffic and the storm on the port cannot be removed.

Table 16 Configuring Action Executed after the Storm Suppression

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the action executed after the storm suppression	**storm-control action** { **shutdown** | **trap** | **logging** }	Mandatory By default, the action executed after the storm is detected by the port is the recording on the device, and the alarm information of detecting the storm is printed on the terminal and output

Note

- When the port is disabled by the storm suppression function and set as Error-Disabled status and if it is necessary to recover automatically, you can configure the command **errdisable recovery cause** to set the above function.
- The L3 Ethernet interface does not support configuring the action executed after the storm suppression.

17.2.4 Configure Broadcast Packet Shielding

Unknown unicast packets, unknown multicast packets, and broadcast packets are broadcast within the VLAN. Ports in some applications do not need to send these packets. If you enable the broadcast packet shielding function for these ports, these ports do not send these packets. This function takes effect in the egress direction of the ports.

Configuration Condition

None

Configure Broadcast Packet Shielding

Table 17 Configuring Broadcast Packet Blocking

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure broadcast packet shielding	**flood-control** { **bcast** | **unknown-mcast** | **unknown-ucast** }	Mandatory By default, broadcast packets, unknown multicast packets, and unknown unicast packets are not shielded on the egress port

17.2.5 Configure Port UNI/NNI Type

Configure Port UNI/NNI Type

Uni port is the connection port between the user device and a network; nni port is the connection interface between networks. On one device, the nni port and uni port or nni ports are interconnected with no isolation; uni ports are isolated from each other.

Table 18 Configuring UNI/NNI Attribute

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		only within the aggregation group.
Configure UNI/NNI attribute	**port-type** { **nni** | **uni** }	Mandatory By default, the UNI/NNI type of the L2 Ethernet interface and aggregation group is **nni**

Note

- The L3 Ethernet interface does not support the UNI/NNI type.

Configure Connectivity of Uni Port

By default, all uni ports of one device are isolated from each other. However, to realize the intercommunication between the specified multiple uni ports, but not change the isolation relation between these uni ports and other uni ports, you can configure the connectivity of the uni port.

When configuring the connectivity on the specified uni port, you can only set whether the uni port can forward packets to other uni ports, without affecting whether other uni ports can forward packets to the specified uni port. Therefore, to realize the intercommunication between the multiple uni ports, you should configure as community on these uni ports separately.

Table 19 Configuring the Connectivity of uni Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure Connectivity of uni Port	**uni-isolate** { **community | isolated** }	Mandatory By default, the uni port cannot forward packets to other uni ports

Note

- This command can take effect only on the uni port.
- The L3 Ethernet interface does not support the configuration of the connectivity of the uni port.

17.2.6 Configure Basic Functions of L3 Ethernet Interface

The Ethernet interface processes the data packets at different levels, so it can work in the L2 mode or L3 mode. If the working mode of the Ethernet interface is set as L2 mode, it will be used as one L2 Ethernet interface; if the working mode of the Ethernet interface is set as L3 mode, it will be used as one L3 Ethernet interface, and its role is equivalent to VLAN interface.

Configuration Condition

None

Configure L3 Ethernet Interface

Table 20 Configuring L3 Ethernet Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure L3 Ethernet interface	**no switchport**	Mandatory By default, the Ethernet interface works in L2 mode and is used as one L2 Ethernet interface

Note

- After the working mode of the Ethernet interface is switched, all the configurations of the Ethernet interface except the description, shutdown, speed, duplex, media-type, mdix, and eee configurations will be restored to the default configuration in a new mode.
- When the Ethernet interface is used as one L3 interface, please refer to the configuration of the basic functions of the VLAN interface for the configuration of the basic functions of the L3 Ethernet interface.

17.2.7 Ethernet Interface Monitoring and Maintaining

Table 21 Ethernet Interface Monitoring and Maintaining

Command	Description
clear interface *interface-name*	Clear the statistics information of the specified L3 Ethernet interface
clear interface { *interface-list* | **switchport** } **statistics**	Clear the packet and traffic statistics information of the port
clear optical { **all** | **interface** *interface-list* } **exception statistic**	Clear the exception statistics information of the optical module inserted on the Ethernet interface
show errdisable flap-values	Display the current setting of triggering executing Link-Flap function

Command	Description
show interface { *interface-list* [**group**] | **switchport** [**brief** [**down** | **up** | **vsl**]] }	Display all information or abstract information of the Ethernet interface or virtual switch link member port
show interface *interface-list* **statistics**	Display the packet and traffic statistics information of the port
show interface switchport statistics [**packet | rate | ratio**]	Display the packet and traffic statistics information of all ports on the device
show interface all statistics [**packet | rate | ratio**]	Display the packet and traffic statistics information of all L2 interfaces and L3 interfaces on the device
show optical { **all** | **interface** *interface-list* } [**detail | exception statistic**]	Display the information of the optical module inserted on the Ethernet interface
show port-type [*interface-list* | { **uni** | **nni** } [**interface** *interface-list*]]	Display the UNI/NNI attribute information of the port
show group-port	Display the attribute information of the same group that the Ethernet interfaces belong to
show interface *interface-list* **rate-peak** [**input** / **output**]	Display the traffic monitoring information of the specified port
show storm-control [**interface** *interface-list*]	Display the storm suppression setting of the specified port
show optical { **all** | **interface** *interface-list* } **omm-disabled status**	Display whether the port is in OMM-disabled status and the reason why the port is in the OMM-disabled status

17.3 Typical Configuration Example of Ethernet Interface

17.3.1 Configure Storm Suppression Function

Network Requirements

- Configure the storm suppression function on the port of the device to suppress the broadcast, unknown unicast and multicast packets, realizing that PC2 can access Internet normally when PC1 sends lots of broadcast, unknown unicast and multicast

packets.

Network Topology

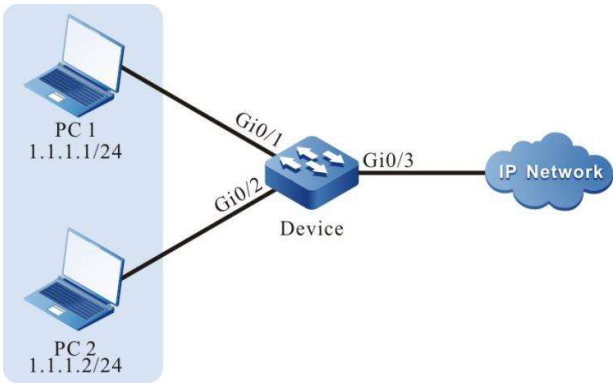


Figure 2- 1 Configure Network Topology of Storm Suppression

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 and gigabitethernet0/2 on Device as Access, permitting the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1,0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

#Configure the link type of port gigabitethernet0/3 on Device as Trunk, permitting the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/3
Device(config-if-gigabitethernet0/3)#switchport mode trunk
Device(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/3)#exit
```

Step 2: Configure the storm suppression function

#Adopt bps limitation mode to suppress the broadcast, unknown unicast and multicast packets on port gigabitethernet0/1 and the suppression rate is 1024Kbps.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#storm-control broadcast kbps 1024
Device(config-if-gigabitethernet0/1)#storm-control unicast kbps 1024
Device(config-if-gigabitethernet0/1)#storm-control multicast kbps 1024
Device(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#View the storm suppression information of port gigabitethernet0/1 on Device.

```
Device#show storm-control interface gigabitethernet 0/1
Status Codes: U - unicast, B - broadcast, M - multicast
 Interface          Unicast    Broadcast  Multicast  Action    Status
 ---------------------------------------------------------------------------------------
 gi0/1              1024kbps   1024kbps   1024kbps   logging   -|-|-
```

#When PC1 sends lots of broadcast, unknown unicast and multicast packets, PC2 also can access Internet normally.

18 Aggregation Group Interface

18.1 Overview

Aggregation group interface is one logical interface. When enabling the link aggregation function on multiple ports, the multiple ports with the same link aggregation feature form the aggregation group and are abstracted to aggregation group interface; meanwhile, the multiple ports with the same attribute are called the member ports of the aggregation group. It is mainly used to expand the link bandwidth and improve the connection reliability.

18.2 Aggregation Group Interface Function Configuration

Table 3- 1 Function Configuration List of Aggregation Group Interface

Configuration Task	
Configure Basic Functions of Aggregation Group Interface	Enter Aggregation Group Configuration Mode
	Configure aggregation group forwarding mode

18.2.1 Configure Basic Functions of Aggregation Group Interface

Configuration Condition

None

Enter Aggregation Group Configuration Mode

Table 1 Entering the Aggregation Group Configuration Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	Mandatory

Note

- Before entering the specified aggregation group configuration mode, first create the corresponding aggregation group.

18.2.2 Monitoring and Maintaining of Aggregation Group Interface

Table 2 Monitoring and Maintaining of Aggregation Group Interface

Command	Description
clear interface switchport link-aggregation *link-aggregation-id* **statistics**	Clear the packet and traffic statistics information of the specified aggregation group
show interface switchport link-aggregation [*link-aggregation-id* | **brief**]	Display all information of the aggregation group
show interface link-aggregation *link-aggregation-id* **statistics**	Display the packet and traffic statistics information of the specified aggregation group
show interface link-aggregation *link-aggregation-id* **rate-peak** [**input** | **output**]	Display the traffic monitoring information of the specified aggregation group
show port-type interface link-aggregation *link-aggregation-id*	Show the UNI/NNI attribute information of the aggregation group

19 VLAN Interface

19.1 Overview

VLAN interface is one logical interface, used to be bound with VLAN and complete the packet forwarding between different VLANs. One VLAN can only be bound to one VLAN interface. One VLAN interface also can only be bound with one VLAN.

19.2 VLAN Interface Function Configuration

Table 4- 1 VLAN Interface Function Configuration List

Configuration Task	
Configure the basic functions of the VLAN interface	Configure VLAN interface
	Configure the logical bandwidth of the interface
	Configure interface delay
	Configure interface MTU

19.2.1 Configure the Basic Functions of the VLAN Interface

Configuration Condition

None

Configure VLAN Interface

Table 4- 2 Configure VLAN Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create VLAN interface	**interface vlan** *vlan-id*	Mandatory By default, do not create VLAN interface.

Note

- VLAN interface is one logical interface. To work normally, you need to create the corresponding VLAN and add the physical port to VLAN. For how to create VLAN and add physical ports to the VLAN, refer to the VLAN-related chapters in the User Manual.
- There is no order requirement for creating VLAN interface, creating VLAN and adding physical port to VLAN.

Configure the Logical Bandwidth of the Interface

The logical bandwidth of the interface affects the calculation of the route cost and QoS, but does not affect the physical bandwidth of the interface. Usually, when the interface is connected to WAN, it is suggested that the logical bandwidth of the user configuration interface is consistent with the actual bandwidth of the leased line.

Table 4- 3 Configure Logical Bandwidth of Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface vlan** *vlan-id*	-
Configure the logical bandwidth of VLAN interface	**bandwidth** *width-value*	Optional By default, the logical bandwidth of the VLAN interface is 100,000 Kbps.

Configure Interface Delay

The interface delay configuration affects the calculation of the routing protocol cost, but does not affect the actual transmission delay of the interface. The user can change the cost of the routing protocol by configuring the interface delay.

Table 4- 4 Configure Interface Delay

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface vlan** *vlan-id*	-
Configure VLAN interface delay	**delay** *delay-time*	Optional By default, the delay of the VLAN interface is 10 and the unit is 10 microsecond.

Configure Interface MTU

The interface MTU decides the maximum length of the IP fragment packet and the user can configure manually.

Table 4- 5 Configure Interface MTU

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface vlan** *vlan-id*	-
Configure VLAN interface MTU	**mtu** *mtu-size*	Mandatory By default, the VLAN interface MTU is 1500 bytes.

19.2.2 VLAN Interface Monitoring and Maintaining

Table 1 Monitoring and Maintaining of VLAN Interface

Command	Description
clear interface vlan *vlan-id*	Clear the statistics information of the specified VLAN interface
show interface vlan *vlan-id*	View the information of the specified VLAN interface
show interface vlan *vlan-id* **original statistics**	View the statistics information of the specified VLAN interface

19.3 Typical Configuration Example of VLAN Interface

19.3.1 Configure VLAN Interface

Network Requirements

- Configure the VLAN interface on Device to realize the intercommunication between PC1 and PC2 of different VLANs.

Network Topology

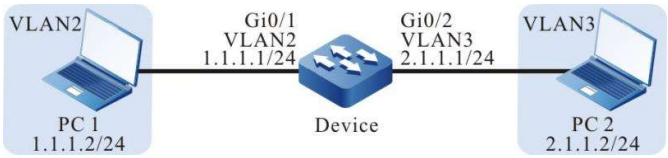


Figure 4- 1 Configure Network Topology of VLAN Interface

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN2 and VLAN3 on Device.

```
Device#configure terminal
Device(config)#vlan 2-3
```

#Configure the link type of port gigabitethernet0/1 and gigabitethernet0/2 on Device as Access. Port gigabitethernet0/1 permits the services of VLAN2 to pass and gigabitethernet0/2 permits the services of VLAN3 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode access
Device(config-if-gigabitethernet0/2)#switchport access vlan 3
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the VLAN interface and IP address on Device.

#Create VLAN2 interface on Device whose IP address is 1.1.1.1 and subnet mask is 255.255.255.0; create VLAN3 interface whose IP address is 2.1.1.1 and subnet mask is 255.255.255.0.

```
Device(config)#interface vlan 2
Device(config-if-vlan2)#ip address 1.1.1.1 255.255.255.0
Device(config-if-vlan2)#exit
Device(config)#interface vlan 3
Device(config-if-vlan3)#ip address 2.1.1.1 255.255.255.0
Device(config-if-vlan3)#exit
```

Step 3: Check the result.

#View the information of VLAN interface on Device.

```
Device#show interface vlan 2
vlan2:
    line protocol is up
    Flags: (0xc008063) BROADCAST MULTICAST ARP RUNNING
    Type: ETHERNET_CSMACD
    Internet address: 1.1.1.1/24
    Broadcast address: 1.1.1.255
    Metric: 0, MTU: 1500, BW: 100000 Kbps, DLY: 100 usec, VRF: global
    Reliability 255/255, Txload 1/255, Rxload 1/255
    Ethernet address is 0012.2355.9913
    5 minutes input rate 0 bits/sec, 0 packets/sec
    5 minutes output rate 0 bits/sec, 0 packets/sec
    0 packets received; 1 packets sent
    0 multicast packets received
    1 multicast packets sent
    0 input errors; 0 output errors
```

```
    0 collisions; 0 dropped
    Unknown protocol 0
Device#show interface vlan 3
vlan3:
    line protocol is up
    Flags: (0xc008063) BROADCAST MULTICAST ARP RUNNING
    Type: ETHERNET_CSMACD
    Internet address: 2.1.1.1/24
    Broadcast address: 2.1.1.255
     Metric: 0, MTU: 1500, BW: 100000 Kbps, DLY: 100 usec, VRF: global
    Reliability 255/255, Txload 1/255, Rxload 1/255
    Ethernet address is 0012.2355.9913
    5 minutes input rate 0 bits/sec, 0 packets/sec
    5 minutes output rate 0 bits/sec, 0 packets/sec
    0 packets received; 1 packets sent
    0 multicast packets received
    1 multicast packets sent
    0 input errors; 0 output errors
    0 collisions; 0 dropped
    Unknown protocol 0
```

#PC1 can ping PC2.

20 Loopback Interface

20.1 Overview

Loopback interface, also called local loopback interface, is logical virtual interface implemented by software. This interface is not affected by the physical status. As long as it is not manually disabled, its status is always enabled status. In dynamic routing protocols such as OSPF, you can select the IP address of the Loopback interface as the Router ID, as the identifier of the device. For packets sent to the Loopback interface, the device considers each packet to be sent to itself and will not forward the packet.

20.2 Loopback Interface Function Configuration

Table 5- 1 Loopback Interface Function Configuration List

Configuration Task	
Configure the basic functions of the Loopback interface	Configuring the Loopback interface
	Configure the logical bandwidth of the interface
	Configure interface delay

20.2.1 Configure the basic functions of the Loopback interface

Configuration Condition

None

Configuring the Loopback interface

Table 5- 2 Configure Loopback Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create Loopback interface	**interface loopback** *unit – number*	Mandatory By default, no Loopback interface is created

Configure the logical bandwidth of the interface

The logical bandwidth of the interface affects the calculation of the route cost and QoS, but does not affect the physical bandwidth of the interface. Usually, when the interface is connected to WAN, it is suggested that the logical bandwidth of the user configuration interface is consistent with the actual bandwidth of the leased line.

Table 5- 3 Configure Logical Bandwidth of Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the logical bandwidth of the interface	**bandwidth** *width-value*	Optional By default, the logical bandwidth of the Loopback interface is 8,000,000 Kbps

Configure interface delay

The interface delay configuration affects the calculation of the routing protocol cost, but does not affect the actual transmission delay of the interface. The user can change the cost of the routing protocol by configuring the interface delay.

Table 5- 4 Configure Interface Delay

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the interface configuration mode	**interface** *interface-name*	-
Configure interface delay	**delay** *delay-time*	Optional By default, the delay of the Loopback interface is 5000, in 10 microseconds

21 Null Interface

21.1 Overview

Null interface is logical virtual interface implemented by software. Any packet sent to the Null interface will be dropped. Dynamic routing protocols such as OSPF will generate automatically summarized routes, and the outlet interface points to the Null interface, which can effectively avoid routing loops. The Null 0 interface is created by the device by default and cannot be disabled or deleted by the user.

21.2 Null Interface Function Configuration

Table 6- 1 Null Interface Function Configuration List

Configuration Task	
Configure the Basic Functions of the Null Interface	Configure the Basic Functions of the Null Interface

21.2.1 Configure the Basic Functions of the Null Interface

Configuration Condition

None

Configure the Basic Functions of the Null Interface

Table 6- 2 Configuring Basic Functions of Null Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter Null interface configuration mode	**interface null 0**	Mandatory
Configure to prohibit transmit ICMP unreachable error packets	**no ip unreachables**	Optional By default, transmitting ICMP unreachable error packets is prohibited

Note

- The Null interface only supports the configuration of allowing or prohibiting transmitting of ICMP unreachable error packets.
- Packets reaching the Null interface will be dropped, you have no need to transmit ICMP unreachable errors.

22 Virtual Switch Link Interface

22.1 Overview

By binding multiple physical ports together, one virtual switch link interface (VSL-Channel) can be formed. The virtual switch link interface is logical link channel for protocol packet interaction and service data forwarding between member switches in the stack system, and each physical port therein is called member port of the virtual switch link.

Each member switch joins the same switch domain, interconnects with each other through the virtual switch link interface, and finally forms one virtual switch.

22.2 Virtual Switch Link Interface Function Configuration

Table 7- 1 Virtual Switch Link Interface Function Configuration List

Configuration Task	
Configure functions of the virtual switch link interface	Enter virtual switch link interface configuration mode

22.2.1 Configure functions of the virtual switch link interface

Configuration Condition

None

Enter virtual switch link interface configuration mode

Table 7-1 Entering Virtual Switch Link Interface Configuration Mode

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter virtual switch link interface configuration mode	vsl-channel *vsl-channel-id*	Mandatory In stand-alone mode, *vsl-channel-id* is a one-dimensional value that represents a virtual switch link interface number. In stack mode, it is a two-dimensional value. The first

Step	Command	Description
		dimension is a virtual switch member number, and the second dimension is a virtual switch link interface number

Note

- Before entering the virtual switch link interface configuration mode, you must first create the corresponding virtual switch link interface.

22.2.2 Monitoring and Maintaining of Virtual Switch Link Interface

Table 7-2 Monitoring and Maintaining of Virtual Switch Link Interface

Command	Description
clear vsl-channel *vsl-channel-id* **statistics**	Clear the packet and traffic statistics information of the specified virtual switch link interface
show vsl-channel *vsl-channel-id* **rate-peak** [**input** | **output**]	Display the traffic monitoring information of the specified virtual switch link interface
show vsl-channel *vsl-channel-id* **statistics**	Display the packet and traffic statistics information of the specified virtual switch link interface

23 Link Aggregation

23.1 Overview

Through link aggregation, multiple physical links between two devices are bound to form a logic link so as to expand link capacity. Within the logic link, the physical links act as redundancy and dynamic backup of each other, providing higher network connection reliability.

23.1.1 Basic Concepts

Aggregation Group and Member Ports

Multiple physical ports are bound to form an aggregation group, and the physical ports are member ports of the aggregation group.

Member Port Status

The member ports of an aggregation group have the following two statuses:

- Selected: The member ports which are in this status can participate in user service traffic forwarding. The member ports in this status are called "the selected ports".
- Unselected: The member ports which are in this status cannot participate in user service traffic forwarding. The member ports in this status are called "the unselected ports".

The rate and duplex mode of an aggregation group is determined by the selected ports in the aggregation group. The rate of an aggregation group is the sum of all selected ports, and the duplex mode of the aggregation group is the same as the duplex mode of the selected ports.

Operation Key

An operation key is the property configuration of member ports. It consists of the rate, duplex mode, and administrative key (that is, the aggregation group number). In property configuration, change of the duplex mode or rate may cause re-calculation of the operation key.

In one aggregation group, if the duplex modes or rates of member ports are different, then the generated operation keys are different. However, the member ports that are in the selected status must have the same operation key.

LACP

Link Aggregation Control Protocol (LACP) is a protocol that is based on IEEE802.3ad. In LACP, Link Aggregation Control Protocol Data Units (LACPDUs) are used to interchange messages between two ends.

LACP Priorities

LACP priorities are categorized into two types: system LACP priorities and port LACP priorities.

- System LACP priorities: They are used to determine the LACP priority order of the devices at two ends.

- Port LACP priorities: They are used to determine the priority order at which the member ports of the local device are selected.

System ID and Port ID

System ID: Aggregation property of a device. It consists of the system LACP priority of the device and the system MAC address. The higher the system LACP priority is, the better the system ID of the device is. If the system LACP priorities are the same, then the smaller the system MAC address is, the better the system ID of the device is.

Port ID: Aggregation property of a port. It consists of the port LACP priority and the port number. The higher the port LACP priority is, the better the port ID is. If the port LACP priorities are the same, then the smaller the port number is, the better the port ID is.

Root Port of an Aggregation Group

The protocols that are applied in an aggregation group receive and send protocol packets through the root port of the aggregation group. The root port of an aggregation group is selected from the member ports of the aggregation group. The physical link of the root port must be in the up status.

23.1.2 Link Aggregation Modes

Link aggregation modes include the static aggregation mode and the dynamic aggregation mode. Aggregation groups are categorized into static aggregation groups and dynamic aggregation groups.

Static Aggregation Mode

In static aggregation mode, the LACP protocol of the member ports of the devices at the two ends is in the disabled status. In the static aggregation group of the local device, set the selected and unselected status for the member ports by following the guidelines as described below:

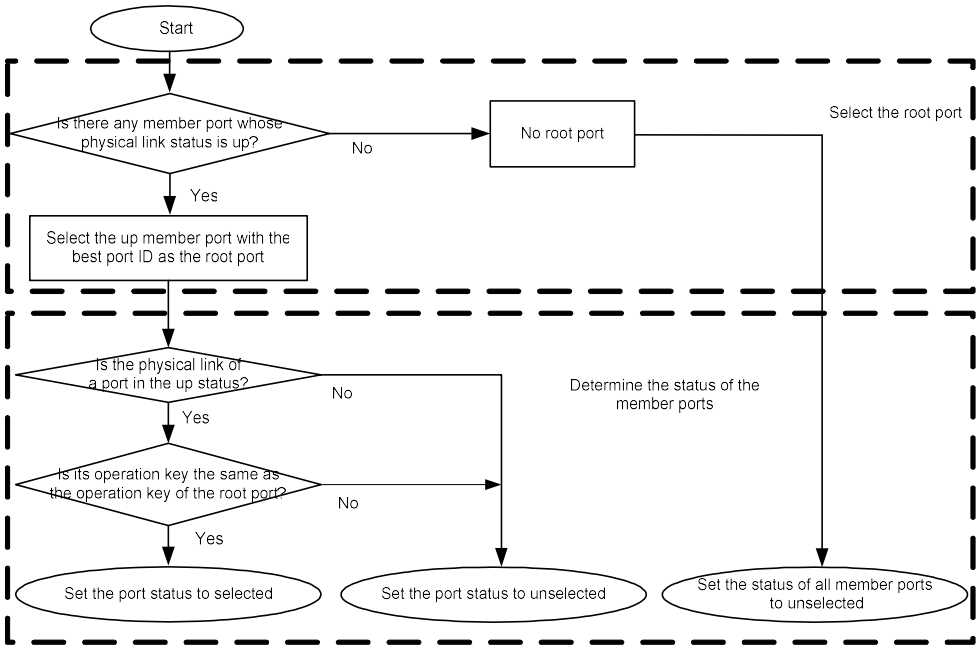


Figure 1-1 Setting the Status of Member Ports in Static Aggregation Mode

Dynamic Aggregation Mode

In dynamic aggregation ports, a port can join in a dynamic aggregation group in two modes, active or passive.

- If the duplex mode of the port is full duplex:

If the port joins in a dynamic aggregation group in active mode, the LACP protocol is enabled for the port.

If the port joins in a dynamic aggregation group in passive mode, the LACP protocol is disabled for the port. After it receives the LACPDU packets from the peer port, the LACP protocol is enabled.

- If the duplex mode of the port is half duplex, no matter the port joins in a dynamic aggregation group in either mode, the LACP protocol is disabled for the port.

In the dynamic aggregation group, set the selected and unselected status for the member ports by following the guidelines as described below:

First determine the device with a better system ID. Then the device determines the statuses of the member ports of the devices at the two ends. The device with the better system ID sets the selected and unselected status for the member ports by following the guidelines as described below:

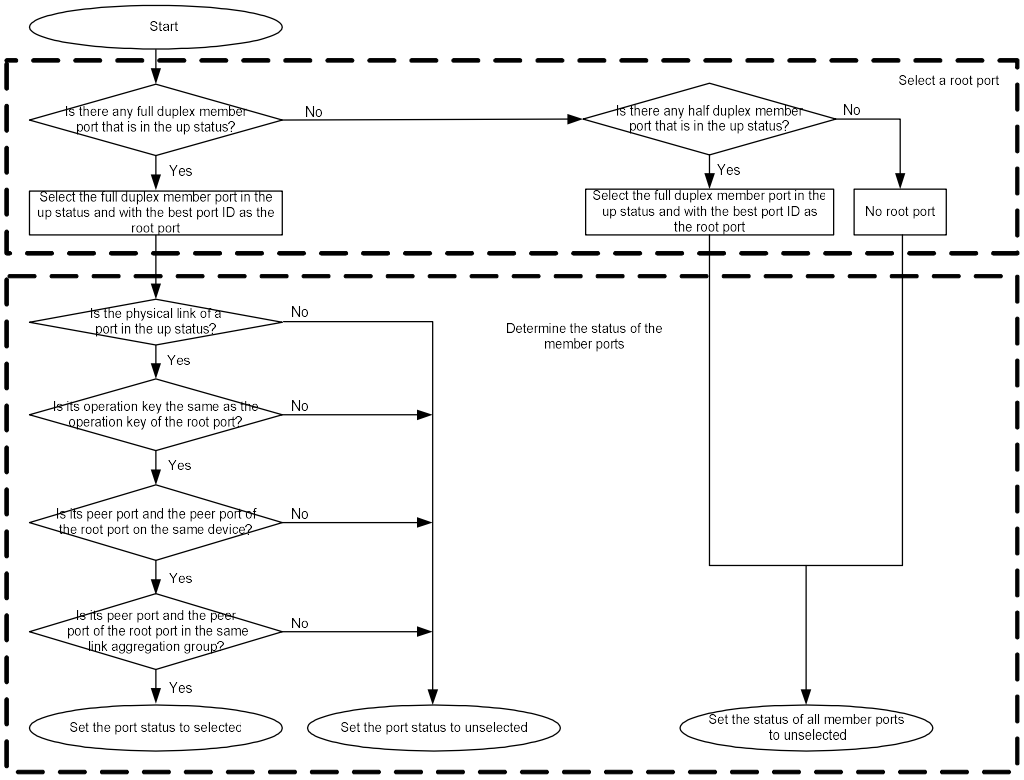


Figure 1-2 Setting the Status of Member Ports in Dynamic Aggregation Mode

23.2 Overview

23.2.1 Load Balancing

Load balance means when the traffic outlet is an aggregation group, chips can enable traffic to realize load balancing between member ports within the aggregation group according to current HASH configuration conditions to improve the bandwidth availability ratio of aggregation group.

23.2.2 HASH KEY

HASH KEY means the KEY value calculated by chips through HASH for port when the traffic selects the specific output port of aggregation group. Generally, different packet types and different switching chips support different values of HSAH KEY. The HASH KEYs supported by different packets are shown in Table 1-1.

Table 1-1 Values of HASH KEY Supported by Different Types of Packet and Their Meanings

Type of HASH KEY	Description
dst-mac	Based on destination MAC address: Realize aggregation load balancing by the destination MAC address of packet.
src-mac	Based on source MAC address: Realize aggregation load balancing by the source MAC address of packet.
src-interface	Based on receiving source interface: Realize aggregation load balancing by the receiving source interface of packet.
vlan	Based on VLAN: Realize aggregation load balancing by the VLAN of packet.
dst-ip	Based on destination IP address: Realize aggregation load balancing by the destination IP address of packet.
l4-dst-port	Based on layer-4 destination port number: Realize aggregation load balancing by the four-layer destination port number of packet.
flow-label	Based on IPv6 flow tag: Realize aggregation load balancing according to the IPv6 flow tag of the packet.
protocol	Based on IP protocol: Realize aggregation load balancing by the IP protocol of packet.
src-ip	Based on source IP address: Realize aggregation load balancing by the source IP address of packet.
l4-src-port	Based on layer-4 source port number: Realize aggregation load balancing by the layer-4 source port number of packet.

For this device, the HASH KEYs supported by different packets are shown in Table 1-2:

Table 1-2 HASH KEYs Supported by Different Packets

Type of Packet	HASH KEY Support
Known unicast packet in L2	dst-mac、src-mac、src-interface、vlan
Known unicast packet in L3	dst-ip、l4-dst-port、flow-label、protocol、src-ip、l4-src-port、src-interface、src-mac、dst-mac、vlan
Other packets in L2	dst-mac、src-mac、src-interface
Other packets in L3 (IPv4/IPv6)	dst-ip、src-ip、src-interface

Note

- The HASH KEY of known unicast packet in L2 can support a combination of one or more combination HASH KEYs.
- The HASH KEY of known unicast packet in L3 can support a combination of one or more HASH KEYs. The HASH KEYs of other L2 packets are fixed and cannot be configured. They use dst-mac, src-mac, and src-interface for load balancing.
- The HASH KEYs of other L3 (IPv4/IPv6) packets are fixed and cannot be configured. They use dst-ip, src-ip, src-interface, l4-src-port and l4-dst-port for load balancing.

23.2.3 Load Balancing Mode

Load balancing mode is a "user-mode" concept specially introduced to shield the difference of chips from different chip manufacturers. In particular, "user" means to all the services that need to use chip load balancing (i.e., business modules, such as aggregation LAC); "mode" is a reusable HASH configuration plan that abstracts underlying HASH resource.

Load balancing mode is distinguished by mode name which has less than 31 characters. By default, there is a default HASH mode "default" and "ecmp_default" in the system. In addition, customizable templates may be provided to users based on current operating mode (stand-alone and stack mode) and chip resource conditions. Generally, each mode comprises HASH KEY configurations of L2 packets and L3 packets.

Users may flexibly configure the load balancing mode and the HASH KEY of corresponding mode as needed. Upon completion of the configuration, they can realize load balancing of traffic according to corresponding mode configuration by referring or binding corresponding mode.

Note

- The name of load balancing mode has less than 31 characters.
- The default load balancing mode name "default" and "ecmp_default" cannot be modified.
- The default load balancing mode "default" and "ecmp_default" cannot be deleted, but can be configured.

23.3 Function Configuration of Load Balancing Mode

Table 1-3 Function Configuration List of Load Balancing Mode

Configuration Task	
Load balancing mode configuration function	Create a load balancing mode and enter the configuration mode
	Configure the HASH KEY of load balancing mode
	Delete the load balancing mode

23.3.1 Create Load Balancing Mode

After successfully creating the load balancing mode, you will enter corresponding configuration mode.

Note

- Stand-alone users can create 1 custom template at most. Stacked users cannot create any custom mode.

Configuration Condition

None

Create Load Balancing Mode

Table 1 Creating Load Balancing Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Create load balancing mode	**load-balance profile** { *profile-name* | default |ecmp_default}	Mandatory

Note

- By default, the modes "default" and "ecmp_default" have been created by the system. Users can directly enter the configuration mode of "default" and "ecmp_default" through the creation command.
- The name of mode created supports English only and has less than 31 characters.

23.3.2 Configure the HASH KEY of Load Balancing Mode

After creating the load balancing mode and successfully entering the mode, you can configure the HASH KEY value of corresponding load balancing mode.

Note

- The mode "default" and "ecmp_default" created by the system by default will configure a set of default HASH KEY. Users can modify the configuration as needed.
- The default configurations of modes "default" and "ecmp_default" are as follows: L2: src-mac, dst-mac; Ip: src-ip, dst-ip, l4-src-port, l4-dst-port.

Caution

- After the user-defined template is created, no HASH KEY value is configured for the new template by default. The user must correctly configure the HASH KEY before it is bound to the service.

Configuration Condition

None

Configure the HASH KEY of Load Balancing Mode

Table 1-5 HASH KEY Configuration of Load Balancing Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the load balancing mode configuration mode	**load-balance profile** { *profile-name* | default|ecmp_default }	Mandatory Same as the command of creating load balancing mode
Configure the HASH KEY used by L2 known unicast packet load	**l2** { [**dst-mac**] [**src-mac**] [**src-interface**] [**vlan**] }	Mandatory One or more HASH KEYs can be combined
Configure the HASH KEY used by L3 known unicast packet load	**ip** { [**dst-ip**] [**l4-src-port**] [**l4-dst-port**] [**protocol**] [**src-interface**] [**src-ip**] [src-mac][dst-mac][vlan] [**flow-label**] }	Mandatory One or more HASH KEYs can be combined
Activate current HASH KEY configuration	**active configuration pending**	Mandatory
Cancel current HASH KEY configuration	**abort configuration pending**	Mandatory

Note

- Configure HASH KEY value through l2 or ip command. It cannot not take effect immediately when in pending status. Only active configuration pending can make it effective.
- Configure HASH KEY value through l2 or ip command. It cannot not take effect immediately when in pending status. Users may cancel the current configuration by using the abort configuration pending command.
- When a new HASH KEY is configured, the original HASH KEY will not be overwritten. The result of activation with the active command combines both the original HASH KEY and the new one.
- When the HASH KEY in pending status is canceled with the abort command, the original HASH KEY will not be modified.
- When the activation fails, which is generally because the HASH KEY configured doesn't meet the requirements, the pending HASH KEY will not be cleared.
- Any HASH KEY can be configured for the user-defined load balancing mode. Yet when the service is bound for use, both L2 and L3 of the mode bound shall have at least a valid

HASH KEY.

- Requirement of "default" and "ecmp_default": At least one HASH KEY is configured for the HASH KEY of L2 and L3.

23.3.3 Configure the Shift Selection for HASHKEY of Load Balancing Mode

In global mode, configure shift selection for the HASH KEY value of corresponding load balancing mode.

Configuration Condition

Global mode

Configure the HASH KEY of Load Balancing Mode

Table 23-6 Configuring Shift Selection for HASH KEY of Load Balancing Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the shift selection for related hashkey	**load-balance hash-control shift{src-mac | dst-mac|src-ip|dst-ip|vlan|l4-src-port|l4-dst-port|src-interface| flow-label| protocol } 0~5**	-

23.3.4 Delete the Load Balancing Mode

Delete the load balancing mode.

Note

- The default "default" and "ecmp_default" in the system cannot be deleted.
- The mode which is referenced by or bound to service cannot be deleted unless all the referencing and binding relations are cancelled.
- Nonexistent mode cannot be deleted.

Configuration Condition

None

Delete the Load Balancing Mode

Table 2 Deleting Load Balancing Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the load balancing mode configuration mode	**no load-balance profile** { *profile-name* }	Mandatory

23.4 Link Aggregation Function Configuration

Table 3 Function Configuration List of Link Aggregation

Configuration Task	
Configure an Aggregation Group	Create an Aggregation Group
	Add Ports into the Aggregation Group
Configure the Load Balancing Mode of an Aggregation Group	Configure the Load Balancing Mode of an Aggregation Group
Configure LACP Priorities	Configure the System LACP Priority
	Configure the Port LACP Priority
Configure hot plug for rapid switch of root port	Configure hot plug for rapid switch of root port

23.4.1 Configure an Aggregation Group

Configuring the aggregation group can realize centralized management of multiple physical ports. Any configuration of the aggregation group will have an impact on all member ports.

Note

- Each aggregation group supports up to 8 ports at the same time.

Configuration Condition

None

Create an Aggregation Group

The aggregation groups at the two ends of an aggregated link must be configured to the same type. Description can be added to each aggregation group to make it easier for network administrators to distinguish the aggregation groups.

Table 4 Configuring Creation of Aggregation Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create an Aggregation Group	**link-aggregation** *link-aggregation-id* **mode** { **manual** | **lacp** }	Mandatory By default, the aggregation group is not created.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	-
Configure aggregation group description information	**description** *description-name*	Optional By default, there is no aggregation group description information.
Configure description information for peer port of aggregation group	**peer-description** *description-name*	Optional By default, the aggregation group has no peer port description information.

Caution

- The protocols that are applied in an aggregation group receive and send protocol packets through the root port of the aggregation group. In static aggregation mode, because the member ports between the devices at two ends do not exchange LACPDU packets, the root ports of the two devices may be on different physical links. In this way, other protocol packets on the aggregation group may fail to be received or sent. To prevent this problem, ensure that the root ports of the devices at the two ends are on the same physical link. In dynamic aggregation mode, the member ports of the devices at two ends exchange LACPDU packets. The negotiation between the two member ports ensures that the root ports of the two devices are on the same physical link.
- After an aggregation group is deleted, all the member ports of the aggregation group are removed from the aggregation group, and then all the member ports adopt the default settings.

This may result in loops in the network. Therefore, before deleting an aggregation group, ensure that the spanning tree function has been enabled or ensure that no loop may occur in the network.

Add Ports into the Aggregation Group

When an aggregation group is created, it is only a logic interface which contains no physical port. In this case, the aggregation function does not take effect. The aggregation function takes effect after ports are added to a static aggregation group. The aggregation function takes effect after local or peer ports are added into a dynamic aggregation group.

Table 5 Adding Ports into Aggregation Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Add Ports into the Aggregation Group	**link-aggregation** *link-aggregation-id* { **manual** | **active** | **passive** }	Mandatory By default, the port is not added into any aggregation group.

Note

- Before adding a port into an aggregation group, the aggregation group must have been created; otherwise, an error message is displayed.
- A port can be added one aggregation group at a time.
- After a port is added into an aggregation group, the some existing configurations (such as loopback detection and VLAN) will be removed from the port.
- Some functions (such as loopback detection) cannot be configured on a member port in an aggregation group; otherwise, an error message is displayed.
- If a port is added into a dynamic aggregation group in passive mode, its peer port must be added into the dynamic aggregation group in active mode. Otherwise, the two ports are both in the unselected status and they cannot participate in user service traffic forwarding.
- The port configured with serviceloop-group cannot be added to this aggregation group.

23.4.2 Configure the Load Balancing Mode of an Aggregation Group

By configuring the load balancing mode of an aggregation group, you can achieve load balancing of service traffic in the aggregation group in a flexible manner.

Configuration Condition

None

Configure the Load Balancing Mode of an Aggregation Group

Table 6 Configuring Load Balancing Mode of an Aggregation Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	-
Configure the load balancing mode of an aggregation group	**load-balance** profile *profile-name*	Mandatory By default, the default mode of aggregation can realize aggregation load balancing.

23.4.3 Configure LACP Priorities

Configuration Condition

None

Configure the System LACP Priority

Configuration of the system LACP priority may affect the system ID, and finally affect the selected/unselected status of member ports of dynamic aggregation groups.

Table 7 Configuration of System LACP Priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the System LACP Priority	**lacp system-priority** *system-priority-value*	Mandatory By default, the system LACP priority is 32768.

Configure the Port LACP Priority

Configuration of the port LACP priority may affect the port ID, and finally affect the selected/unselected status of member ports of aggregation groups.

Table 8 Configuration of Port LACP Priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the Port LACP Priority	**lacp port-priority** *port-priority-value*	Mandatory By default, the port LACP priority is 32768.

23.4.4 Configure Hot Plug for Rapid Switch of Root Port

Configure a hot plug for rapid switch of root port so that when the board where the root port is located is hot-plugged, the peer port can be quickly notified to reselect a root port for rapid stabilization and convergence of the aggregation group.

Note

- The rapid switch notice will be sent only when the board where the root port is located is pulled out.
- Static aggregation group will not send rapid switch notice.

Configuration Condition

None

Configure Hot Plug for Rapid Switch of Root Port

Table 9 Configuration of Hot Plug for Rapid Switch of Root Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure hot plug for rapid switch of root port	**link-aggregation hotswap fast-change-rootport**	Mandatory By default, hot plug for rapid switch of root port is not configured.

23.4.5 Link Aggregation Monitoring and Maintaining

Table 10 Link Aggregation Monitoring and Maintaining

Command	Description
show link-aggregation group [*link-aggregation-id*]	Displays brief information about a specified aggregation group or all existing aggregation groups.
show link-aggregation interface [*interface-name*]	Displays the details of a specified member port of an aggregation group or details of all member ports of the aggregation group.
snmp-server enable traps lacp port-status	Turn on the port status change switch of aggregation group
no snmp-server enable traps lacp port-status	Turn off the port status change switch of aggregation group

23.5 Typical Configuration Example of Link Aggregation

23.5.1 Configure a Static Aggregation Group

Network Requirements

- Device1 is connected to PC1, Device2 is connected to PC2 and PC3, and the three PCs are in the same network segment. Device1 and Device2 are interconnected through Trunk ports.
- A static aggregation group is configured between Device1 and Device2 for bandwidth increase, load sharing, and service backup.

Network Topology

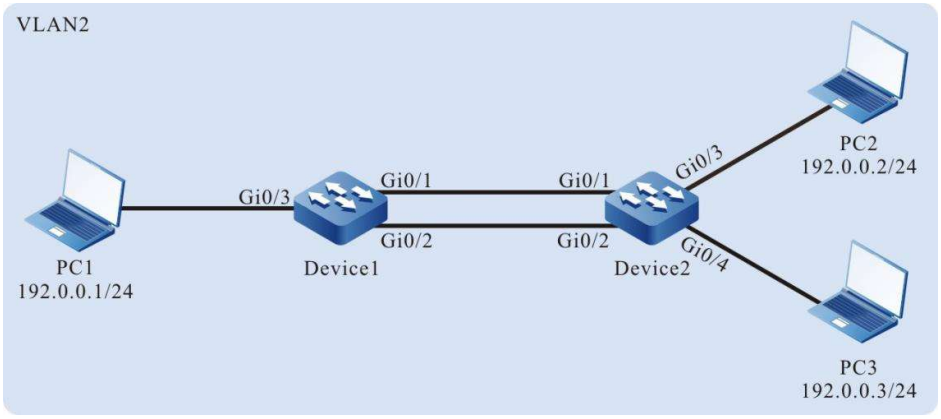


Figure 1-3 Networking for Configuring a Static Aggregation Group

Configuration Steps

Step 1: Create a static aggregation group.

#On Device1, create static aggregation group 1.

```
Device1#configure terminal
Device1(config)#link-aggregation 1 mode manual
```

#On Device2, create static aggregation group 2.

```
Device2#configure terminal
Device2(config)#link-aggregation 1 mode manual
```

Step 2: Add ports into the aggregation group.

#On Device1, add ports gigabitethernet0/1 and gigabitethernet0/2 into aggregation group 1 in Manual mode.

```
Device1(config)#interface gigabitethernet 0/1,0/2
Device1(config-if-range)#link-aggregation 1 manual
Device1(config-if-range)#exit
```

#On Device2, add ports gigabitethernet0/1 and gigabitethernet0/2 into aggregation group 1 in Manual mode.

```
Device2(config)#interface gigabitethernet 0/1,0/2
Device2(config-if-range)#link-aggregation 1 manual
Device2(config-if-range)#exit
```

#After the configuration is completed, check the status of aggregation group 1 on the devices.

Here takes Device1 for example:

```
Device1#show link-aggregation group 1
 Link Aggregation 1
  Type: switchport
  Mode: Manual
   User: LAC
   Description:
   Peer-description:
  Load balance profile: default
  Number of ports in total: 2
  Number of ports attached: 2
  Root port: gigabitethernet0/1
  gigabitethernet0/1: ATTACHED
  gigabitethernet0/2: ATTACHED
```

According to the system display, ports gigabitethernet0/1 and gigabitethernet0/2 are both in the ATTACHED state in aggregation group 1, and aggregation of aggregation group 1 is successful.

Note

- For the method of checking Device2, refer to the method of checking Device1.

Step 3: Configure the load balancing mode of the aggregation group.

#Create load balancing mode linkagg-profile on Device1.

```
Device1(config)#load-balance profile linkagg-profile
```

Under the load balancing mode linkagg-profile on Device1, configure the packet load hash-key, make L2 packet loaded by destination MAC, and make IP packet loaded by destination IP.

```
Device1(config-hashprofile)#l2 dst-mac
Device1(config-hashprofile)#ip dst-ip
Device1(config-hashprofile)#active configuration pending
```

#On Device1, configure the load balancing mode of aggregation group 1 as linkagg-profile.

```
Device1(config)#interface link-aggregation 1
```

Device1(config-link-aggregation1)#load-balance profile linkagg-profile

Step 4: Configure a VLAN, and configure the link type of the aggregation group and ports.

#On Device1, create VLAN2, configure the link type of aggregation group 1 as Trunk, allow services of VLAN2 to pass, and configure PVID as 2.

```
Device1(config)#vlan 2
Device1(config-vlan2)#exit
Device1(config)#interface link-aggregation 1
Device1(config-link-aggregation1)#switchport mode trunk
Device1(config-link-aggregation1)#switchport trunk allowed vlan add 2
Device1(config-link-aggregation1)#switchport trunk pvid vlan 2
Device1(config-link-aggregation1)#exit
```

#On Device1, configure the link type of port gigabitethernet0/3 as Access, and allow services of VLAN2 to pass.

```
Device1(config)#interface gigabitethernet 0/3
Device1(config-if-gigabitethernet0/3)#switchport mode access
Device1(config-if-gigabitethernet0/3)#switchport access vlan 2
Device1(config-if-gigabitethernet0/3)#exit
```

#On Device2, create VLAN2, configure the link type of aggregation group 1 as Trunk, allow services of VLAN2 to pass, and configure PVID as 2. (Omitted)

#On Device2, configure the link type of ports gigabitethernet0/3 and gigabitethernet0/4 as Access, and allow services of VLAN2 to pass. (Omitted)

Step 5: Check the result.

#Check the aggregation bandwidth of aggregation group 1 on the devices.

Here takes Device1 for example:

```
Device1#show interface link-aggregation 1
link-aggregation 1 configuration information
    Description      :
     Peer-description :
    Status          : Enabled
    Link            : Up
    Act Speed       : 2000
    Act Duplex      : Full
    Port Type       : Nni
    Pvid            : 2
```

According to the system display, the interface bandwidth of the aggregation group 1 on Device1 is 2000 M.

Note

- For the method of checking Device2, refer to the method of checking Device1.

#On Device1, view current valid load balancing mode of aggregation group 1.

```
Device1#show link-aggregation group 1
```

```
Link Aggregation 1
 Type: switchport
 Mode: Manual
  User: LAC
  Description:
  Peer-description :
Load balance profile: linkagg-profile
Number of ports in total: 2
Number of ports attached: 2
Root port: gigabitethernet0/1
gigabitethernet0/1: ATTACHED
gigabitethernet0/2: ATTACHED
```

According to the system display, the current load balancing mode of aggregation group 1 is dst-ip.

#During the process of service interaction between PC1 and PC2 and PC3, load balancing of data is achieved on the aggregated links. If a link in the aggregation group becomes faulty, the other links provide service backup.

23.5.2 Configure a Dynamic Aggregation Group

Network Requirements

- Device1 is connected to PC1, Device2 is connected to PC2 and PC3, and the three PCs are in the same network segment. Device1 and Device2 are interconnected through Trunk ports.
- A dynamic aggregation group is configured between Device1 and Device2 for bandwidth increase, load sharing, and service backup.

Network Topology

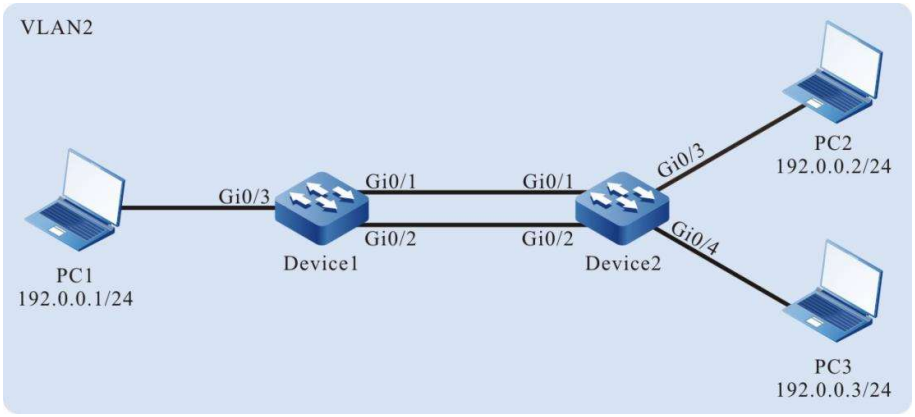


Figure 1-4 Networking for Configuring a Dynamic Aggregation Group

Configuration Steps

Step 1: Create a dynamic aggregation group.

#On Device1, create dynamic aggregation group 1.

```
Device1#configure terminal
```

```
Device1(config)#link-aggregation 1 mode lacp
```

#On Device2, create dynamic aggregation group 1.

```
Device2#configure terminal
Device2(config)#link-aggregation 1 mode lacp
```

Step 2: Add ports into the aggregation group.

#On Device1, add ports gigabitethernet0/1 and gigabitethernet0/2 into aggregation group 1 in Active mode.

```
Device1(config)#interface gigabitethernet 0/1,0/2
Device1(config-if-range)#link-aggregation 1 active
Device1(config-if-range)#exit
```

#On Device2, add ports gigabitethernet0/1 and gigabitethernet0/2 into aggregation group 1 in Active mode.

```
Device2(config)#interface gigabitethernet 0/1,0/2
Device2(config-if-range)#link-aggregation 1 active
Device2(config-if-range)#exit
```

#After the configuration is completed, check the status of aggregation group 1 on the devices.

Here takes Device1 for example:

```
Device1#show link-aggregation group 1
 Link Aggregation 1
  Type: switchport
  Mode: LACP
   User: LAC
   Description:
   Peer-description:
 Load balance profile: default
 Number of ports in total: 2
 Number of ports attached: 2
 Root port: gigabitethernet0/1
 gigabitethernet0/1: ATTACHED
 gigabitethernet0/2: ATTACHED
```

According to the system display, ports gigabitethernet0/1 and gigabitethernet0/2 are both in the ATTACHED state in aggregation group 1, and aggregation of aggregation group 1 is successful.

Note

- For the method of checking Device2, refer to the method of checking Device1.

Step 3: Configure the load balancing mode of the aggregation group.

#Create load balancing mode linkagg-profile on Device1.

```
Device1(config)#load-balance profile linkagg-profile
```

Under the load balancing mode linkagg-profile on Device1, configure the packet load hash-key, make L2 packet loaded by destination MAC, and make IP packet loaded by destination IP.

```
Device1(config-hashprofile)#l2 dst-mac
Device1(config-hashprofile)#ip dst-ip
Device1(config-hashprofile)#active configuration pending
```

#On Device1, configure the load balancing mode of aggregation group 1 as linkagg-profile.

```
Device1(config)#interface link-aggregation 1
Device1(config-link-aggregation1)#load-balance profile linkagg-profile
```

#Create load balancing mode linkagg-profile on Device2. (Omitted)

#Under the load balancing mode linkagg-profile on Device2, configure the packet load hash-key, make L2 packet loaded by destination MAC, and make IP packet loaded by destination IP. (Omitted)

#On Device2, configure the load balancing mode of aggregation group 1 as linkagg-profile. (Omitted)

Step 4: Configure a VLAN, and configure the link type of the aggregation group and ports.

#On Device1, create VLAN2, configure the link type of aggregation group 1 as Trunk, allow services of VLAN2 to pass, and configure PVID as 2.

```
Device1(config)#vlan 2
Device1(config-vlan2)#exit
Device1(config)#interface link-aggregation 1
Device1(config-link-aggregation1)#switchport mode trunk
Device1(config-link-aggregation1)#switchport trunk allowed vlan add 2
Device1(config-link-aggregation1)#switchport trunk pvid vlan 2
Device1(config-link-aggregation1)#exit
```

#On Device1, configure the link type of port gigabitethernet0/3 as Access, and allow services of VLAN2 to pass.

```
Device1(config)#interface gigabitethernet 0/3
Device1(config-if-gigabitethernet0/3)#switchport mode access
Device1(config-if-gigabitethernet0/3)#switchport access vlan 2
Device1(config-if-gigabitethernet0/3)#exit
```

#On Device2, create VLAN2, configure the link type of aggregation group 1 as Trunk, allow services of VLAN2 to pass, and configure PVID as 2. (Omitted)

#On Device2, configure the link type of ports gigabitethernet0/3 and gigabitethernet0/4 as Access, and allow services of VLAN2 to pass. (Omitted)

Step 5: Check the result.

#Check the aggregation bandwidth of aggregation group 1 on the devices.

Here takes Device1 for example:

```
Device1#show interface link-aggregation 1
link-aggregation 1 configuration information
      Description      :
```

```
 Peer-description :
Status          : Enabled
Link            : Up
Act Speed       : 2000
Act Duplex      : Full
Port Type       : Nni
Pvid            : 2
```

According to the system display, the interface bandwidth of the aggregation group on Device1 is 2000 M.

Note

- For the method of checking Device2, refer to the method of checking Device1.

#After configuration, view the load balancing mode configured on Device1.

```
Device1#show load-balance configuration

Profile:default
    Configuration Valid currently:
        L2: src-mac dst-mac
        Ip: src-ip dst-ip
    Configuration Valid-pending to be applied:
        L2:
        Ip:
    Configuration Invalid-pending to be applied:
        L2:
        Ip:
Profile:linkagg-profile
    Configuration Valid currently:
        L2: dst-mac
        Ip: dst-ip
    Configuration Valid-pending to be applied:
        L2:
        Ip:
    Configuration Invalid-pending to be applied:
        L2:
        Ip:
```

#After configuration, view current valid load balancing mode on Device1.

```
Device1#show link-aggregation group 1
 Link Aggregation 1
  Type: switchport
  Mode: LACP
   User: LAC
   Description:
   Peer-description :
  Load balance profile: linkagg-profile
  Number of ports in total: 2
  Number of ports attached: 2
  Root port: gigabitethernet0/1
  gigabitethernet0/1: ATTACHED
  gigabitethernet0/2: ATTACHED
```

According to the system display, the current load balancing mode of aggregation group 1 is dst-ip.

#During the process of service interaction between PC1 and PC2 and PC3, load balancing of data is achieved on the aggregated links. If a link in the aggregation group becomes faulty, the other links provide service backup.

24 Port Isolation

24.1 Overview

Port isolation is a security feature that is based on ports. According to the actual requirement, you can configure certain ports to be isolated from a specified port, that is, configure some isolated ports for a specified port. In this way, the packets that are received by the specified port cannot be forwarded to the isolated ports. This enhances the network security, and also provides a flexible networking scheme.

24.2 Port Isolation Function Configuration

Table 2-1 Function Configuration List of Port Isolation

Configuration Task	
Configure the basic function of port isolation.	Configure port isolation.
Configure the isolation function for member ports of the aggregation group.	Configure isolation function for member ports of the aggregation group.

24.2.1 Configure the Basic Function of Port Isolation

The port isolation function realizes unidirectional packet isolation. Assuming that port B is configured as the isolated port of port A, then if a packet whose target port is port B enters port A, the port is directly discarded. However, if a packet whose target port is port B enters port B, the port is normally forwarded. The isolated port can be a port or an aggregation group.

Port isolation, configured based on aggregation group.

- Ports in the same isolation group are isolated from each other.

Ports in the isolation group can be configured as ingress, egress and both. The resolution is shown below:

Table 1 Configuring Mode Forwarding

Packet ingress port mode	Packet egress port mode	Whether it can be normally forwarded
ingress mode	ingress mode	Normal forwarding
ingress mode	egress mode	Locked
ingress mode	both mode	Locked
egress mode	ingress mode	Normal forwarding
egress mode	egress mode	Normal forwarding
egress mode	both mode	Normal forwarding
both mode	ingress mode	Normal forwarding
both mode	egress mode	Locked
both mode	both mode	Locked

- Ports in the isolation group normally communicate with those not in the isolation group

Ports in different isolation groups can normally communicate with each other

Configuration Condition

Isolation group has been created

Configure Port Isolation

Table 2-3 Configuration of Port Isolation

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter isolation group configuration mode	**isolate group** *group-id*	Mandatory
Add ports into the isolation group	**interface** *interface-list* [**ingress | egress | both**]	Mandatory

Step	Command	Description
		By default, the port is not added into any isolation group.
Add aggregation group into the isolation group.	**interface link-aggregation** *link-aggregation-id* [**ingress | egress | both**]	Mandatory By default, the aggregation group is not added into any isolation group.

Note

- When the port is added into an isolation group, the isolation group needs to be created.

24.2.2 Port Isolation Monitoring and Maintaining

Table 2-4 Port Isolation Monitoring and Maintaining

Command	Description
show isolate { **group** [*group-id*] **| interface** *interface-list* **| interface link-aggregation** *link-aggregation-id* }	Show port isolation information

24.3 Typical Configuration Example of Port Isolation

24.3.1 Configure Port Isolation

Network Requirements

- Connect PC1 and PC2 to Device, in the same VLAN2.
- Configure port isolation on Device so that PC1 and PC2 cannot communicate with each other.

Network Topology

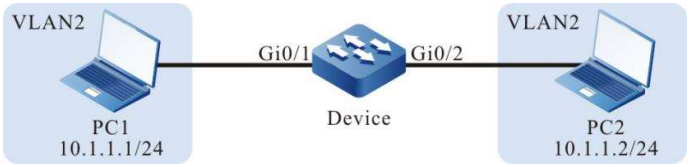


Figure 2-1 Configuration of Network Topology for Port Isolation

Configuration Steps

Step 1: Configure VLANs and the link type of the ports.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 on Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1-0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure port isolation.

#Configure isolation group on Device

```
Device#config terminal
Device(config)#isolate group 1
Device(config-isolate-group1)#
Device(config-isolate-group1)#end
Device#show isolate group 1
------------------------------------------------------------
        isolate group 1
ingress member:
egress member :
both member   :
```

#Configure mutual isolation for ports gigabitethernet0/1 and gigabitethernet0/2 on Device.

```
Device#config terminal
Device(config)#isolate group 1
Device(config-isolate-group1)#interface gigabitethernet 0/1-0/2

Device#show isolate group 1
------------------------------------------------------------
        isolate group 1
ingress member:
egress member :
both members   : gi0/1-0/2
```

#View the information of port isolation on Device.

```
Device#show isolate interface gigabitethernet 0/1-0/2
```

```
interface gigabitethernet0/1 isolated information
isolate group 1 mode: both
isolated interface:
        gi0/2
interface gigabitethernet0/2 isolated information
  isolate group 1 mode: both
  isolated interface:
          gi0/1
```

Step 3: Check the result.

#PC1 cannot communicate with PC2.

25 VLAN

25.1 Overview

In a switched Ethernet, each port in the device is an independent collision domain, but all the ports belong to a broadcast domain. When a terminal device sends broadcast packets, all devices in the Local Area Network (LAN) can receive the packets. This not only wastes network bandwidth, but also brings hidden troubles.

Virtual Local Area Network (VLAN) is a technology through which devices in the same LAN can be divided in a logic manner. The devices in the same VLAN can communicate with each other at layer 2, while the devices from different VLANs are isolated at layer 2. In this way, broadcast packets are limited within a VLAN.

VLANs comply with IEEE 802.1Q. This standard defines a new frame encapsulation format, in which a 4-byte VLAN tag containing VLAN information is added after the source MAC address of a traditional data frame.

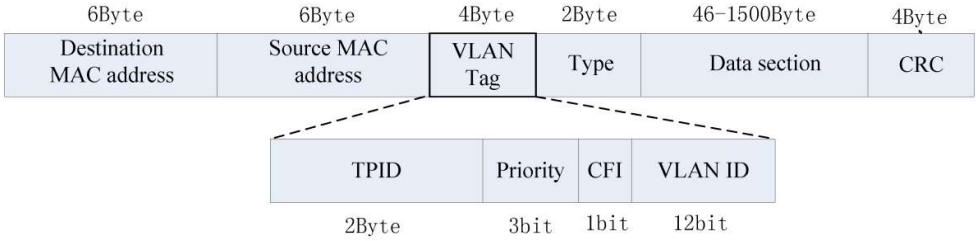


Figure 3-1 IEEE 802.1Q Frame Encapsulation Format

A VLAN tag contains the following four fields:

- Tag Protocol Identifier (TPID): It is used to determine whether a VLAN tag is carried by the data frame. The length is 2 bytes, and the value is fixed to be 0x8100, indicating a standard 802.1Q tag.
- Priority: It is the 802.1p priority. The length is 3 bits and the value range is 0-7. Packets with different priorities can obtain services of different levels.
- Canonical Format Indicator (CFI): It indicates whether the MAC address is encapsulated in a standard format for transmission in different media. The length is 1 bit. The value 0

indicates that the MAC address is encapsulated in a standard format while the value 1 indicates that the MAC address is encapsulated in a non-standard format.

- VLAN ID: It indicates the VLAN to which the packet belongs. The length is 12 bits, and the value range is 0-4095, where 0 and 4095 are protocol reserved values, and the available VLAN IDs are in the range of 1-4094.

VLANs have the following advantages:

- Establishes virtual workgroups flexibly. Users with the same requirements can be divided into one VLAN, without being limited by their physical locations.
- Limits broadcast domains. A VLAN is a broadcast domain. Layer-2 unicast, multicast, and broadcast frames can be forwarded only within the domain, and they cannot enter other VLANs directly. This prevents broadcast storms.
- Improves the network security. Different VLANs are isolated at layer two, and the VLANs cannot communicate with each other directly.

According to applications, VLANs are categorized into the following four types:

- Port-based VLANs
- MAC address-based VLANs
- IP subnet-based VLANs
- Protocol-based VLANs

By default, in the order of priorities from high to low, the four types of VLANs are: IP subnet-based VLANs, MAC-based VLANs, protocol-based VLANs, and port-based VLANs. On one port, the VLAN takes effect according to the priority levels, and only one type of VLAN takes effect.

25.2 VLAN Function Configuration

Table 3-1 VLAN Function Configuration List

Configuration Task	
Configure basic attributes for VLAN	Configure VLAN
	Configure VLAN name
Configure a Port-Based VLAN	Configure the Port Link Type
	Add an Access Port into the VLAN
	Configure a Trunk Port to Allow Services of a VLAN to Pass

Configuration Task	
	Add a Hybrid Port into the VLAN
	Configure PVIDs for Ports
Configure a MAC Address-Based VLAN	Configure a MAC Address-Based VLAN
Configure an IP Subnet-Based VLAN	Configure an IP Subnet-Based VLAN
Configure a Protocol-Based VLAN	Configure a Protocol-Based VLAN
Configure the Types of Frames that Can Be Received by the Port	Configure the Types of Frames that Can Be Received by the Port

25.2.1 Configure basic attributes for VLAN

Configuration Condition

None

Configure VLAN

Each VLAN is an independent broadcast domain. Users within the same VLAN can communicate with each other in Layer 2, while those in different VLANs are isolated from each other in Layer 2.

Table -2 Configuring VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create VLAN	**vlan** *vlan-list*	Mandatory By default, the system creates VLAN1 automatically. If a single VLAN is created, you will enter the VLAN configuration mode after

Step	Command	Description
		creation. If multiple VLANs are created, you will maintain in current configuration mode after creation.

Configure VLAN name

For the convenience of memorization and management, VLAN name can be configured according to VLAN service type, function, and connection status.

Table -3 Configuring VLAN Name

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure VLAN name	**name** *vlan-name*	Mandatory By default, the name of VLAN1 is "DEFAULT", and those of other VLANs are "VLAN*vlan-id*", e.g. "VLAN0100".

25.2.2 Configure a Port-Based VLAN

A port-based VLAN, also called port VLAN, is a VLAN of the simplest division type. After a port is added into the VLAN, the port can forward packets that belong to the VLAN.

Configuration Condition

None

Configure the Port Link Type

According to the VLAN tag handling modes, the following three link types are available:

- Access type: The packets that have been forwarded do not carry VLAN tags. Ports of this

type are usually connected to user devices.

- Trunk type: The packets from the VLANs in which the PVID is located do not carry VLAN tags, while the packets from other VLANs still carry VLAN tags.
- Hybrid type: The packets from the specified VLAN can be configured not to carry or carry VLAN tags. Ports of the type can be connected to user devices or interconnected with network devices.

The ports of the Trunk type and the ports of the Hybrid type cannot be converted to each other directly. They need to be converted to the Access type before being converted to another type.

Table -4 Configuring Link Type of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the Port Link Type	**switchport mode** { **access** | **hybrid** | **trunk** }	Mandatory By default, the port link type is the Access type.

Caution

- Some commands can be configured only on the ports with the specified link type. Therefore, if the port link type is converted to another type, the functions that are configured on the port with the original link type may become invalid.

Add an Access Port into the VLAN

One Access port can belong to only one VLAN. When an Access port is added into a specified VLAN, it exits from the current VLAN and then enters the specified VLAN. If the VLAN to which the Access port is to be added does not exists, the VLAN is automatically created.

Table -5 Adding Access Port into VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the port link type as the Access type.	**switchport mode access**	Mandatory By default, the port link type is the Access type.
Add an Access port into the specified VLAN.	**switchport access vlan** *vlan-id*	Mandatory By default, the Access port is added into VLAN1.

Configure a Trunk Port to Allow Services of a VLAN to Pass

If a Trunk port allows services of an existing VLAN to pass, the port allows forwarding packets of the VLAN. If the VLAN that the Trunk port allows to pass does not exist, the VLAN will not be created automatically and you must create the VLAN before the port allows forwarding packets of the VLAN.

Table -6 Configuring Trunk Port to Allow VLAN to Pass

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the port link type as the Trunk type.	**switchport mode trunk**	Mandatory By default, the port link type is the Access type.
Configure a Trunk port to allow a VLAN to pass.	**switchport trunk allowed vlan** { **all** | **add** *vlan-list* }	Mandatory By default, the Trunk port allows VLAN1 to pass.
Configure the packets from the VLAN in which the PVID is located to be forwarded with VLAN tags reserved.	**vlan dot1q tag pvid**	Optional By default, the packets from the VLAN in which the PVID is located are forwarded without VLAN tags.

Add a Hybrid Port into the VLAN

If the VLAN to which the Access port is to be added does not exist, the VLAN is automatically created.

Table -7 Adding Hybrid Port into VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the port link type as the Hybrid type.	**switchport mode hybrid**	Mandatory By default, the port link type is the Access type.
Add a Hybrid port to a specified VLAN in a specified mode.	**switchport hybrid** { **untagged** | **tagged** } **vlan** *vlan-list*	Mandatory By default, the Hybrid port is added into VLAN1 in Untagged mode.

Configure PVIDs for Ports

Port VLAN ID (PVID) is an important parameter of a port. When a port receives an Untag packet, it adds a VLAN tag to the packet, and the VLAN ID of the VLAN tag is the PVID of the port.

The PVID of an Access port is the ID of the VLAN to which it belongs, so the PVID of the Access port can be configured only by changing the VLAN to which it belongs. The Trunk port and hybrid port can belong to multiple VLANs, and their PVIDs can be configured according to the actual requirement.

The Trunk port and Hybrid port must be added into the VLAN to which their PVIDs belong; otherwise, packets of the VLAN to which their PVIDs belong cannot be forwarded, and the port discards the received Untag packets.

Table -8 Configuring PVID of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure PVID of Trunk port	**switchport trunk pvid vlan** *vlan-id*	Mandatory, select one according to the link type of port By default, the port LACP is VLAN1.
Configure PVID of Hybrid port	**switchport hybrid pvid vlan** *vlan-id*	

Note

- In configuring the PVID for a port, the VLAN to which the PVID belongs must have been created; otherwise, the configuration fails, and an error message is prompted.

25.2.3 Configure a MAC Address-Based VLAN

MAC address-based VLANs, also called MAC VLANs, are classified according to the source MAC addresses of the packets. After a MAC VLAN is configured, if the port receives an Untag packet and the source MAC address of the packet matches a MAC VLAN entry, the system adds a VLAN tag for the packet, in which the VLAN ID matches the VLAN ID in the MAC VLAN entry.

After the physical location of the user is changed, if the MAC address of the user is not changed, the VLAN to which the user port belongs need not be re-configured.

Configuration Condition

None

Configure a MAC Address-Based VLAN

Table -9 Configuring MAC-based VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure a MAC VLAN entry.	**mac-vlan mac-address** *mac-address* **vlan** *vlan-id*	Mandatory By default, no MAC VLAN entry is configured.
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable the MAC VLAN function of the port.	**mac-vlan enable**	Mandatory By default, the MAC VLAN function is disabled on the port.

Note

- The port on which the MAC VLAN function is enabled must be added into the VLAN that matches the entry; otherwise, the port cannot forward packets of the VLAN, and the packets that match the source MAC address will be discarded.

25.2.4 Configure an IP Subnet-Based VLAN

IP subnet-based VLANs, also called IP subnet VLANs, are classified according to the source IP addresses of the packets. After an IP subnet VLAN is configured, if the port receives an Untag packet and the source IP address of the packet matches an IP subnet VLAN entry, the system adds a VLAN tag for the packet, in which the VLAN ID matches the VLAN ID in the IP subnet VLAN entry.

After the physical location of the user is changed, if the IP address of the user is not changed, the VLAN to which the user port belongs need not be re-configured.

Configuration Condition

None

Configure an IP Subnet-Based VLAN

Table - 10 Configuring IP Subnet-based VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure an IP subnet-based VLAN entry	**ip-subnet-vlan ipv4** *ip-address* **mask** *mask* **vlan** *vlan-id*	Mandatory By default, no IP subnet VLAN entry is configured.
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable the IP subnet VLAN function of the port	**ip-subnet-vlan enable**	Mandatory By default, the IP subnet VLAN function is disabled on the port.

Note

- The port on which the IP subnet VLAN function is enabled must be added into the VLAN that matches the entry; otherwise, the port cannot forward packets of the VLAN, and the packets that match the source IP address will be discarded.

25.2.5 Configure a Protocol-Based VLAN

Protocol-based VLANs, also called protocol VLANs, are classified according to the frame encapsulation formats and protocol types of packets. After a protocol profile is defined, a port is configured to match a protocol profile, and the protocol VLAN function is enabled for the port, if the port receives an Untag packet that matches the protocol profile, the port adds a VLAN tag for the packet. The VLAN ID matches the VLAN ID defined in the profile.

After the physical location of the user is changed, if the frame encapsulation format of the user packets and protocol type are not changed, the VLAN to which the user port belongs need not be re-configured.

Configuration Condition

None

Configure a Protocol-Based VLAN

Table 25-11 Configuring Protocol-based VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Define protocol profile	**protocol-vlan profile** *profile-index* **frame-type** *frame-type* **ether-type** *ether-type*	Mandatory By default, the protocol profile is not defined.
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure the protocol profile that matches the port	**protocol-vlan profile** *profile-index* **vlan** *vlan-id*	Mandatory By default, the port doesn't match any protocol profile.
Enable the protocol VLAN function of the port	**protocol-vlan enable**	Mandatory By default, the protocol VLAN function is disabled on the port.

Note

- The port for which a matching protocol profile has been configured and the protocol VLAN function has been enabled must be added into the VLAN corresponding to the protocol profile that it matches; otherwise, the port cannot forward packets of the VLAN, and the packets matching the protocol will be discarded.

25.2.6 Configure the Types of Frames that Can Be Received by the Port

Configuration Condition

None

Configure the Types of Frames that Can Be Received by the Port

You can configure the types of frames that can be received by a port so that the port receives only Untag packets, receives only Tag packets, or receives both of them. The packets that fail to meet the requirement will be discarded.

Table 25-12 Configuring Types of Frames that Can be Received by the Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the Types of Frames that Can Be Received by the Port	**switchport accept frame-type** { **all** | **untag** | **tag** }	Mandatory By default, the type of frames that can be received by a port is all, that is, receiving both Untag and Tag packets.

25.2.7 VLAN Monitoring and Maintaining

Table 25-13 VLAN Monitoring and Maintaining

Command	Description
show ip-subnet-vlan	Show the information of IP subnet VLAN
show mac-vlan	Show the information of MAC VLAN
show protocol-vlan [**profile**]	Show the information of protocol VLAN
show running-config vlan	Show the information of VLAN configuration
show vlan [*vlan-id*]	Show the information of specified VLAN or all created VLAN

Command	Description
show vlan statistics	Show the number of created VLANs
show vlan summary	Show the VLAN information of static creation and dynamic learning
show { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* } **vlan status**	Show the VLAN information of specified port or aggregation group

25.3 VLAN Typical Configuration Example

25.3.1 Configure a Port-Based VLAN

Network Requirements

- Server1 and PC1 are in the office network, while Server2 and PC2 are in the production network.
- You need to configure the port-based VLAN functions to isolate PC1 and PC2 so that PC1 can access only Server1 and PC2 can access only Server2.

Network Topology

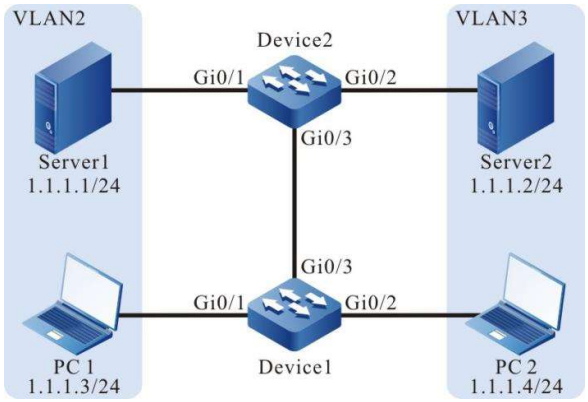


Figure 3-2 Configuring Network Topology of VLAN based on Port

Configuration Steps

Step 1: Configure VLAN and port link type on Device1.

#Create VLAN2 and VLAN3 on Device1.

```
Device1#configure terminal
Device1(config)#vlan 2-3
```

#Configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 on Device1 as Access. Port gigabitethernet0/1 allows the pass of services of VLAN2 while port gigabitethernet0/2 allows the pass of services of VLAN3.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#switchport mode access
Device1(config-if-gigabitethernet0/1)#switchport access vlan 2
Device1(config-if-gigabitethernet0/1)#exit
Device1(config)#interface gigabitethernet0/2
Device1(config-if-gigabitethernet0/2)#switchport mode access
Device1(config-if-gigabitethernet0/2)#switchport access vlan 3
Device1(config-if-gigabitethernet0/2)#exit
```

#On Device1, configure the link type of port gigabitethernet0/3 as Trunk, and allow the pass of services of VLAN2 and VLAN3.

```
Device1(config)#interface gigabitethernet 0/3
Device1(config-if-gigabitethernet0/3)#switchport mode trunk
Device1(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 2-3
Device1(config-if-gigabitethernet0/3)#exit
```

Step 2: Configure VLAN and port link type on Device2.

#Create VLAN2 and VLAN3 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2-3
```

#Configure the link type of port gigabitethernet0/1 and gigabitethernet0/2 on Device2 as Access. Port gigabitethernet0/1 allows the services of VLAN2 to pass and gigabitethernet0/2 allows the services of VLAN3 to pass.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode access
Device2(config-if-gigabitethernet0/1)#switchport access vlan 2
Device2(config-if-gigabitethernet0/1)#exit
Device2(config)#interface gigabitethernet0/2
Device2(config-if-gigabitethernet0/2)#switchport mode access
Device2(config-if-gigabitethernet0/2)#switchport access vlan 3
Device2(config-if-gigabitethernet0/2)#exit
```

#On Device2, configure the link type of port gigabitethernet0/3 as Trunk, and allow services of VLAN2 and VLAN3 to pass.

```
Device2(config)#interface gigabitethernet 0/3
Device2(config-if-gigabitethernet0/3)#switchport mode trunk
Device2(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 2-3
Device2(config-if-gigabitethernet0/3)#exit
```

Step 3: Check the result.

#View the information of VLAN on Device1.

```
Device1#show vlan 2
```

```
---- ---- -------------------------------- ------- --------- ------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- ------------------------------
1    2    VLAN0002                         static  Tagged    gi0/3
                                           Untagged  gi0/1
Device1#show vlan 3
---- ---- -------------------------------- ------- --------- ------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- ------------------------------
1    3    VLAN0003                         static  Tagged    gi0/3
                                           Untagged  gi0/2
```

#View the information of VLAN on Device2.

```
Device2#show vlan 2
---- ---- -------------------------------- ------- --------- ------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- ------------------------------
1    2    VLAN0002                         static  Tagged    gi0/3
                                           Untagged  gi0/1
Device2#show vlan 3
---- ---- -------------------------------- ------- --------- ------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- ------------------------------
1    3    VLAN0003                         static  Tagged    gi0/3
                                           Untagged  gi0/2
```

PC1 and PC2 cannot communicate with each other. PC1 can access Server1 only, and PC2 can access Server2 only.

25.3.2 Configure a MAC Address-Based VLAN

Network Requirements

- PC1 and PC2 can access the network through different ports of Device.
- The MAC-address based VLAN functions need to be configured so that the PCs with the specified MAC addresses can access the server through different ports. PCs which do not have a specified MAC address can access the server only through a specified port.

Network Topology

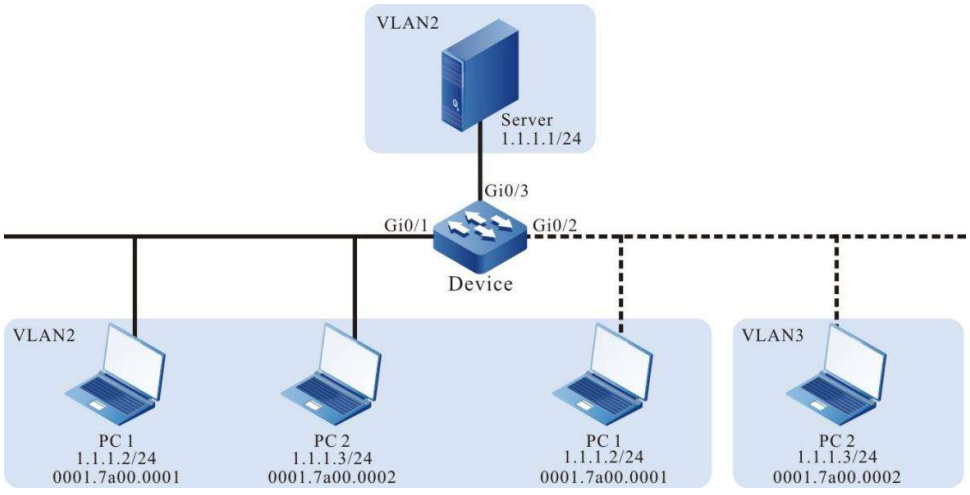


Figure 3-3 Configuring Network Topology of VLAN based on MAC

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

Create VLAN2 and VLAN3 on Device.

```
Device#configure terminal
Device(config)#vlan 2-3
```

#Configure the link type of ports gigabitethernet0/1 and gigabitethernet0/3 on Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1,0/3
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

#On Device, configure the link type of port gigabitethernet0/2 as Hybird, and allow services of VLAN2 and VLAN3 to pass. PVID is 3.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode hybrid
Device(config-if-gigabitethernet0/2)#switchport hybrid untagged vlan 2-3
Device(config-if-gigabitethernet0/2)#switchport hybrid pvid vlan 3
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure a MAC-based VLAN function.

#Configure a MAC-based VLAN entry on the Device so that the packet with the source MAC address of 0001.7a00.0001 is forwarded in VLAN 2.

```
Device(config)#mac-vlan mac-address 0001.7a00.0001 vlan 2
```

#On the port gigabitethernet0/2 of the Device, enable MAC-based VLAN functions.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#mac-vlan enable
Device(config-if-gigabitethernet0/2)#exit
```

Step 3: Check the result.

#On the Device, view the information of MAC VLAN entry and the enabling status of port.

```
Device#show mac-vlan
                          total 256,    used 1,    left 255

---------------------------------MAC-VLAN---------------------------------
NO.   Mac Address     Dynamic Vlan  Static Vlan  Current Pri  Static Pri
----- --------------- ------------ ------------ ------------ -----------
1     0001.7a00.0001  0            2            -            -

-----------------------------ENABLE MAC-VLAN-----------------------------
gi0/2
```

#PC1 can access the server when connected from port gigabitethernet0/1 or gigabitethernet0/2, and PC2 can access the server only when connected from port gigabitethernet0/1.

25.3.3 Configure an IP Subnet-Based VLAN

Network Requirements

- Server1 is an office network server, whicle Server2 is a production network server.
- You need to configure the IP subnet-based VLAN functions so that PC1 can access Server1 only and PC2 can access Server2 only.

Network Topology

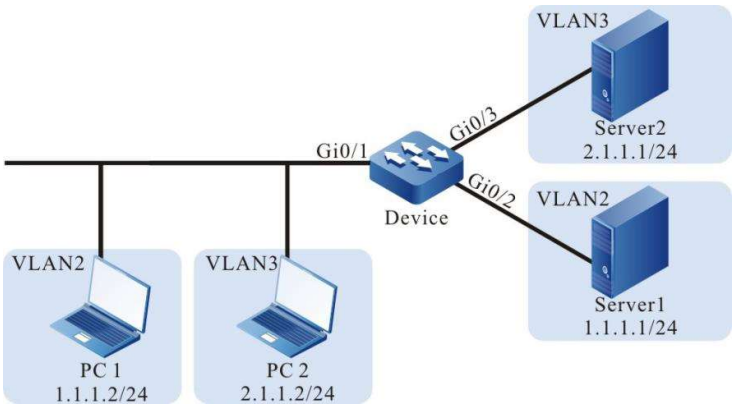


Figure 3-4 Configuring Network Topology for IP Subnet-based VLAN

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN2 and VLAN3 on Device.

```
Device#configure terminal
Device(config)#vlan 2-3
```

#On Device, configure the link type of port gigabitethernet0/1 as Hybird, and allow services of VLAN2 and VLAN3 to pass. PVID is 2.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode hybrid
Device(config-if-gigabitethernet0/1)#switchport hybrid untagged vlan 2-3
Device(config-if-gigabitethernet0/1)#switchport hybrid pvid vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the link type of ports gigabitethernet0/2 and gigabitethernet0/3 on Device as Access. Port gigabitethernet0/2 allows the services of VLAN2 to pass and gigabitethernet0/3 allows the services of VLAN3 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode access
Device(config-if-gigabitethernet0/2)#switchport access vlan 2
```

```
Device(config)#interface gigabitethernet 0/3
Device(config-if-gigabitethernet0/3)#switchport mode access
Device(config-if-gigabitethernet0/3)#switchport access vlan 3
Device(config-if-gigabitethernet0/3)#exit
```

Step 2: Configure an IP subnet-based VLAN function.

#Configure an IP subnet-based VLAN entry on the Device so that the packet with the source IP address belonging to the 2.1.1.0/24 network segment is forwarded in VLAN 3.

```
Device(config)#ip-subnet-vlan ipv4 2.1.1.0 mask 255.255.255.0 vlan 3
```

#On the port gigabitethernet0/1 of the Device, enable IP subnet-based VLAN functions.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip-subnet-vlan enable
Device(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#On the Device, view the information of IP subnet VLAN entry and the enabling status of port.

```
Device(config)#show ip-subnet-vlan
-------------------------IP-SUBNET-VLAN-------------------------
NO.   IP              MASK              VLAN   PRI
------ ------------------ ------------------ ------- ----------
1     2.1.1.0         255.255.255.0     3      -

----------------------Enable SUBNET-VLAN----------------------
gi0/1

------------------Enable SUBNET-VLAN Priority------------------
```

PC1 can access Server1 only, and PC2 can access Server2 only.

25.3.4 Configure a Protocol-Based VLAN

Network Requirements

- In Ethernet, PC is a host, while Server1 and Server2 are two servers.
- Configure protocol-based VLAN functions so that when the protocol-based VLAN functions are not enabled by the port on the Device, PC can only access Server1; when the port enables the protocol-based VLAN function, PC can only access Server2.

Network Topology

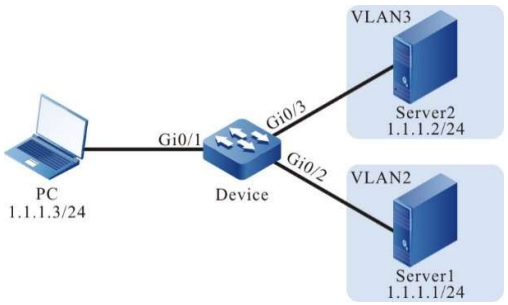


Figure 1 Configuring Network Topology of VLAN based on Protocol

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN2 and VLAN3 on Device.

```
Device#configure terminal
Device(config)#vlan 2-3
```

#On Device, configure the link type of port gigabitethernet0/1 as Hybird, and allow services of VLAN2 and VLAN3 to pass. PVID is VLAN 2.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport hybrid untagged vlan 2-3
Device(config-if-gigabitethernet0/1)#switchport hybrid pvid vlan 2
```

#Configure the link type of ports gigabitethernet0/2 and gigabitethernet0/3 on Device as Access. Port gigabitethernet0/2 allows the services of VLAN2 to pass and gigabitethernet0/3 allows the services of VLAN3 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode access
Device(config-if-gigabitethernet0/2)#switchport access vlan 2
Device(config-if-gigabitethernet0/2)#exit
Device(config)#interface gigabitethernet 0/3
Device(config-if-gigabitethernet0/3)#switchport mode access
Device(config-if-gigabitethernet0/3)#switchport access vlan 3
Device(config-if-gigabitethernet0/3)#exit
```

Step 2: Configure a protocol-based VLAN function.

#Configure protocol profile based on the ETHERII encapsulated IP (0x0800) packet on the Device.

```
Device(config)#protocol-vlan profile 1 frame-type ETHERII ether-type 0x0800
```

#Apply the packet matching the protocol profile mentioned above on the port gigabitethernet0/1 of Device to be forwarded in VLAN 3, and enable the protocol VLAN function.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#protocol-vlan enable
Device(config-if-gigabitethernet0/1)#protocol-vlan profile 1 vlan 3
Device(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#On the Device, view the information of protocol VLAN entry and the enabling status of port.

```
Device#show protocol-vlan profile

----------------------------PROTOTOCL-VLAN--------------------------
Profile   Frame-type     Ether-type
------------------------------------------------------------------
1         ETHERII        0x800

-----------------------Enable PROTOCOL-VLAN-----------------------
gi0/1

--------------------Enable PROTOCOL-VLAN Profile--------------------
gi0/1: total-profiles 1
       vlan 3, profile 1
```

#When the port gigabitethernet0/1 fails to enable the protocol-based VLAN functions, PC can only access Server1; when the port gigabitethernet0/1 enables the protocol-based VLAN function, PC can only access Server2.

26 QinQ and VLAN Mapping

26.1 Overview

QinQ (802.1Q in 802.1Q) is the extension based on 802.1Q protocol. It adds a layer of 802.1Q tag (VLAN Tag) to the original 802.1Q packet header to increase the number of VLAN to 4094×4094 through double layers of VLAN Tag. QinQ encapsulates the user's private network VLAN Tag in the public network VLAN Tag so that the packet can transmit in the backbone network (public network) of the operator with double layers of VLAN Tag. In the public network, the packet only spreads according to outer VLAN Tag (i.e. VLAN Tag of public network). Users' private network VLAN Tags are shielded. This saves VLAN ID of public network and provides users with a simple two-payer VPN (Virtual Private Network) tunnel.

QinQ can be divided into the following types according to the rules of adding VLAN Tag:

- Basic QinQ;
- Port-based flexible QinQ.

VLAN mapping is also the extension based on 802.1Q protocol. It is different from QinQ. Instead of encapsulating a layer of VLAN Tag based on the original VLAN Tag of the packet, VLAN mapping replaces the original VLAN Tag of the packet with a new one. This means the packet still has only one layer of VLAN Tag.

VLAN mapping can be divided into the following types by mapping rules:

- 1: 1 VLAN mapping. This means only a private network VLAN is mapped to a public network VLAN;
- N: 1 VLAN mapping. This means one ore more private network VLANs can be mapped to a public network VLAN.

The port-based flexible QinQ, 1:1 VLAN mapping and N:1 VLAN mapping all need to be configured with mapping entries from private network VLAN to public network VLAN. Users can configure 4096 mapping entries at most.

26.2 QinQ and VLAN Mapping Function Configuration

Table 26 QinQ and VLAN Mapping Function Configuration List

Configuration Task	
Configure basic QinQ function	Enable basic QinQ function

Configuration Task	
Configure port-based flexible QinQ function	Configure port-based flexible QinQ function
Configure 1: 1 VLAN mapping function	Configure 1: 1 VLAN mapping function
Configure N: 1 VLAN mapping function	Configure N: 1 VLAN mapping function
Configure the protocol type of outer VLAN Tag of the port	Configure the protocol type of outer VLAN Tag of the port
Configure the priority replication function	Enable the priority replication function
Configure QinQ Drop function	Enable QinQ Drop function

26.2.1 Configure Basic QinQ Function

After the port is configured with the basic QinQ function, the device adds a layer of VLAN tag to the packets received by the port. The VLAN ID of VLAN tag is the PVID of the port.

Configuration Condition

Before configuring the basic QinQ function, the following tasks should be completed:

- Configure PVID of port, which is the VLAN ID of outer VLAN Tag added after the port enables basic QinQ.

Enable Basic QinQ Function

Table 26 Enabling Basic QinQ Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enable basic QinQ function	**vlan dot1q-tunnel enable**	Mandatory By default, the basic QinQ function is disabled.

Note

- Under the same port, the basic QinQ function cannot be used with the following functions: QinQ Evc, flexible QINQ, 1:1 VLAN mapping, N:1 VLAN mapping, and configure the protocol type of outer VLAN Tag of the port as a non-default value.

26.2.2 Configure Port-based Flexible QinQ Function

After the port is configured with port-based flexible QinQ, if the VLAN ID of the outermost VLAN tag of the packet matches the port-based flexible QinQ entry, the specified outer VLAN tag is added to the packet; if the VLAN ID of the packet's outermost VLAN Tag does not match the port-based flexible QinQ entry, the flexible QINQ will not process this packet.

Configuration Condition

Before configuring the port-based flexible QinQ function, the following tasks should be completed:

- Configure the port link type as Trunk or Hybrid;
- Configure PVID of port;
- Configure the port with the VLAN of the added outer VLAN Tag to ensure that the packet with outer VLAN Tag can pass.

Configure Port-based Flexible QinQ Function

Table 1 Configuring Port-based Flexible QinQ Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	
Configure port-based flexible QinQ entry	**vlan dot1q-tunnel** *inner-vlan-list outer-vlan-id*	Mandatory By default, the port-based flexible QinQ entry is not configured.

Note

- Under the same port, the port-based flexible QinQ function cannot be used with the following functions: QinQ Evc, basic QINQ, 1:1 VLAN mapping, and N:1 VLAN mapping.
- When the configured port-based flexible QinQ entry conflicts with the existing one on the port, a prompt of conflict will be given.

26.2.3 Configure 1: 1 VLAN Mapping Function

For a port, 1:1 VLAN mapping entries only have a one-to-one relationship with each other, which means only one private network VLAN can be mapped to one public network VLAN.

After the port is configured with 1:1 VLAN mapping, if the VLAN ID of the packet's outermost VLAN Tag matches the entry of the 1:1 VLAN mapping, the VLAN ID of the packet's outermost VLAN Tag will be replaced with the specified VLAN ID; otherwise, the 1:1 VLAN mapping will not process the packet.

Configuration Condition

Before configuring the 1:1 VLAN mapping function, the following tasks should be completed:

- Configure the port link type as Trunk or Hybrid;
- Configure PVID of port;
- Configure the port with the VLAN of the new outer VLAN Tag to ensure that the packet with outer VLAN Tag being replaced can pass.

Configure 1: 1 VLAN Mapping Function

Table 2 Configuring 1:1 VLAN Mapping Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	

Step	Command	Description
		within the aggregation group.
Configure 1:1 VLAN mapping entry	**vlan dot1q-tunnel mapping** *former-vlan-id mapping-vlan-id*	Mandatory By default, no 1: 1 VLAN mapping entry is configured.

Note

- Under the same port, the 1: 1 VLAN mapping function cannot be used with the following functions: QinQ Evc, basic QINQ, flexible QINQ, and N:1 VLAN mapping.
- When the configured 1: 1 VLAN mapping entry conflicts with the existing port-based one on the port, a prompt of conflict will be given.

26.2.4 Configure N: 1 VLAN Mapping Function

For a port, multiple N:1 VLAN mapping entries can be configured. They may have a many-to-one relationship with each other, which means one or more private network VLANs can be mapped to one public network VLAN.

After the port is configured with N:1 VLAN mapping, if the VLAN ID of the outermost VLAN tag of the packet matches the N:1 VLAN mapping entry, the VLAN ID of the packet's outermost VLAN Tag is replaced with the specified VLAN ID; otherwise, the N:1 VLAN mapping will not process this packet.

Configuration Condition

Before configuring the N:1 VLAN mapping function, the following tasks should be completed:

- Configure the port link type as Trunk or Hybrid;
- Configure the port with the VLAN of the new outer VLAN Tag to ensure that the packet with outer VLAN Tag being replaced can pass.

Configure N: 1 VLAN Mapping Function

Table 3 Configuring N:1 VLAN Mapping Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	
Enable N: 1 VLAN mapping function	**vlan dot1q-tunnel mapping n-to-1 enable**	Mandatory By default, the N: 1 VLAN mapping function is not enabled.
Configure N:1 VLAN mapping entry	**vlan dot1q-tunnel mapping n-to-1** *former-vlan-list mapping-vlan-id*	Mandatory By default, no N: 1 VLAN mapping entry is configured.

Note

- Under the same port, the N: 1 VLAN mapping function cannot be used with the following functions: QinQ Evc, basic QINQ, port-based flexible QinQ, 1:1 VLAN mapping, and

configure the protocol type of outer VLAN Tag of the port as a non-default value.

26.2.5 Configure the Protocol Type of Outer VLAN Tag of the Port

The port can identify whether the packet carries corresponding VLAN Tag according to the TPID (Tag Protocol Identifier) value: when the port receives the packet, if the TPID value configured for the port is consistent with the corresponding field in the packet, it means that the packet has carried corresponding VLAN Tag; otherwise, the device deems the received packet as Untag.

Some manufacturers' devices may set the TPID field of the outer VLAN Tag of the QinQ packet as 0x9100 or other values. Inoder to become compatible with these devices, the TPID value of the outer VLAN Tag of this device's port should be configured as an equal value.

Configuration Condition

None

Configure the Protocol Type of Outer VLAN Tag of the Port

The device supports 2 different TPID configurations. The TPID configured ranging from 0x0001 to 0xffff shall not be reserved protocol fields, such as 0x0806 and 0x0800.

Table 4 Configuring Protocol Type for Outer VLAN Tag of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	

Step	Command	Description
		configuration takes effect only within the aggregation group.
Configure the protocol type of outer VLAN Tag of the port	**frame-tag tpid** *type-value*	Optional By default, the protocol type of outer VLAN Tag of the port is 0x8100.

Note

- Under the same port, the operation of configuring protocol type for the outer VLAN Tag of port cannot be used with the following functions: QinQ Evc, basic QINQ, flexible QINQ, 1:1 VLAN mapping, and N:1 VLAN mapping.

26.2.6 Configure the Priority Replication Function

After the priority replication function is configured on the port, the priority field of the outer VLAN Tag of the original packet will be replicated to that of the outer VLAN Tag of the packet.

Configuration Condition

Before configuring the priority replication function, the following tasks should be completed:

- Configure basic QinQ function, port-based flexible QinQ function, or 1:1 VLAN mapping function.

Enable the Priority Replication Function

Table 26 Enabling Priority Replication Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enable the priority replication function	**inner-priority-trust enable**	Mandatory By default, the priority replication function is not enabled.

26.2.7 Configure QinQ Drop Function

After the port is configured with QinQ Drop function, if the port receives the packet which doesn't match port-based flexible QinQ entry, 1:1 VLAN mapping entry and N:1 mapping entry, it will discard it.

Configuration Condition

Before configuring the QinQ Drop function, the following tasks should be completed:

- Configure port-based flexible QinQ, 1:1 VLAN mapping, and N:1 VLAN mapping.

Enable QinQ Drop Function

Table 26 Enabling QinQ Drop Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	
Enable QinQ Drop function	**vlan dot1q-tunnel drop**	Mandatory By default, the QinQ Drop function is disabled.

Note

- Under the same port, QinQ Drop shall not be used with QinQ Evc.

26.2.8 QinQ and VLAN Mapping Monitoring and Maintaining

Table 5 QinQ and VLAN Mapping Monitoring and Maintaining

Command	Description
show vlan dot1q-tunnel	Show port-based flexible QinQ configuration
show vlan dot1q-tunnel mapping	Show 1: 1 VLAN mapping configuration
show vlan dot1q-tunnel mapping n-to-1 configuration	Show N: 1 VLAN mapping configuration

26.3 Example of typical QinQ and VLAN Mapping Configuration

26.3.1 Configure Basic QinQ

Network Requirements

- Intranet users CE1 and CE2, CE3 and CE4 communicate through the operator's network. CE1 and CE2 use intranet VLAN 10 - VLAN 20, while CE3 and CE4 use intranet VLAN 15 - VLAN 30. PE1 and PE2 are edge devices for the operator's network.
- Configure basic QinQ on PE1 and PE2 so that CE1 and CE2 communicate with each other through the operator's public network VLAN 100, and CE3 and CE4 communicate with each other through VLAN 101. The data has double layers of Tag when transmitting on the operator's network.

Network Topology

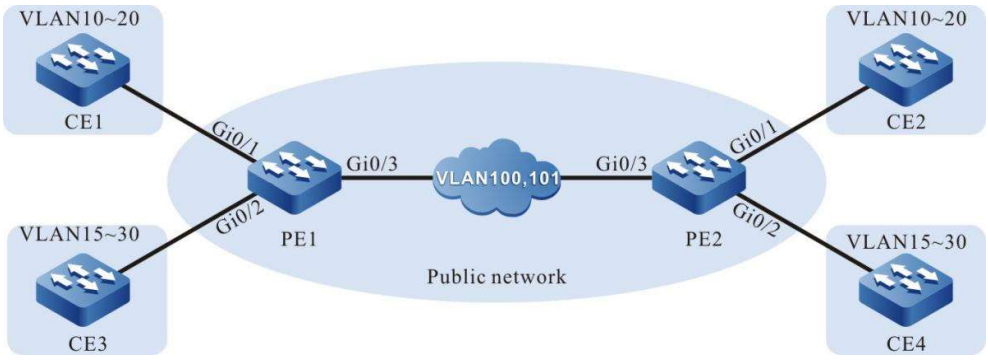


Figure 26 Configuring Network Topology of Basic QinQ

Configuration Steps

Step 1: Configure PE1.

#Create VLAN10~VLAN30 and VLAN100~VLAN101 on PE1.

```
PE1#configure terminal
PE1(config)#vlan 10-30,100-101
```

#On PE1, configure the link type of port gigabitethernet0/1 as Trunk, and allow services of VLAN10~VLAN20 and VLAN100 to pass. Configure PVID as 100.

```
PE1(config)#interface gigabitethernet 0/1
PE1(config-if-gigabitethernet0/1)#switchport mode trunk
PE1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 10-20,100
PE1(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 100
PE1(config-if-gigabitethernet0/1)#exit
```

#On PE1, configure the link type of port tengigabitethernet0/2 as Trunk, and allow services of VLAN15~VLAN30 and VLAN101 to pass. Configure PVID as 101.

```
PE1(config)#interface gigabitethernet 0/2
PE1(config-if-gigabitethernet0/2)#switchport mode trunk
PE1(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 15-30,101
PE1(config-if-gigabitethernet0/2)#switchport trunk pvid vlan 101
PE1(config-if-gigabitethernet0/2)#exit
```

#On PE1, configure the link type of port tengigabitethernet0/3 as Trunk, and allow services of VLAN100 and VLAN101 to pass. Configure PVID as 1.

```
PE1(config)#interface gigabitethernet0/3
PE1(config-if-gigabitethernet0/3)#switchport mode trunk
PE1(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 100,101
PE1(config-if-gigabitethernet0/3)#switchport trunk pvid vlan 1
PE1(config-if-gigabitethernet0/3)#exit
```

#On ports gigabitethernet0/1 and gigabitethernet0/2 of PE1, enable basic QinQ function.

```
PE1(config)#interface gigabitethernet 0/1
PE1(config-if-gigabitethernet0/1)#vlan dot1q-tunnel enable
PE1(config-if-gigabitethernet0/1)#exit
PE1(config)#interface gigabitethernet 0/2
PE1(config-if-gigabitethernet0/2)#vlan dot1q-tunnel enable
PE1(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure PE2.

#Create VLAN10~VLAN30 and VLAN100~VLAN101 on PE2.

```
PE2#configure terminal
PE2(config)#vlan 10-30,100-101
```

#On PE2, configure the link type of port gigabitethernet0/1 as Trunk, and allow services of VLAN10~VLAN20 and VLAN100 to pass. Configure PVID as 100.

```
PE2(config)#interface gigabitethernet 0/1
PE2(config-if-gigabitethernet0/1)#switchport mode trunk
PE2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 10-20,100
PE2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 100
PE2(config-if-gigabitethernet0/1)#exit
```

#On PE2, configure the link type of port gigabitethernet0/2 as Trunk, and allow services of VLAN15~VLAN30 and VLAN101 to pass. Configure PVID as 101.

```
PE2(config)#interface gigabitethernet 0/2
PE2(config-if-gigabitethernet0/2)#switchport mode trunk
PE2(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 15-30,101
PE2(config-if-gigabitethernet0/2)#switchport trunk pvid vlan 101
PE2(config-if-gigabitethernet0/2)#exit
```

#On PE2, configure the link type of port gigabitethernet0/3 as Trunk, and allow services of VLAN100 and VLAN101 to pass. Configure PVID as 1.

```
PE2(config)#interface gigabitethernet 0/3
PE2(config-if-gigabitethernet0/3)#switchport mode trunk
PE2(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 100,101
PE2(config-if-gigabitethernet0/3)#switchport trunk pvid vlan 1
PE2(config-if-gigabitethernet0/3)#exit
```

#On ports gigabitethernet0/1 and gigabitethernet0/2 of PE2, enable basic QinQ function.

```
PE2(config)#interface gigabitethernet 0/1
PE2(config-if-gigabitethernet0/1)#vlan dot1q-tunnel enable
PE2(config-if-gigabitethernet0/1)#exit
PE2(config)#interface gigabitethernet 0/2
PE2(config-if-gigabitethernet0/2)#vlan dot1q-tunnel enable
PE2(config-if-gigabitethernet0/2)#exit
```

Step 3: Check the result.

#Services between intranet users CE1 and CE2 can communicate on the operator's network VLAN100 through PE1 and PE2 with double layers of Tag; those between CE3 and CE4 can communicate on the operator's network VLAN101 through PE1 and PE2 with double layers of Tag.

26.3.2 Configure Flexible QinQ

Network Requirements

- Intranet users CE1 and CE2, CE3 and CE4 communicate through the operator's network. CE1 and CE2 use intranet VLAN 10 - VLAN 20, while CE3 and CE4 use intranet VLAN 15 - VLAN 30. PE1 and PE2 are edge devices for the operator's network.
- Configure flexible QinQ rules on PE1 and PE2 so that CE1 and CE2, CE3 and CE4 can communicate with each other through the operator's public network VLAN 100 and VLAN101. The data has double layers of Tag when transmitting on the operator's network.

Network Topology

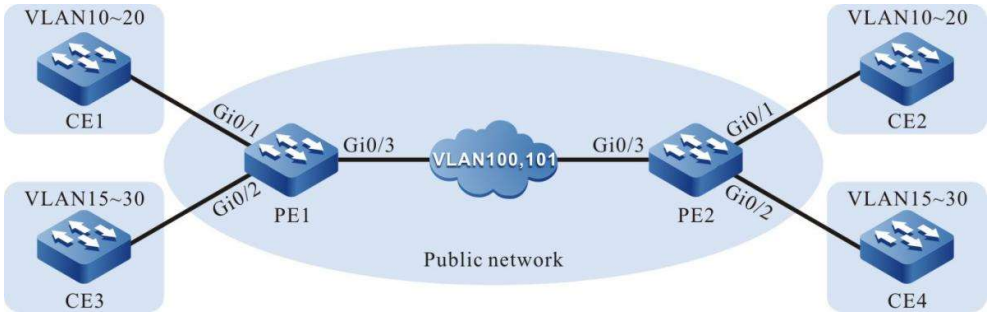


Figure 1 Configuring Network Topology of Flexible QinQ

Configuration Steps

Step 1: Configure PE1.

#Create VLAN 10~VLAN30 and VLAN100~VLAN101 on PE1.

```
PE1#configure terminal
PE1(config)#vlan 10-30,100-101
```

#On PE1, configure the link type of port gigabitethernet0/1 as Trunk, and allow services of VLAN10~VLAN20 and VLAN100 to pass. Configure PVID as 100.

```
PE1(config)#interface gigabitethernet 0/1
PE1(config-if-gigabitethernet0/1)#switchport mode trunk
PE1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 10-20,100
PE1(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 100
PE1(config-if-gigabitethernet0/1)#exit
```

#On PE1, configure the link type of port gigabitethernet0/2 as Trunk, and allow services of VLAN15~VLAN30 and VLAN101 to pass. Configure PVID as 101.

```
PE1(config)#interface gigabitethernet 0/2
PE1(config-if-gigabitethernet0/2)#switchport mode trunk
PE1(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 15-30,101
PE1(config-if-gigabitethernet0/2)#switchport trunk pvid vlan 101
PE1(config-if-gigabitethernet0/2)#exit
```

#On PE1, configure the link type of port gigabitethernet0/3 as Trunk, and allow services of VLAN100 and VLAN101 to pass. Configure PVID as 1.

```
PE1(config)#interface gigabitethernet 0/3
PE1(config-if-gigabitethernet0/3)#switchport mode trunk
PE1(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 100,101
PE1(config-if-gigabitethernet0/3)#switchport trunk pvid vlan 1
PE1(config-if-gigabitethernet0/3)#exit
```

#Configure flexible QinQ function on the port gigabitethernet0/1 of PE1 so that outer Tag VLAN100 is added to the data of VLAN10~VLAN20.

```
PE1(config)#interface gigabitethernet 0/1
PE1(config-if-gigabitethernet0/1)#vlan dot1q-tunnel 10-20 100
PE1(config-if-gigabitethernet0/1)#exit
```

#Configure QinQ function on the port gigabitethernet0/2 of PE1 so that outer Tag VLAN101 is added to the data of VLAN15~VLAN30.

```
PE1(config)#interface gigabitethernet 0/2
PE1(config-if-gigabitethernet0/2)#vlan dot1q-tunnel 15-30 101
PE1(config-if-gigabitethernet0/2)#exit
```

#View the information of flexible QinQ entry on PE1.

```
PE1#show vlan dot1q-tunnel
Interface          priority-default   Inner VlanId   Outer VlanId   inner-priority-trust   Inner VlanId Count
-----------------  ----------------   ------------   ------------   --------------------   ------------------
gi0/1              disable            10-20          100            /                      11
gi0/2              disable            15-30          101            /                      16
```

Step 2: Configure PE2.

#Create VLAN 10~VLAN30 and VLAN100~VLAN101 on PE2.

```
PE2#configure terminal
PE2(config)#vlan 10-30,100-101
```

#On PE2, configure the link type of port gigabitethernet0/1 as Trunk, and allow services of VLAN10~VLAN20 and VLAN100 to pass. Configure PVID as 100.

```
PE2(config)#interface gigabitethernet 0/1
PE2(config-if-gigabitethernet0/1)#switchport mode trunk
PE2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 10-20,100
PE2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 100
PE2(config-if-gigabitethernet0/1)#exit
```

#On PE2, configure the link type of port gigabitethernet0/2 as Trunk, and allow services of VLAN15~VLAN30 and VLAN101 to pass. Configure PVID as 101.

```
PE2(config)#interface gigabitethernet 0/2
PE2(config-if-gigabitethernet0/2)#switchport mode trunk
PE2(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 15-30,101
PE2(config-if-gigabitethernet0/2)#switchport trunk pvid vlan 101
PE2(config-if-gigabitethernet0/2)#exit
```

#On PE2, configure the link type of port gigabitethernet0/3 as Trunk, and allow services of VLAN100 and VLAN101 to pass. Configure PVID as 1.

```
PE2(config)#interface gigabitethernet 0/3
PE2(config-if-gigabitethernet0/3)#switchport mode trunk
PE2(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 100,101
PE2(config-if-gigabitethernet0/3)#switchport trunk pvid vlan 1
PE2(config-if-gigabitethernet0/3)#exit
```

#Configure flexible QinQ function on the port gigabitethernet0/1 of PE2 so that outer Tag VLAN100 is added to the data of VLAN10~VLAN20.

```
PE2(config)#interface gigabitethernet 0/1
PE2(config-if-gigabitethernet0/1)#vlan dot1q-tunnel 10-20 100
PE2(config-if-gigabitethernet0/1)#exit
```

#Configure flexible QinQ function on the port gigabitethernet0/2 of PE2 so that outer Tag VLAN101 is added to the data of VLAN15~VLAN30.

```
PE2(config)#interface gigabitethernet 0/2
PE2(config-if-gigabitethernet0/2)#vlan dot1q-tunnel 15-30 101
PE2(config-if-gigabitethernet0/2)#exit
```

#View the information of flexible QinQ entry on PE2.

```
PE2#show vlan dot1q-tunnel

Interface           priority-default    Inner VlanId    Outer VlanId    inner-priority-trust    Inner VlanId Count
------------------  ----------------    ------------    ------------    --------------------    ------------------
gi0/1               disable             10-20           100             /                       11

gi0/2               disable             15-30           101             /                       16
```

Step 3: Check the result.

#Services between intranet users CE1 and CE2 can communicate on the operator's network VLAN100 through PE1 and PE2 with double layers of Tag; those between CE3 and CE4 can communicate on the operator's network VLAN101 through PE1 and PE2 with double layers of Tag.

26.3.3 Configure 1: 1 VLAN Mapping

Network Requirements

- Intranet users CE1 and CE2, CE3 and CE4 communicate through the operator's network. CE1 and CE2 use intranet VLAN2, while CE3 and CE4 use intranet VLAN3. PE1 and PE2 are edge devices for the operator's network.
- Configure 1:1 VLAN rules on PE1 and PE2 so that CE1 and CE2, CE3 and CE4 can communicate with each other through the operator's public network VLAN 100 and VLAN101. The data has a single layer of Tag when transmitting on the operator's network.

Network Topology

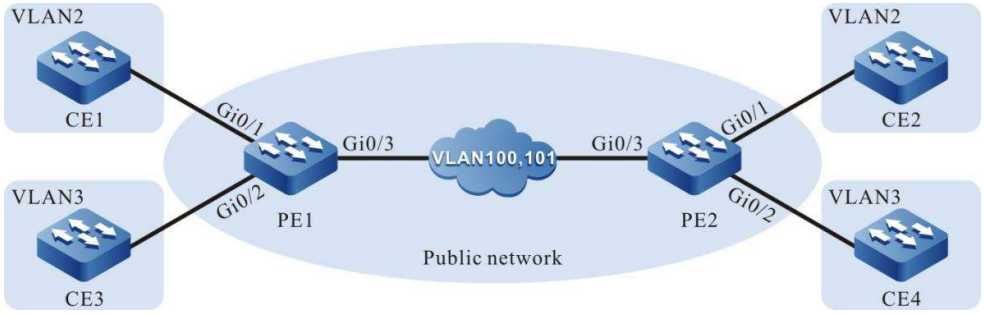


Figure 26 Configuring Network Topology of 1:1 VLAN Mapping

Configuration Steps

Step 1: Configure PE1.

#Create VLAN 2~VLAN3 and VLAN100~VLAN101 on PE1.

```
PE1#configure terminal
PE1(config)#vlan 2-3,100-101
```

#On PE1, configure the link type of port gigabitethernet0/1 as Trunk, and allow services of VLAN2 and VLAN100 to pass. Configure PVID as 1.

```
PE1(config)#interface gigabitethernet 0/1
PE1(config-if-gigabitethernet0/1)#switchport mode trunk
PE1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2,100
PE1(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
PE1(config-if-gigabitethernet0/1)#exit
```

#On PE1, configure the link type of port gigabitethernet0/2 as Trunk, and allow services of VLAN3 and VLAN101 to pass. Configure PVID as 1.

```
PE1(config)#interface gigabitethernet 0/2
PE1(config-if-gigabitethernet0/2)#switchport mode trunk
PE1(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 3,101
PE1(config-if-gigabitethernet0/2)#switchport trunk pvid vlan 1
PE1(config-if-gigabitethernet0/2)#exit
```

#On PE1, configure the link type of port gigabitethernet0/3 as Trunk, and allow services of VLAN100 and VLAN101 to pass. Configure PVID as 1.

```
PE1(config)#interface gigabitethernet 0/3
PE1(config-if-gigabitethernet0/3)#switchport mode trunk
PE1(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 100,101
PE1(config-if-gigabitethernet0/3)#switchport trunk pvid vlan 1
PE1(config-if-gigabitethernet0/3)#exit
```

#Configure 1:1 VLAN mapping function on the port gigabitethernet0/1 of PE1 so that the data of VLAN2 is modified into VLAN100.

```
PE1(config)#interface gigabitethernet 0/1
PE1(config-if-gigabitethernet0/1)#vlan dot1q-tunnel mapping 2 100
PE1(config-if-gigabitethernet0/1)#exit
```

#Configure 1:1 VLAN mapping function on the port gigabitethernet0/2 of PE1 so that the data of VLAN3 is modified into VLAN101.

```
PE1(config)#interface gigabitethernet 0/2
PE1(config-if-gigabitethernet0/2)# vlan dot1q-tunnel mapping 3 101
PE1(config-if-gigabitethernet0/2)#exit
```

#View the information of 1:1 VLAN mapping entry on PE1.

```
PE1#show vlan dot1q-tunnel mapping
---------------------------------- -------VLAN DOT1Q-TUNNEL MAPPING------ ----------------------------------------
Interface          priority-default   Former VlanId  Mapping VlanId  inner-priority-trust   Former VlanId Count
------------------ ------------------ -------------- --------------- ---------------------  ------------------
gi0/1              disable            2              100             /                      1
gi0/2              disable            3              101             /                      1
```

Step 2: Configure PE2.

#Create VLAN 2~VLAN3 and VLAN100~VLAN101 on PE2.

```
PE2#configure terminal
PE2(config)#vlan 2-3,100-101
```

#On PE2, configure the link type of port gigabitethernet0/1 as Trunk, and allow services of VLAN2 and VLAN100 to pass. Configure PVID as 1.

```
PE2(config)#interface gigabitethernet 0/1
PE2(config-if-gigabitethernet0/1)#switchport mode trunk
PE2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2,100
PE2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
PE2(config-if-gigabitethernet0/1)#exit
```

#On PE2, configure the link type of port gigabitethernet0/2 as Trunk, and allow services of VLAN3 and VLAN101 to pass. Configure PVID as 1.

```
PE2(config)#interface gigabitethernet 0/2
PE2(config-if-gigabitethernet0/2)#switchport mode trunk
PE2(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 3,101
PE2(config-if-gigabitethernet0/2)#switchport trunk pvid vlan 1
PE2(config-if-gigabitethernet0/2)#exit
```

#On PE2, configure the link type of port gigabitethernet0/3 as Trunk, and allow services of VLAN100 and VLAN101 to pass. Configure PVID as 1.

```
PE2(config)#interface gigabitethernet 0/3
PE2(config-if-gigabitethernet0/3)#switchport mode trunk
PE2(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 100,101
PE2(config-if-gigabitethernet0/3)#switchport trunk pvid vlan 1
PE2(config-if-gigabitethernet0/3)#exit
```

#Configure 1:1 VLAN mapping function on the port gigabitethernet0/1 of PE2 so that the data of VLAN2 is modified into VLAN100.

```
PE2(config)#interface gigabitethernet 0/1
PE2(config-if-gigabitethernet0/1)#vlan dot1q-tunnel mapping 2 100
PE2(config-if-gigabitethernet0/1)#exit
```

#Configure 1:1 VLAN mapping function on the port gigabitethernet0/2 of PE2 so that the data of VLAN3 is modified into VLAN101.

```
PE2(config)#interface gigabitethernet 0/2
PE2(config-if-gigabitethernet0/2)#vlan dot1q-tunnel mapping 3 101
PE2(config-if-gigabitethernet0/2)#exit
```

#View the information of 1:1 VLAN mapping entry on PE2.

```
PE2#show vlan dot1q-tunnel mapping
---------------------------------- -------VLAN DOT1Q-TUNNEL MAPPING------ ----------------------------------------
Interface          priority-default   Former VlanId  Mapping VlanId  inner-priority-trust   Former VlanId Count
------------------ ------------------- -------------- ---------------- ---------------------  -------------------
gi0/1              disable            2              100              /                      1
gi0/2              disable            3              101              /                      1
```

Step 3: Check the result.

#Services between intranet users CE1 and CE2 can communicate on the operator's network VLAN100 through PE1 and PE2 with a single layer of Tag; those between CE3 and CE4 can communicate on the operator's network VLAN101 through PE1 and PE2 with a single layer of Tag.

26.3.4 Configure N: 1 VLAN Mapping

Network Requirements

- On Device2, in different VLANs, services of PC1 and PC2 are isolated from each other.
- Configure N: 1 VLAN mapping function on Device1 so that the service packets of PC1 and PC2 transmit in the same VLAN when passing through Device1 to save VLAN resource.

Network Topology

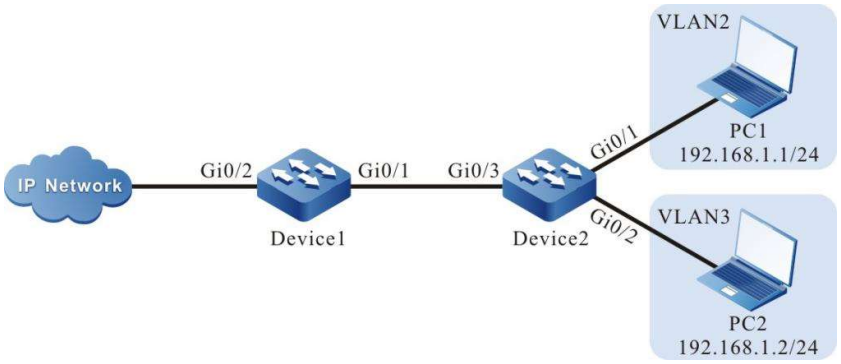


Figure 26 Configuring Network Topology of N:1 VLAN Mapping

Configuration Steps

Step 1: Configure Device1.

#Create VLAN2~VLAN4 on Device1.

```
Device1#configure terminal
```

```
Device1(config)#vlan 2-4
```

#On Device1, configure the link type of port gigabitethernet0/1 as Trunk, and allow services of VLAN2~VLAN4 to pass. Configure PVID as 1.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#switchport mode trunk
Device1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2-4
Device1(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
```

#Configure N:1 VLAN mapping function on the port gigabitethernet0/1 of Device1 so that the VLAN2 and VLAN3 are mapped to VLAN4.

```
Device1(config-if-gigabitethernet0/1)#vlan dot1q-tunnel mapping n-to-1 enable
Device1(config-if-gigabitethernet0/1)#vlan dot1q-tunnel mapping n-to-1 2-3 4
Device1(config-if-gigabitethernet0/1)#exit
```

#On Device1, configure the link type of port gigabitethernet0/2 as Trunk, and allow services of VLAN2~VLAN4 to pass. Configure PVID as 1.

```
Device1(config)#interface gigabitethernet 0/2
Device1(config-if-gigabitethernet0/2)#switchport mode trunk
Device1(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2-4
Device1(config-if-gigabitethernet0/2)#switchport trunk pvid vlan 1
Device1(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure Device2.

#Create VLAN2 and VLAN3 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2-3
```

#Configure the link type of port gigabitethernet0/1 on Device2 as Access, allowing the services of VLAN2 to pass.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode access
Device2(config-if-gigabitethernet0/1)#switchport access vlan 2
Device2(config-if-gigabitethernet0/1)#exit
```

#Configure the link type of port gigabitethernet0/2 on Device2 as Access, allowing the services of VLAN3 to pass.

```
Device2(config)#interface gigabitethernet 0/2
Device2(config-if-gigabitethernet0/2)#switchport mode access
Device2(config-if-gigabitethernet0/2)#switchport access vlan 3
Device2(config-if-gigabitethernet0/2)#exit
```

#On Device2, configure the link type of port gigabitethernet0/3 as Trunk, and allow services of VLAN2 and VLAN3 to pass. Configure PVID as 1.

```
Device2(config)#interface gigabitethernet 0/3
Device2(config-if-gigabitethernet0/3)#switchport mode trunk
Device2(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 2-3
Device2(config-if-gigabitethernet0/3)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/3)#exit
```

Step 3: Check the result.

#View the information of N:1 VLAN mapping entry on Device1.

```
Device1# show vlan dot1q-tunnel mapping n-to-1 configuration
---- -------------------- ------- ------------------------------------ -------------
NO.  Name                 Status  Customer Member                      Service VLAN
---- -------------------- ------- ------------------------------------ -------------
1    gi0/1                enable  2-3                                  4
```

#On Device2, services of PC1 and PC2 are isolated from each other. The service packet of PC1 transmits in VLAN2, and that of PC2 in VLAN3.

#The service packets of PC1 and PC2 that access IP Network are forwarded via the VLAN4 of Device1.

27 Super-VLAN

27.1 Overview

Different VLANs are isolated from each other at layer 2. To enable them to communicate with each other, you must configure a VLAN interface and IP address for each VLAN. However, this mode consumes a large number of scarce IP address resources. Super-VLAN, also called VLAN aggregation, can solve this problem effectively. A common VLAN, after being added into a super-VLAN, becomes a sub-VLAN of the super-VLAN. If the Address Resolution Protocol (ARP)/ND proxy function is enabled for the super-VLAN, the super-VLAN shares its VLAN interface with its sub-VLANs. In this way, the sub-VLANs take the VLAN interface IP/IPv6 address of the super-VLAN as the gateway to implement layer-3 communication. This saves IP address resources.

27.2 VLAN Function Configuration

Table 27 Super-VLAN Function Configuration List

Configuration Task	
Configure a super VLAN.	Configure a super VLAN.
Configure sub-VLAN members of the super-VLAN.	Configure sub-VLAN members of the super-VLAN.
Enable the ARP proxy function.	Enable the ARP proxy function.
Enable the ND proxy function.	Enable the ND proxy function.

27.2.1 Configure a Super VLAN

Configuration Condition

None

Configure a Super VLAN

On the Super-VLAN, VLAN can be configured, but port cannot be added. The Super-VLAN shall not be the existing VLAN or Sub-VLAN.

Table 27 Configuring Super-VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create Super-VLAN	**super-vlan** *vlan-id*	Mandatory By default, no Super-VLAN is created. Upon creation of the Super-VLAN, you will enter the Super-VLAN configuration mode automatically.
Configure description for Super-VLAN	**description** *description*	Optional By default, Super-VLAN is described as "SuperVLAN*vlan-id*", such as "SuperVLAN0100".

27.2.2 Configure Sub-VLAN Members of the Super-VLAN

Configuration Condition

None

Configure Sub-VLAN Members of theSsuper-VLAN

One super-VLAN supports a maximum of 8 sub-VLAN members, and one VLAN can become the sub-VLAN member of only one super-VLAN. On a sub-VLAN, a VLAN interface cannot be configured but a port can be added into it. The method for adding a port into a sub-VLAN is the same as the method for adding a port into a common VLAN. The VLAN ID of a sub-VLAN must not be identical with the VLAN ID of an existing super-VLAN.

Table 1 Configuring Sub-VLAN Members of Super-VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the super-VLAN configuration mode.	**super-vlan** *vlan-id*	-
Configure sub-VLAN members of the super-VLAN.	**sub-vlan** *vlan-list*	Mandatory By default, a super-VLAN is not configured with sub-VLAN members.

Caution

- If Sub-VLAN has been configured, it cannot be configured as an exclusive EIPS control VLAN.

27.2.3 Enable the ARP Proxy Function

Configuration Condition

Before enabling the ARP proxy function, ensure that:

- The VLAN interface corresponding to the super-VLAN and the IP address have been configured.

Configure the ARP Proxy Function

After the ARP proxy function of a super-VLAN is configured, the sub-VLANs can communicate with each other at layer 3 through ARP proxy.

Table 2 Enabling ARP Proxy Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the super-VLAN configuration mode.	**super-vlan** *vlan-id*	-

Step	Command	Description
Enable the ARP proxy function.	**arp proxy enable**	Mandatory By default, the ARP proxy function is disabled.

Note

- The ARP proxy function relies on the layer-3 forwarding function. If the device does not support the layer-3 forwarding function, the ARP proxy function does not take effect.

27.2.4 Enable the ND Proxy Function

Configuration Condition

Before enabling the ND proxy function, ensure that:

- The VLAN interface corresponding to the super-VLAN and the IPv6 address have been configured.

Configure the ND Proxy Function

After the ND proxy function of a super-VLAN is configured, the sub-VLANs can communicate with each other at IPv6 layer 3 through ND proxy.

Table 3 Enabling ND Proxy Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the super-VLAN configuration mode.	**super-vlan** *vlan-id*	-
Enable the ND proxy function.	**nd local-proxy enable**	Mandatory By default, the ND proxy function is disabled.

Note

- The ND proxy function relies on the layer 3 forwarding function. If the device does not support the IPv6 layer 3 forwarding function, the ND proxy function does not take effect.

27.2.5 VLAN Monitoring and Maintaining

Table 4 Super-VLAN Monitoring and Maintaining

Command	Description
show super-vlan [*vlan-id*]	Displays the information about the specified super-VLAN.
show super-vlan config { *vlan-id* **| all** }	Show Super-VLAN configuration information
show super-vlan [*vlan-id*] **portlist**	Show the information of port under the management of Super-VLAN
show super-vlan *vlan-id* **sub-vlan** *vlan-id* **portlist**	Show the information of port under the management of Sub-VLAN

27.3 Super-VLAN Typical Configuration Example

27.3.1 Configure a Super VLAN

Network Requirements

- PC1 and PC2 are two hosts in Sub-VLAN2, PC3 is a host in Sub-VLAN3, and Server is a server in VLAN5.
- The super-VLAN function has been configured on Device. Then, PC1 and PC2 can intercommunicate with each other at layer2. PC1 and PC2 can intercommunicate with PC3 at layer3, and they can access the server.

Network Topology

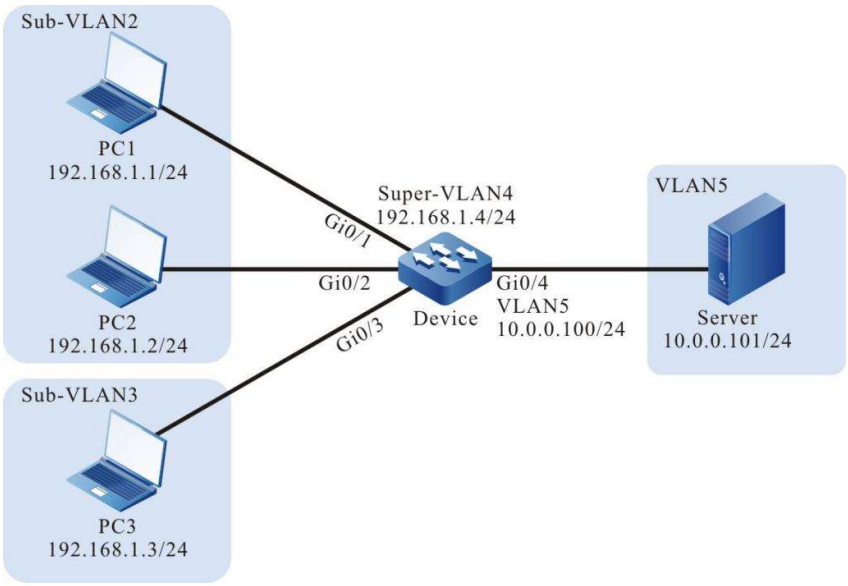


Figure 1 Network Topology for Configuration of Super-VLAN

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN2, VLAN3 and VLAN5 on Device.

```
Device#configure terminal

Device(config)#vlan 2-3,5
```

#On the Device, configure the IP address of VLAN interface 4 as 192.168.1.4 and mask as 255.255.255.0; configure the IP address of VLAN interface 5 as 10.0.0.100 and mask as 255.255.255.0.

```
Device(config)#interface vlan 4
Device(config-if-vlan4)#ip address 192.168.1.4 255.255.255.0
Device(config-if-vlan4)#exit
Device(config)#interface vlan 5
Device(config-if-vlan5)#ip address 10.0.0.100 255.255.255.0
Device(config-if-vlan5)#exit
```

#Configure the link type of port gigabitethernet0/1~gigabitethernet0/2 on the Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1,0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

#Configure the link type of port gigabitethernet0/3 on the Device as Access, allowing the services of VLAN3 to pass.

```
Device(config)#interface gigabitethernet 0/3
Device(config-if-gigabitethernet0/3)#switchport mode access
Device(config-if-gigabitethernet0/3)#switchport access vlan 3
Device(config-if-gigabitethernet0/3)#exit
```

#Configure the link type of port gigabitethernet0/4 on the Device as Access, allowing the services of VLAN5 to pass.

```
Device(config)#interface gigabitethernet 0/4
Device(config-if-gigabitethernet0/4)#switchport mode access
Device(config-if-gigabitethernet0/4)#switchport access vlan 5
Device(config-if-gigabitethernet0/4)#exit
```

#View the information of VLAN and port of the Device.

```
Device#show vlan 2
---- ---- -------------------------------- ------- --------- ------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- ------------------------------
1    2    VLAN0002                         static  Untagged  gi0/1  gi0/2
Device#show vlan 3
---- ---- -------------------------------- ------- --------- ------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- ------------------------------
1    3    VLAN0003                         static  Untagged  gi0/3
Device#show vlan 5
---- ---- -------------------------------- ------- --------- ------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- ------------------------------
1    5    VLAN0005                         static  Untagged  gi0/4
```

Step 2: Configure the Super-VLAN function on the Device.

#On the Device, configure VLAN4 as Super-VLAN, VLAN2 and VLAN3 as Sub-VLAN, and enable ARP proxy.

```
Device(config)#super-vlan 4
Device(config-super-vlan4)#sub-vlan 2,3
Device(config-super-vlan4)#arp proxy enable
Device(config-super-vlan4)#exit
```

#View the information of Super-VLAN on the Device.

```
Device#show super-vlan
-------------------------------------------------------------------------------
NO.  SuperVlan  Description                Arp Proxy  SubVlan Member
-------------------------------------------------------------------------------
1    4          SuperVLAN0004              enable     2-3
```

Caution

- To achieve intercommunication between hosts in different Sub-VLANs at layer 3, the ARP proxy function must be enabled.
- Super-VLAN and Sub-VLAN must be in the same spanning tree instance.

Step 3: Check the result. Use the ping command to check the connectivity between PC1, PC2, PC3 and the server.

#PC1 and PC2 in Sub-VLAN2 can ping each other successfully.

#PC1 and PC2 in Sub-VLAN2 and PC3 in Sub-VLAN3 can ping each other successfully.

#PC1, PC2, and PC3 in Sub-VLANs and the server can ping each other successfully.

28 PVLAN

28.1 Overview

In order to isolate all users from each other and allow them to access common resources, usually each user need to be provided with a VLAN. However, for the application scenarios with many users, since there are only 4,094 VLANs in total, when the number of users exceeds this figure, the number of VLANs will become a bottleneck and make it difficult to conduct configuration, management and maintenance. To cope with this problem, PVLAN (Private VLAN) is born. Through a flexible VLAN configuration mode, it can effectively configure and utilize VLAN and IP address resources, and simplify network configuration.

PVLAN employs a two-layer VLAN structure, i.e. Primary VLAN and Secondary VLAN. Generally, Primary VLAN connects with uplink device, and Secondary VLAN with downlink device. According to the forwarding rules of layer 2, Secondary VLANs are divided into the following two types:

- Isolated VLAN: Member ports, whether within the same Isolated VLAN or not, are isolated from each other at layer 2. Users can be isolated from each other only if the ports connecting users are added to the Isolated VLAN;
- Community VLAN: The forwarding rules of Community VLAN are the same as those of common VLAN. Member ports in the same Community VLAN can communicate with each other at layer 2, and stay isolated from those of other Community VLAN and Isolated VLAN.

After Primary VLAN and Secondary VLAN are associated with each other, the member ports in Secondary VLAN can directly communicate with those in Primary VLAN at layer 2, and with the outside through the VLAN interface on Primary VLAN at layer 3.

PVLAN has two specific port link types, i.e. Promiscuous and Host. Promiscuous port can only be added to Primary VLAN, and Host port can only be added to Secondary VLAN. The Host port added to the Community VLAN is also called Community port, and the Host port added to the Isolated VLAN is also called Isolated port.

28.2 PVLAN Function Configuration

Table 28 PVLAN Function Configuration List

Configuration Task	
Configure Primary VLAN	Configure Primary VLAN
Add ports into Primary VLAN	Add ports into Primary VLAN
Configure Secondary VLAN	Configure Secondary VLAN
Add ports into Secondary VLAN	Add ports into Secondary VLAN
Configure the association relationship between Primary VLAN and Secondary VLAN	Configure the association relationship between Primary VLAN and Secondary VLAN

28.2.1 Configure Primary VLAN

The uplink device recognizes Primary VLAN only. It never cares about its associated Secondary VLAN.

Configuration Condition

None

Configure Primary VLAN

Table 28 Configuring Primary VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure the VLAN type as Primary VLAN	**private-vlan primary**	Mandatory By default, all VLANs are common.

28.2.2 Add ports into Primary VLAN

Only the ports with link type being Promiscuous can be added into Primary VLAN. The ports added into Primary VLAN can communicate with other member ports in Primary VLAN and the member ports in Secondary VLAN associated with this Primary VLAN at layer 2. Generally, Promiscuous ports are used as uplink ports.

Configuration Condition

Before adding ports into Primary VLAN, the following tasks should be completed:

- Configure the type of VLAN where ports are added as Primary VLAN.

Add ports into Primary VLAN

Table 28 Adding Ports into Primary VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the port link type as Promiscuous	**switchport mode private-vlan promiscuous**	Mandatory By default, the port link type is the Access type.
Add Promiscuous ports into Primary VLAN	**private-vlan promiscuous** *vlan-id*	Mandatory By default, Promiscuous ports are not added into any VLAN.

Note

- If the port is not added into Primary VLAN when the port link type is configured as Promiscuous, the PVLAN function of the port will not take effect, and the Promiscuous port will be exclusive for PVLAN, which means other functions cannot be applied to the Promiscuous port. Therefore, it is recommended to complete the configuration as per the steps mentioned above.

28.2.3 Configure Secondary VLAN

The downlink device recognizes Primary VLAN only. It never cares about its associated Primary VLAN.

Configuration Condition

None

Configure Secondary VLAN

Table 6-4 Configuring Secondary VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure the VLAN type as Secondary VLAN	**private-vlan** { **community** | **isolated** }	Mandatory By default, all VLANs are common.

28.2.4 Add Ports into Secondary VLAN

Only the ports with the link type being Host can be added into Secondary VLAN which has two types: Community VLAN and Isolated VLAN. The ports added into Community VLAN can only communicate with other member ports in this Community VLAN and the member ports in the Primary VLAN associated with this Community VLAN at layer 2. The ports added into Isolated VLAN can only communicate with the member ports in the Primary VLAN associated with this Isolated VLAN at layer 2. Generally, Host ports are used as downlink ports.

Configuration Condition

Before adding ports into Secondary VLAN, the following tasks should be completed:

- Configure the type of VLAN where ports are added as Secondary VLAN.

Add Ports into Secondary VLAN

Table 6-5 Adding Ports into Secondary VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	At least one option must be selected. After you enter the interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the port link type as Host.	**switchport mode private-vlan host**	Mandatory By default, the link type is Access.
Add Host ports into Secondary VLAN	**private-vlan host** *vlan-id*	Mandatory By default, Host ports are not added into any VLAN.

Note

- The host in Secondary VLAN cannot communicate with the VLAN interface of this device at layer 3.
- If the port is not added into Primary VLAN when the port link type is configured as Host, the PVLAN function of the port will not take effect, and the Host port will be exclusive for PVLAN, which means other functions cannot be applied to the Host port. Therefore, it is recommended to complete the configuration as per the steps mentioned above.

28.2.5 Configure the Association Relationship Between Primary VLAN and Secondary VLAN

After association is established, the hosts in Primary VLAN can communicate with those in the associated Secondary VLAN at layer 2. One Primary VLAN can associate with one Isolated VLAN at most and 192 Community VLANs. One Secondary VLAN can associate with one Primary VLAN only.

Configuration Condition

Before associating Primary VLAN with Secondary VLAN, the following tasks should be completed:

- Configure the type of VLAN in current VLAN configuration mode as Primary VLAN.

Configure the Association Relationship Between Primary VLAN and Secondary VLAN

Table 1 Configuring Association Relationship Between Primary VLAN and Secondary VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure the association relationship of Primary VLAN	**private-vlan association add** *vlan-list*	Mandatory By default, Primary VLAN doesn't associate with any Secondary VLAN.

Note

- If the Primary VLAN associates with a common VLAN, the association will not take effect unless the type of common VLAN is changed to Secondary VLAN.
- If Secondary VLAN is associated with Primary VLAN, then for the MAC address entry dynamically learned through Secondary VLAN, the VLAN recorded in FDB table is the Primary VLAN associated with this Secondary VLAN rather than the Secondary VLAN itself.

28.2.6 PVLAN Monitoring and Maintaining

Table 28 PVLAN Monitoring and Maintaining

Command	Description
show private-vlan [*vlan-id*]	Show PVLAN information

28.3 Typical PVLAN Configuration Example

28.3.1 Configure PVLAN

Network Requirements

- PC1 and PC2 belong to Secondary VLAN2; PC3 and PC4 belong to Secondary VLAN3; Server belongs to Primary VLAN4.
- Configure PVLAN on the Device for intercommunication in Secondary VLAN2, mutual isolation in Secondary VLAN3, isolation between Secondary VLAN2 and Secondary VLAN3, and intercommunication of both Secondary VLAN2 and Secondary VLAN3 with Primary VLAN4.

Network Topology

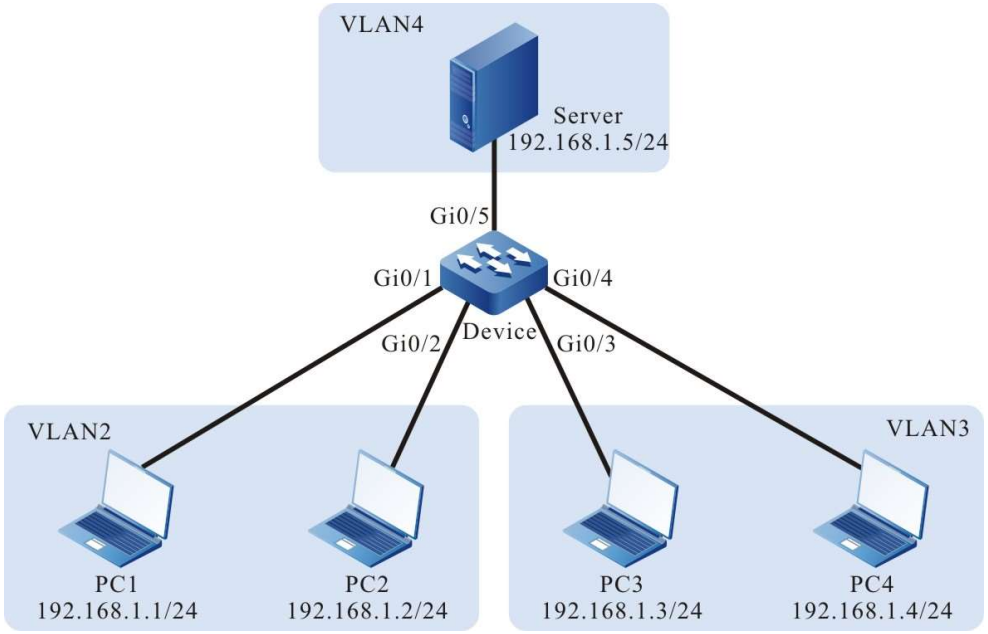


Figure 28 Network Topology for Configuration of PVLAN

Configuration Steps

Step 1: Configure VLAN on the Device.

#Create VLAN2~VLAN4 on the Device.

```
Device#configure terminal
Device(config)#vlan 2-4
```

Step 2: Configure the PVLAN function on the Device.

#On the Device, configure VLAN4 as Primary VLAN, VLAN2 as Community VLAN, and VLAN3 as Isolated VLAN.

```
Device(config)#vlan 4
Device(config-vlan4)#private-vlan primary
Device(config-vlan4)#vlan 2
Device(config-vlan2)#private-vlan community
Device(config-vlan2)#vlan 3
Device(config-vlan3)#private-vlan isolated
Device(config-vlan3)#exit
```

#Associate Primary VLAN4 with Community VLAN2 and Isolated VLAN3 on the Device.

```
Device(config)#vlan 4
Device(config-vlan4)#private-vlan association add 2,3
Device(config-vlan4)#exit
```

#Configure the link type of port gigabitethernet0/1~gigabitethernet0/2 on the Device as Host, and add them into VLAN2.

```
Device(config)#interface gigabitethernet 0/1-0/2
Device(config-if-range)#switchport mode private-vlan host
Device(config-if-range)#private-vlan host 2
Device(config-if-range)#exit
```

#Configure the link type of port gigabitethernet0/3~gigabitethernet0/4 on the Device as Host, and add them into VLAN3.

```
Device(config)#interface gigabitethernet 0/3-0/4
Device(config-if-range)#switchport mode private-vlan host
Device(config-if-range)#private-vlan host 3
Device(config-if-range)#exit
```

#Configure the link type of port gigabitethernet0/5 on the Device as Promiscuous, and add it into VLAN4.

```
Device(config)#interface gigabitethernet 0/5
Device(config-if-gigabitethernet0/5)#switchport mode private-vlan promiscuous
Device(config-if-gigabitethernet0/5)#private-vlan promiscuous 4
Device(config-if-gigabitethernet0/5)#exit
```

Step 3: Check the result.

#View the information of PVLAN on the Device.

```
Device#show private-vlan
```

```
---- -------- --------- ---------------- ---------------------------------- ----------------------------------
NO.  Primary  Secondary  Type             Interface(Primary)                 Interface(Secondary)
---- -------- --------- ---------------- ---------------------------------- ----------------------------------
1    4        3          isolated         gi0/5                              gi0/3     gi0/4
2    4        2          community        gi0/5                              gi0/1     gi0/2
```

#The two hosts PC1 and PC2 in Community VLAN2 can ping each other successfully.

#The two hosts PC3 and PC4 in Isolated VLAN3 cannot ping each other successfully.

#The two hosts PC1 and PC2 in Community VLAN2 cannot ping PC3 and PC4 in Isolated VLAN3 successfully.

#Both PC1 and PC2 in Community VLAN2 can ping the Server successfully.

#Both PC3 and PC4 in Isolated VLAN3 can ping the Server successfully.

29 Voice-VLAN

29.1 Overview

Voice-VLAN is a mechanism that provides security and Quality of Service (QoS) guarantee for voice data flows. In a network, usually two types of traffic coexists, voice data and service data. During transmission, voice data has a higher priority than service data so as to reduce delay and packet loss that may occur during the transmission process. Voice-VLAN can automatically recognize voice traffic and distribute the voice traffic to a specific VLAN with QoS guarantee.

29.2 Voice-VLAN Function Configuration

Table 29 Voice-VLAN Function Configuration List

Configuration Task	
Configure a Voice-VLAN	Configure a Voice-VLAN
Configure an OUI Address	Configure an OUI Address
Enable the Voice-VLAN Function of a Port	Enable the Voice-VLAN Function of a Port
Configure the Voice-VLAN Working Mode on the Port	Configure a Voice-VLAN to Automatic Mode
	Configure a Voice-VLAN to Manual Mode
Enable the security mode of Voice-VLAN	Enable the security mode of Voice-VLAN
Enable the lldp-med authentication mode of Voice-VLAN	Enable the lldp-med authentication mode of Voice-VLAN

29.2.1 Configure a Voice-VLAN

A voice VLAN is used to transmit voice packets. The 802.1 priorities of the recognized voice packets are replaced with the priority of the voice-VLAN. Then the packets are distributed into the voice VLAN for forwarding. A device supports a maximum of one voice-VLAN.

Configuration Condition

Before configuring Voice-VLAN, the following tasks should be completed:

- Create the VLAN specified as Voice-VLAN.

Configure a Voice-VLAN

Table 1 Configuring Voice-VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Specify a VLAN as Voice-VLAN	**voice vlan** *vlan-id* **cos** *priority*	Mandatory By default, Voice-VLAN is not configured, i.e. the Voice-VLAN function is not enabled globally.

29.2.2 Configure an OUI Address

Configuration Condition

Before configuring an OUI address, ensure that:

- The voice-VLAN function is globally enabled.
- The voice-VLAN function is enabled on the port.

Configure an OUI Address

Organizationally Unique Identifiers (OUIs) are used to identify voice packets that are sent by voice devices of manufacturers. After a port that works in voice-VLAN automatic mode receives an Untag packet, it takes out the MAC address of the packet and performs the AND operation with the OUI mask. If the obtained address range is the same as the OUI address, it indicates that matching the OUI address succeeds, and the packet is recognized as a voice packet.

Table 2 Configuring OUI Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure an OUI Address	**voice vlan oui-mac** *oui-mac-address* **mask** *mask* **name** *oui-name*	Mandatory By default, there are 5 default OUI addresses. The device can support 32 OUI addresses at most.

29.2.3 Enable the Voice-VLAN Function of a Port

After the voice-VLAN function is enabled on a port, the port uses a method according to the voice-VLAN working mode to automatically recognize the received packets.

Configuration Condition

Before enabling the voice-VLAN function of a port, ensure that:

- The voice-VLAN function is globally enabled.
- The port has been added into the voice-VLAN.

Enable the Voice-VLAN Function of a Port

Table 3 Enabling Voice-VLAN Function of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	

Step	Command	Description
		only within the aggregation group.
Enable the Voice-VLAN Function of a Port	**voice vlan enable**	Mandatory By default, the port doesn't enable the Voice-VLAN function.

Note

- The security mode of Voice-VLAN does not support aggregation group. That is to say, when the device enables the security mode of Voice-VLAN, the aggregation group cannot enable the Voice-VLAN function; or when an aggregation group of the device enables the Voice-VLAN function, the security mode of Voice-VLAN cannot be enabled.
- The lldp-med authentication mode of Voice-VLAN does not support aggregation group. That is to say, when the device enables the lldp-med authentication mode of Voice-VLAN, the aggregation group cannot enable the Voice-VLAN function; or when an aggregation group of the device enables the Voice-VLAN function, the lldp-med authentication mode of Voice-VLAN cannot be enabled.

29.2.4 Configure the Voice-VLAN Working Mode on the Port

The voice-VLAN of a port can work in automatic mode or manual mode. The ports working in different voice-VLAN modes recognize voice packets in different ways.

- Automatic mode: If the packets received by the port are Untag packets and the source MAC address of the packets matches an OUI address, the packets are regarded as voice packets.
- Manual mode: If the packets received by the port are Untag packets, or Tag packets with the VLAN ID being the port PVID, the packets are regarded as voice packets.

Configuration Condition

Before configuring the voice-VLAN working mode of a port, ensure that:

- The voice-VLAN function is globally enabled.
- The voice-VLAN function of the port has been enabled.

Configure a Voice-VLAN to Automatic Mode

Table 4 Configuring Automatic Mode of Voice-VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	
Make the port work under the automatic mode of Voice-VLAN	**voice vlan mode auto**	Mandatory By default, the port works under the automatic mode of Voice-VLAN.

Configure a Voice-VLAN to Manual Mode

Table 5 Configuring Manual Mode of Voice-VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode,
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	

Step	Command	Description
		the subsequent configuration takes effect only within the aggregation group.
Make the port work under the manual mode of Voice-VLAN	**no voice vlan mode auto**	Mandatory By default, the port works under the automatic mode of Voice-VLAN.

Note

- If the port is used to transmit Tagged voice data, the port type should be configured as Trunk or Hybrid only, and the PVID shall not be Voice-VLAN.
- If the port under the manual mode of Voice-VLAN is used to transmit untagged voice data, the PVID must be Voice-VLAN.
- The lldp-med authentication mode of Voice-VLAN does not support manual mode of the port. That is to say, when the device enables the lldp-med authentication mode of Voice-VLAN, the port cannot be configured as the manual mode of Voice-VLAN; or when an port is configured as the manual mode of Voice-VLAN, the lldp-med authentication mode of Voice-VLAN cannot be enabled.

29.2.5 Enable the Security Mode of Voice-VLAN

After the Voice-VLAN security mode is enabled, the device will perform source MAC address matching check on each packet that will enter Voice-VLAN for transmission, and discard those that fail to match the OUI address.

Configuration Condition

Before enabling the security mode of voice-VLAN, the following tasks should be completed:

- The voice-VLAN function is globally enabled.

Enable the Security Mode of Voice-VLAN

Table 6 Enabling Security Mode of Voice-VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enable the security mode of Voice-VLAN	**voice vlan security enable**	Mandatory By default, the security mode of Voice-VLAN is disabled.

Note

- The security mode of Voice-VLAN does not support aggregation group. That is to say, when the aggregation group of the device enables the function of Voice-VLAN, the security mode of Voice-VLAN cannot be enabled; or when the device enables the security mode of Voice-VLAN, the aggregation group cannot enable the function of Voice-VLAN.

29.2.6 Enable the lldp-med Authentication Mode of Voice-VLAN

After the lldp-med authentication mode of Voice-VLAN is enabled, the device deems the OUI configured by the user or the default OUI as an authentication whitelist, and performs matching check on the source MAC address of the voice device advertised by lldp-med. Only the voice packet sent from the voice device which matches the whitelist can enter the Voice-VLAN for transmission.

Configuration Condition

Before enabling the lldp-med authentication mode of Voice-VLAN, the following tasks should be completed:

- The voice-VLAN function is globally enabled.

Enable the lldp-med Authentication Mode of Voice-VLAN

Table 7 Enabling lldp-med Authentication Mode of Voice-VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the lldp-med authentication mode of Voice-VLAN	**voice vlan lldp-med authentication**	Mandatory By default, the lldp-med authentication mode of Voice-VLAN is disabled.

Note

- The lldp-med authentication mode of Voice-VLAN does not support aggregation group. That is to say, when the aggregation group of the device enables the function of Voice-VLAN, the lldp-med authentication mode of Voice-VLAN cannot be enabled; or when the device enables the lldp-med authentication mode of Voice-VLAN, the aggregation group cannot enable the function of Voice-VLAN.
- The lldp-med authentication mode of Voice-VLAN does not support manual mode of the port. That is to say, when any port is configured as the manual mode of Voice-VLAN, the lldp-med authentication mode of Voice-VLAN cannot be enabled; or when the device enables the lldp-med authentication mode of Voice-VLAN, the port cannot be configured as the manual mode of Voice-VLAN.
- After the lldp-med authentication mode of Voice-VLAN is enabled, the telephone which doesn't support lldp cannot work under normal conditions.

29.2.7 Voice-VLAN Monitoring and Maintaining

Table 8 Voice-VLAN Monitoring and Maintaining

Command	Description
show voice vlan { **all** | **interface** [*interface-name*] | **link-aggregation** [*link-aggregation-id*] | **oui** | **lldp-med authenticated-mac** }	Show the information of Voice-VLAN

29.3 Typical Example of Configuration of Voice-VLAN

29.3.1 Configure a Voice-VLAN to Manual Mode

Network Requirements

- IP Phone and PC can access IP Network through Device.
- The voice-VLAN in manual mode has been configured on Device. If the network is normal, IP Phone and PC can normally access IP Network. If the network is congested, IP Phone has a higher priority than PC in accessing IP Network.

Network Topology

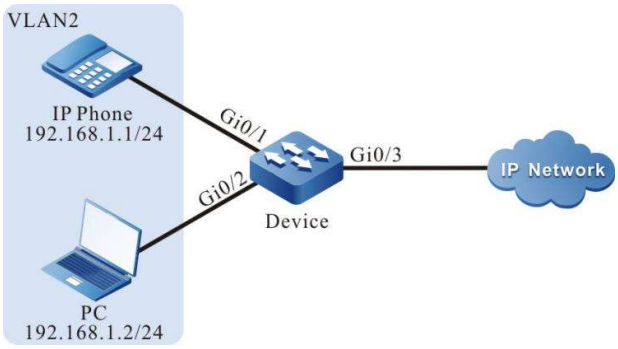


Figure 29 Network Topology for Configuration of Manual Mode of Voice-VLAN

Configuration Steps

Step 1: Configure the link type of VLAN and port.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 and gigabitethernet0/2 on Device as Access, permitting the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1,0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

#Configure the link type of port gigabitethernet0/3 on the Device as Trunk, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/3
Device(config-if-gigabitethernet0/3)#switchport mode trunk
Device(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/3)#exit
```

Step 2: Configure Voice-VLAN function.

#Configure VLAN2 as Voice-VLAN on the Device, with the value of Cos being 7.

```
Device(config)#voice vlan 2 cos 7
```

#Configure the manual mode of Voice-VLAN on the port gigabitethernet0/1 of the Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#voice vlan enable
Device(config-if-gigabitethernet0/1)#no voice vlan mode auto
Device(config-if-gigabitethernet0/1)#exit
```

#View the information of Voice-VLAN on the Device.

```
Device#show voice vlan all
 Voice Vlan Global Information:  Voice Vlan enable
  Voice Vlan security:  disable
```

```
Voice Vlan lldp-med authentication:  disable
Voice Vlan VID: 2, Cos: 7
Default OUI number: 5
User config OUI number: 0

Voice vlan interface information:
 Interface            Mode
 ---------------------------------------
 gi0/1                Manual-Mode

Voice Vlan OUI information: Total: 5
 MacAddr         Mask            Name
 ----------------------------------------------------------------
 0003.6b00.0000  ffff.ff00.0000  Cisco-phone  default
 006b.e200.0000  ffff.ff00.0000  H3C-Aolynk-phone  default
 00d0.1e00.0000  ffff.ff00.0000  Pingtel-phone  default
 00e0.7500.0000  ffff.ff00.0000  Polycom-phone  default
 00e0.bb00.0000  ffff.ff00.0000  3Com-phone  default
```

Step 3: Check the result.

#The 802.1 priority of the packets that are sent to IP Phone is modified to 7, and the 802.1P priority of the packets sent by PC to IP Network is not modified.

#When the network is normal, IP Phone and PC can normally access IP Network.

#If the network is congested, IP Phone can access IP Network with a priority higher than PC.

29.3.2 Configure a Voice-VLAN to Automatic Mode

Network Requirements

- IP Phone and PC access IP Network through port gigabitethernet0/1 of Device. The MAC address of IP Phone is 0001.0001.0001, and the MAC address of PC is 0002.0002.0002.
- The voice-VLAN in automatic mode has been configured. In this way, if the network is normal, IP Phone and PC can normally access IP network. If the network is congested, IP Phone has a higher priority than PC in accessing IP Network.

Network Topology

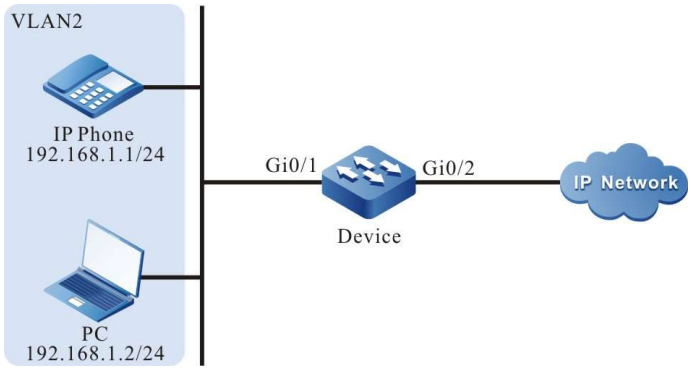


Figure 1 Network Topology for Configuring Automatic Mode of Voice-VLAN

Configuration Steps

Step 1: Configure the link type of VLAN and port.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1 on the Device as Trunk, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)# switchport mode trunk
Device(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the link type of port gigabitethernet0/2 on the Device as Trunk, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure Voice-VLAN function.

#Configure VLAN2 as Voice-VLAN on the Device, and change corresponding value of Cos to 7.

```
Device(config)#voice vlan 2 cos 7
```

#Configure the automatic mode of Voice-VLAN on the port gigabitethernet0/1 of the Device.

```
Device(config)# interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#voice vlan enable
Device(config-if-gigabitethernet0/1)#voice vlan mode auto
```

```
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the OUI address which corresponds to the MAC address 0001.0001.0001 of IP Phone on the Device.

```
Device(config)#voice vlan oui-mac 0001.0001.0001 mask ffff.ffff.0000 name voice-vlan
```

#View the information of Voice-VLAN on the Device.

```
Device#show voice vlan all
 Voice Vlan Global Information:  Voice Vlan enable
  Voice Vlan security:  disable
 Voice Vlan lldp-med authentication:  disable
 Voice Vlan VID: 2, Cos: 7
 Default OUI number: 5
 User config OUI number: 1

 Voice vlan interface information:
  Interface            Mode
  -------------------------------------
  gi0/1                Auto-Mode

 Voice Vlan OUI information: Total: 6
   MacAddr          Mask             Name
  ---------------------------------------------------------------
  0001.0001.0000   ffff.ffff.0000   voice-vlan
  0003.6b00.0000   ffff.ff00.0000   Cisco-phone  default
  006b.e200.0000   ffff.ff00.0000   H3C-Aolynk-phone  default
  00d0.1e00.0000   ffff.ff00.0000   Pingtel-phone  default
  00e0.7500.0000   ffff.ff00.0000   Polycom-phone  default
  00e0.bb00.0000   ffff.ff00.0000   3Com-phone  default
```

Step 3: Check the result.

#The 802.1 priority of the packets that are sent to IP Phone is modified to 7, and the 802.1P priority of the packets sent by PC to IP Network is not modified.

#When the network is normal, IP Phone and PC can normally access IP Network.

#If the network is congested, IP Phone can access IP Network with a priority higher than PC.

29.3.3 Configure the Security Mode of Voice-VLAN

Network Requirements

- IP Phone and PC access IP Network through port gigabitethernet0/1 of Device. The MAC address of IP Phone is 0001.0001.0001, and the MAC address of PC is 0002.0002.0002.
- Configure the security mode of Voice-VLAN on the Device so that IP Phone rather than PC can normally access IP Network.

Network Topology

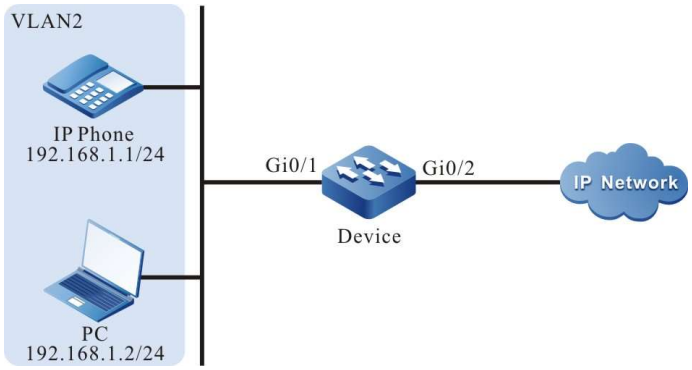


Figure 2 Network Topology for Configuring Security Mode of Voice-VLAN

Configuration Steps

Step 1: Configure the link type of VLAN and port.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 on the Device as Trunk, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode trunk
Device(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the link type of port gigabitethernet0/2 on the Device as Trunk, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure Voice-VLAN function.

#Configure VLAN2 as Voice-VLAN on the Device, and change corresponding value of Cos to 7.

```
Device(config)#voice vlan 2 cos 7
```

#Globally enable the security mode of Voice-VLAN on the Device.

```
Device(config)# voice vlan security enable
```

#Configure the automatic mode of Voice-VLAN on the port gigabitethernet0/1 of the Device.

```
Device(config)# interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#voice vlan enable
Device(config-if-gigabitethernet0/1)#voice vlan mode auto
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the OUI address which corresponds to the MAC address 0001.0001.0001 of IP Phone on the Device.

```
Device(config)#voice vlan oui-mac 0001.0001.0001 mask ffff.ffff.0000 name voice-vlan
```

#View the information of Voice-VLAN on the Device.

```
Device#show voice vlan all
 Voice Vlan Global Information:  Voice Vlan enable
 Voice Vlan security:  enable
 Voice Vlan lldp-med authentication:  disable
 Voice Vlan VID: 2, Cos: 7
 Default OUI number: 5
 User config OUI number: 1

 Voice vlan interface information:
  Interface            Mode
  -------------------------------------
  gi0/1                Auto-Mode

 Voice Vlan OUI information: Total: 6
  MacAddr         Mask            Name
  ---------------------------------------------------------------
  0001.0001.0000  ffff.ffff.0000  voice-vlan
  0003.6b00.0000  ffff.ff00.0000  Cisco-phone  default
  006b.e200.0000  ffff.ff00.0000  H3C-Aolynk-phone  default
  00d0.1e00.0000  ffff.ff00.0000  Pingtel-phone  default
  00e0.7500.0000  ffff.ff00.0000  Polycom-phone  default
  00e0.bb00.0000  ffff.ff00.0000  3Com-phone  default
```

Step 3: Check the result.

#The 802.1 priority of the packets that are sent to IP Phone is modified to 7.

#PC shall not access IP Network.

29.3.4 Configure the lldp-med Authentication Mode of Voice-VLAN

Network Requirements

- IP Phone (it can send the LLDP packets that carry voice field) and PC access IP Network through port gigabitethernet0/1 of the Device. The MAC address of IP Phone is 0001.0001.0001, and the MAC address of PC is 0002.0002.0002.
- Configure the lldp-med authentication mode of Voice-VLAN on the Device so that IP Phone rather than PC can normally access IP Network.

Network Topology

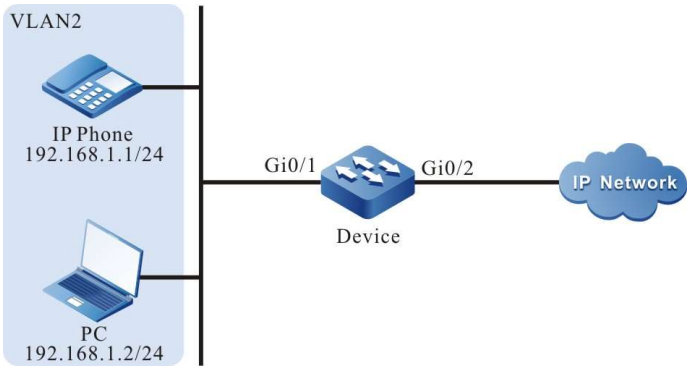


Figure 7-4 Network Topology for Configuration of lldp-med Authentication Mode of Voice-VLAN

Configuration Steps

Step 1: Configure the link type of VLAN and port.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 on the Device as Trunk, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode trunk
Device(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the link type of port gigabitethernet0/2 on the Device as Trunk, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure Voice-VLAN function.

#Configure VLAN2 as Voice-VLAN on the Device, and change corresponding value of Cos to 7.

```
Device(config)#voice vlan 2 cos 7
```

#Globally enable the lldp-med authentication mode of Voice-VLAN on the Device.

```
Device(config)#voice vlan lldp-med authentication
```

#Configure the automatic mode of Voice-VLAN on the port gigabitethernet0/1 of the Device.

```
Device(config)# interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#voice vlan enable
Device(config-if-gigabitethernet0/1)#voice vlan mode auto
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the OUI address which corresponds to the MAC address 0001.0001.0001 of IP Phone on the Device.

```
Device(config)#voice vlan oui-mac 0001.0001.0001 mask ffff.ffff.0000 name voice-vlan
```

#View the information of Voice-VLAN on the Device.

```
Device#show voice vlan all
 Voice Vlan Global Information:  Voice Vlan enable
Voice Vlan security:  disable
Voice Vlan lldp-med authentication:  enable
Voice Vlan VID: 2, Cos: 7
Default OUI number: 5
User config OUI number: 1

Voice vlan interface information:
 Interface            Mode
 ---------------------------------------
 gi0/1                Auto-Mode

Voice Vlan OUI information: Total: 6
 MacAddr         Mask            Name
 ------------------------------------------------------------
 0001.0001.0000  ffff.ffff.0000  voice-vlan
 0003.6b00.0000  ffff.ff00.0000  Cisco-phone  default
 006b.e200.0000  ffff.ff00.0000  H3C-Aolynk-phone  default
 00d0.1e00.0000  ffff.ff00.0000  Pingtel-phone  default
 00e0.7500.0000  ffff.ff00.0000  Polycom-phone  default
 00e0.bb00.0000  ffff.ff00.0000  3Com-phone  default

Voice Vlan lldp-med authenticated mac information:
 MacAddr         Interface
 ------------------------------------------------
 0001.0001.0001  gi0/1
```

Step 3: Check the result.

#The 802.1 priority of the packets that are sent to IP Phone is modified to 7.

#PC shall not access IP Network.

30 MAC Address Table Management

30.1 Overview

A MAC address entry consists of the MAC address of a terminal, the device port that is connected to the terminal, and the ID of the VLAN to which the port belongs. After a device receives a data packet, it matches the destination MAC address of the packet with the MAC address table entries that are saved in the device so as to locate a packet forwarding port efficiently.

MAC addresses are categorized into two types: dynamic MAC addresses and static MAC addresses. Static MAC addresses are categorized into static forwarding MAC addresses and static filtering MAC addresses.

Dynamic MAC address learning is the basic MAC address learning mode of the devices. Each dynamic MAC address entry has aging time. If no packet whose source MAC address matches a MAC address entry is received by the corresponding VLAN and port, the device deletes the MAC address entry.

The dynamic MAC address learning/forwarding process is as follows:

- When a device receives a packet, it searches the MAC address table of the corresponding VLAN for the MAC address entry that matches the source MAC address of the packet. If no corresponding matching entry is available, the source MAC address of the packet is written into the MAC address table, and the aging time timer of the new MAC address entry is started. If a matching MAC address entry is found, the aging time of the MAC address entry is updated.
- In the corresponding VLAN, the device searches the MAC address table for MAC address entry that matches the destination MAC address of the packet. If no matching entry is available, the packet is flooded to the other ports with the same VLAN ID. If a matching MAC address entry is available, the packet is forwarded through the specified port.

Static filtering MAC addresses are used to isolate devices which are aggressive, preventing the devices from communicating with external devices.

The configuration/forwarding process of static filtering MAC addresses is as follows:

- Static filtering MAC addresses can only be configured by users.
- If the source MAC address or destination MAC address of a packet matches a static filtering MAC address entry in the corresponding VLAN, the packet is discarded.

Static forwarding MAC addresses are used to control the routing principle of packets, and prevent frequent MAC address migration of MAC address entries in the table. MAC address migration means that: A device learns a MAC address from port A, then the device receives packets whose source MAC address is the same as the MAC address from port B, and port B and port A belong to the same VLAN. At this time, the forwarding port saved in the MAC address entry is updated from port A to port B.

The configuration/forwarding process of static forwarding MAC addresses is as follows:

- Static forwarding MAC addresses are configured by users.
- If the destination MAC address of a packet matches a static MAC address entry in the corresponding VLAN, the packet is forwarded through the specified port.

One port can learn the same MAC address from different VLANs, but one MAC address can only be learned by one port in one VLAN.

30.2 MAC Address Management Function Configuration

Table 30 MAC Address Management Function Configuration List

Configuration Task	
Configure management properties of MAC addresses.	Configure the MAC address aging time.
	Configure the MAC address learning capability.
Configure limitations on MAC address learning.	Configure limitations on port-based dynamic MAC address learning.
	Configure limitations on VLAN-based dynamic MAC address learning.
	Configure limitations on system-based dynamic MAC address learning.
Configure static MAC addresses.	Configure static filtering MAC addresses.
	Configure static forwarding MAC addresses that are bound to a port.
	Configure static forwarding MAC addresses that are bound to an aggregation group.
	Configure static forwarding MAC addresses of multiple output interfaces

30.2.1 Configure Management Properties of MAC Addresses

MAC address management properties include: MAC address aging time, and the MAC address learning capability of ports.

Each dynamic MAC address entry has aging time. If no packet whose source MAC address matches a MAC address entry is received by the specified VLAN, the device deletes the MAC address entry. If the specified VLAN receives a packet whose source MAC address matches a MAC address entry, the device resets the aging time of the MAC address entry.

Static MAC addresses can only be configured and deleted by users, so static MAC addresses cannot age.

If devices in the network have idle ports and the ports do not allow free use, then the MAC address learning capability can be disabled on the port. Then, the packets received by the port will all be discarded. In this way, these ports cannot access the network, and hence the security of the network is improved.

Configuration Condition

None

Configure the MAC Address Aging Time

The dynamic MAC address aging time set in a device takes effect globally. The value range of the MAC address aging time is:

- 0: MAC addresses do not age, that is, the learned dynamic MAC addresses do not age.
- 10-1000000: Aging time of dynamic MAC addresses. Unit: second. Default: 300.

If the aging time is configured too long, the MAC address table in the device may contain a large number of MAC address entries that are no long in use. In this way, the large number of invalid entries may use up MAC address resources, and new valid MAC address entries fail to be added to the device. If the aging time is configured too short, the device may frequently delete valid MAC address entries, affecting the device forwarding performance. Therefore, you need to configure a reasonable value for the aging time according to the actual environment.

Table 1 Configuring MAC Address Aging Time

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure the MAC address aging time.	**mac-address aging-time** *aging-time-value*	Mandatory By default, the MAC address aging time is set to 300 seconds.

Configure the MAC Address Learning Capability

MAC address learning capability can be enabled and disabled only for dynamic MAC address learning. By default, the MAC address learning capability is enabled on a port. Then the port learns MAC address entries and forwards corresponding packets. If the MAC address learning capability is enabled on a port, the port does not learn dynamic MAC addresses, and the received packets are discarded.

Table 2 Configuring MAC Address Learning Capability

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable the MAC address learning capability on a port or aggregation group.	**mac-address learning**	Mandatory By default, the MAC address learning capability is enabled on a port.

Configure the MAC Address Learning Function

MAC address learning function can be enabled and disabled for dynamic MAC address learning packet forwarding. By default, the MAC address learning function is enabled on a port. At this moment, the port can learn MAC address entries and forward packets. If the MAC address learning function is disabled on a port, the port does not learn dynamic MAC addresses, but can still forward packets.

Table 3 Configuring MAC Address Learning Function

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable the MAC address learning function on a port or aggregation group	**mac-address learning action forward**	Mandatory By default, the MAC address learning function is enabled on a port.

30.2.2 Configure Limitations on MAC Address Learning

Limitations on MAC address learning are categorized into two types: limitations on port-based dynamic MAC address learning and limitations on VLAN-based dynamic MAC address learning.

If a large number of dynamic MAC address entries have been learned by the device, it takes a long time for the device to search the MAC address table before forwarding packets, and this may cause degradation of the device performance. Therefore, you can configure limitations on dynamic MAC address learning to improve the device performance. If you configure limitations on dynamic MAC address learning on a port or VLAN, the number of access terminals can be controlled.

Configuration Condition

None

Configure Limitations on Port-based Dynamic MAC Address Learning

If the number of MAC address entries that have been learned by a port has reached the threshold value, the port discards the packets whose source MAC addresses are not in the MAC address forwarding table.

Table 30 Configuring Limitations on Port-based Dynamic MAC Address Learning

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure limitations on port-based dynamic MAC address learning.	**mac-address max-mac-count** *max-mac-count-value*	Mandatory By default, there are no limitations on dynamic MAC address learning on a port. The value range of the threshold of dynamic MAC address learning is 1-32767.

Note

- In configuring limitations on port-based dynamic MAC address learning, if the configured threshold value is smaller than the number of existing dynamic MAC address entries on the port, the device prompts to manually clear some existing dynamic MAC address entries. After the MAC addresses are cleared, the configuration takes effect immediately.

Configure Limitations on VLAN-based Dynamic MAC Address Learning

If the number of MAC address entries that have been learned by a specified VLAN has reached the threshold value, the VLAN discards the packets whose source MAC addresses are not in the MAC address forwarding table.

Table 4 Configuring Limitations on VLAN-based Dynamic MAC Address Learning

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure limitations on VLAN-based dynamic MAC address learning.	**mac-address vlan** *vlan-id* **max-mac-count** *max-mac-count-value*	Mandatory By default, there are no limitations to the dynamic MAC address learning in VLAN. The value range of the threshold of dynamic MAC address learning is 1-32767.

Note

- In configuring limitations on VLAN-based dynamic MAC address learning, if the configured threshold value is smaller than the number of existing dynamic MAC address entries in the current VLAN, the device prompts to manually clear some existing dynamic MAC address entries. After the MAC addresses are cleared, the configuration takes effect immediately.

30.2.3 Configure Static MAC Addresses

Static MAC addresses are categorized into two types: static forwarding MAC addresses and static filtering MAC addresses.

The configured MAC addresses must be legal unicast MAC addresses instead of broadcast, multicast, or all-0 addresses.

One MAC address can only be configured as a static forwarding MAC address or a static filtering MAC address in a VLAN.

Configuration Condition

None

Configure Static Filtering MAC Addresses

After static filtering MAC address entries are configured, if the source or destination MAC addresses of the packets that are received by the corresponding VLAN match static filtering MAC address entries, the

packets are discarded. This function prevents trustless devices from accessing the network, and prevents fraud and attacking activities of illegal users.

Table 30 Configuring Static Filtering MAC Address

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure static filtering MAC addresses.	**mac-address static** *mac-address-value* **vlan** *vlan-id* **drop**	Mandatory By default, there is no static filtering MAC address in the device.

Configure Static Forwarding MAC Addresses that are Bound to a Port

With static forwarding MAC address entries configured, after the corresponding VLAN receives packets, the port matches the destination MAC addresses of the packets with the static forwarding MAC address entries that are configured on the device. If they match successfully, the device forwards the packets through the specified port. This function helps to control the routing principle of packets more flexibly, and prevents frequent migration of MAC address entries in the table.

Table 5 Configuring Static Forwarding MAC Address Bound to a Port

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure static forwarding MAC addresses that are bound to a port.	**mac-address static** *mac-address-value* **vlan** *vlan-id* **interface** *interface-name*	Mandatory By default, no static forwarding MAC address is configured in the device.

Configure Static Forwarding MAC Addresses that are Bound to an Aggregation Group

With static forwarding MAC address entries configured, after the aggregation group receives packets, the port matches the destination MAC addresses of the packets with the static forwarding MAC address entries that are configured on the device. If they match successfully, the device forwards the packets through the specified aggregation group. This function helps to control the routing principle of packets more flexibly, and prevents frequent migration of MAC address entries in the table.

Table 6 Configuring Static Forwarding MAC Address Bound to an Aggregation Group

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure static forwarding MAC addresses that are bound to an aggregation group.	**mac-address static** *mac-address-value* **vlan** *vlan-id* **interface link-aggregation** *link-aggregation-id*	Mandatory By default, no static forwarding MAC address is configured in the device.

Note

- Before configuring the command, ensure that the specified aggregation group has been created.

30.2.4 MAC Address Management Monitoring and Maintaining

Table 7 MAC Address Management Monitoring and Maintaining

Command	Description
clear mac-address dynamic { *mac-address-value* **| all** / **interface** *interface-list* | **interface link-aggregation** *link-aggregation-id* | **vlan** *vlan-id* [*mac-address-value* / **interface** *interface-list* | **interface link-aggregation** *link-aggregation-id*] }	Clear the MAC address entries that are dynamically learned
show mac-address interface *interface-list* { **all** | **dynamic** | **static** [**config**] }	Show information of the MAC address entries on a port
show mac-address interface link-aggregation *link-aggregation-id* { **all** | **dynamic** | **static** [**config**] }	Show information of the MAC address entries in an aggregation group
show mac-address vlan *vlan-id* { **all** | **dynamic** | **static** [**config**] }	Show information of the MAC address entries in VLAN

Command	Description
show mac-address drop [*mac-address-value* | **config**]	Show information of the static filtering MAC address entries in the system
show mac-address dynamic [*mac-address-value*]	Show information of the dynamic MAC address entries in the system
show mac-address static [*mac-address-value* **| config**]	Show information of the static forwarding MAC address entries in the system
show mac-address system-mac	Show the MAC address used by the system
show mac-address { *mac-address-value* **| all** }	Show information of the MAC address entries in the system or the specified ones
show mac-address aging-time	Show information of the dynamic MAC address entry aging time
show mac-address max-mac-count { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* | **vlan** { *vlan-id* | **all** } }	Show information of the limitations on dynamic MAC address learning in the system
show mac-address count [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* | **vlan** *vlan-id*]	Show statistical information of the MAC address entries in the system

30.3 Function Configuration for Software Learning

30.3.1 Function Configuration for Software Learning

After the software learning function is enabled, the MAC address entries are learned through software.

Configuration Condition

None

Enable Software Learning Function

Table 8 Enabling Software Learning Function

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enable software learning function	**mac-address software-learning enable**	It is disabled by default.

Disable Software Learning Function

Table 9 Disabling Software Learning Function

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Disable software learning function	**no mac-address software-learning enable**	After the software learning function is disabled, the MAC address entries are learned through chip.

Note

- In standalone mode, it is hardware learning by default. Using this command to switch to software learning.
- In stack mode, it is software learning by default. Using this command to switch to hardware learning.

30.3.2 Monitoring and Maintenance of Software Learning Function

Table 10 Software Learning Monitoring and Maintaining

Command	Description
show mac-address software-learning	View whether the status of software learning is enabled or disabled

30.4 Configure Function of MAC Address Migration Log

30.4.1 Configure Function of MAC Address Migration Log

The function of MAC address migration log can be manually enabled and disabled. After this function is enabled, when any MAC address entry has address migration, an address migration log is recorded.

Configuration Condition

None

Enable the Function of MAC Address Migration Log

Table 11 Enabling Function of MAC Address Migration Log

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enable the function of address migration log	**mac-address move log**	Default On

Disable the Function of MAC Address Migration Log

Table 12 Disabling Function of MAC Address Migration Log

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Disable the function of address migration log	**no mac-address move log**	After the address migration log function is disabled, the log information is not recorded when the MAC address entries have address migration.

30.4.2 Monitoring and Maintenance of MAC Address Migration Log Function

Table 13 MAC Address Migration Monitoring and Maintaining

Command	Description
clear mac-address move log{*mac-address***}**	Clear MAC address migration log
show mac-address move config	View the information about configuration of MAC address migration log function.
show mac-address move log {*mac-address-value* | **count** *count* | **hardlearn** | **start-time** [*time*] **end-time** [*time*] **}**	View MAC address migration log.

31 Spanning Tree

31.1 Overview

IEEE 802.1D defines the standard Spanning Tree Protocol (STP) to eliminate network loops, preventing data frames from circulating or multiplying in loops, which may result in network congestion and affect normal communication in the network. Through the spanning tree algorithm, STP can determine where loops may exist in a network, block ports on redundant links, and trim the network into a tree structure in which no loops exist to prevent devices from receiving duplicated data frames. When the active path is faulty, STP recovers the connectivity of the blocked redundant links to ensure normal services. On the basis of STP, Rapid Spanning Tree Protocol (RSTP) and Multiple Spanning Tree Protocol (MSTP) are developed. The basic principles of the three protocols are the same, while RSTP and MSTP are improved versions of STP. Our company has implemented the VIST and Rapid-VIST spanning tree protocols that are compatible with Cisco's spanning tree. In particular, while improving the convergence performance, Rapid-VIST inherits the function of VIST loop removal.

In STP, the following basic concepts are defined:

- Root bridge: Root of the finally formed tree structure of a network. The device with the highest priority acts as the root bridge.
- Root Port (RP): The port which is nearest to the root bridge. The port is not on the root bridge, and it communicates with the root bridge.
- Designated bridge: If the device sends Bridge Protocol Data Unit (BPDU) configuration information to a directly connected device or directly connected LAN, the device is regarded as the designated bridge of the directly connected device or directly connected LAN.
- Designated port: The designated bridge forwards BPDU configuration information through the designated port.
- Path cost: It indicates the link quality, and it is related to the link rate. Usually, a higher link rate means a smaller path cost, and the link is better.

The devices that run STP implement calculation of the spanning tree by exchanging BPDU packets, and finally form a stable topology structure. BPDU packets are categorized into the following two types:

- Configuration BPDUs: They are also called BPDU configuration messages which are

used to calculate and maintain the spanning tree topology.

- Topology Change Notification (TCN) BPDUs: When the network topology structure changes, they are used to inform other devices of the change.

BPDU packets contain information that is required in spanning tree calculation. The major information includes:

- Root bridge ID: It consists of the root bridge priority and the MAC address.
- Root path cost: It is the minimum path cost to the root bridge.
- Designated bridge ID: It consists of the designated bridge priority and the MAC address.
- Designated port ID: It consists of the designated port priority and port number.
- Message Age: Life cycle of BPDU configuration messages while they are broadcast in a network.
- Hello Time: Transmitting cycle of BPDU configuration messages.
- Forward Delay: Delay in port status migration.
- Max Age: Maximum life cycle of configuration messages in a device.

The election process of STP is as follows:

- Initial status.

The local device takes itself as the root bridge to generate BPDU configuration messages and sends the messages. In the BPDU packets, the root bridge ID and designated bridge ID are the local bridge ID, and root path cost is 0, and the specified port is the transmitting port.

Each port of the device generates a port configuration message which is used for spanning tree calculation. In the port configuration message, the root bridge ID and the designated bridge ID are the local bridge ID, the root path cost is 0, and the specified port is the local port.

- Update port configuration messages.

After the local device receives a BPDU configuration message from another device, it compares the message with the port configuration message of the receiving port. If the received configuration message is better, the device uses the received BPDU configuration message to replace the port configuration message. If the port configuration message is better, the device does not perform any operation.

The principle of comparison is as follows: The root bridge IDs, root path cost, designated bridge IDs, designated port IDs, and receiving port IDs should be compared in order. The smaller value is better. If the values of previous item are the same, compare the next item.

- Select the root bridge.

The device that sends the optimal configuration message in the entire network is selected as the root bridge.

- Select port roles and port status.

All ports of the root bridge are designated ports, and the ports are in the Forwarding status. The designated bridge selects the optimal port configuration message from all ports. The receiving port of the message is selected as the root port, and the root port is in the Forwarding status. The other ports calculate designated port configuration messages according to the root port configuration message.

The calculation method is as follows: The root bridge ID is the route ID of the root port configuration message, the root path cost is the sum of the root path cost of the root port configuration message and the root port path cost, the designated bridge ID is the bridge ID of the local device, and the designated port is the local port.

Based on the port configuration message and the calculated designated port configuration message, determine port rules: If the designated port configuration message is better, the local port is selected as the designated port, and the port is in the Forwarding status. Then, the port configuration message is replaced by the designated port configuration message, and the designated port sends port configuration messages periodically at the interval of Hello Time. If the port configuration message is better, the port is blocked. The port is then in the Discarding status, and the port configuration message is not modified.

After the root bridge, root port, and designated port are selected, the tree structure network topology is set up successfully. Only the root port and the designated port can forward data. The other ports are in the Discarding status. They can only receive configuration messages but cannot send configuration messages or forward data.

If the root port of a non-root bridge fails to receive configuration messages periodically, the active path is regarded as faulty. The device re-generates a BPDU configuration message and TCN BPDU with itself as the root bridge and sends the messages. The messages causes re-calculation of the spanning tree and then a new active path is obtained.

Before receiving new configuration messages, the other devices do not find the network topology change, so their root ports and designated port still forward data through the original path. The newly selected root port and designated port migrate to the Forwarding status after two Forward Delay periods to ensure that the new configuration message has been broadcast to the entire network and prevent occurrence of temporary loops that may be caused if both old and new root ports and designate ports forward data.

RSTP defined in IEEE 802.1w is developed based on STP, and it is the improved version of STP. RSTP realizes fast migration of port status and hence shortens the time required for a network to set up stable topology. RSTP is improved in the following aspects:

- It sets a backup port, that is, alternate port, for the root port. If the root port is blocked, the alternate port can fast switch over to become a new root port.
- It sets a backup port, that is, backup port, for the designated port. If the designated port is blocked, the backup port can fast switch over to become a new designated port.
- In a point-to-point link of two directly-connected devices, the designated port can enter the Forwarding status without delay only after a handshake with the downstream bridge.

- Some ports are not connected to the other bridges or shared links, instead, they are directly connected with user terminals. These ports are defined as edge ports. The status changes of edge ports do not affect the network connectivity, so the ports can enter the Forwarding status without delay.

However, both RSTP and STP form a single spanning tree, which has the following shortages:

- Only one spanning tree is available in the entire network. If the network size is large, the network convergence takes a long time.
- Packets of all VLANs are forwarded through one spanning tree, therefore no load balancing is achieved.

MSTP defined in IEEE 802.1s is an improvement of STP and RSTP, and it is backward compatible with STP and RSTP. MSTP introduces the concept of region and instance. MSTP divides a network into multiple regions. Each region contains multiple instances, one instance can set up mapping with one or more VLANs, and one instance corresponds to one spanning tree. One port may have different port role and status in different instances. In this way, packets of different VLANs are forwarded in their own paths.

In MSTP, definition of the following concepts is added:

- MST domain: It consists of multiple devices in the switching network and the network between the devices. The devices in an MST domain must meet the following requirements: The spanning tree function has been enabled on the devices. They have the same MST domain, MSTP level, and VLAN mapping table. They are directly connected physically.
- Internal Spanning Tree (IST): It is the spanning tree of instance 0 in each domain.
- Common Spanning Tree (CST): If each MST domain is regarded as a device, then the spanning trees that connect MST domains are CSTs.
- Common and Internal Spanning Tree (CIST): It consists of the ISTs of MST domains and the CSTs between the MST domains. It is a single spanning tree that connects all devices in the network.
- Multiple Spanning Tree Instance (MSTI): Spanning trees in MST domains. Each instance has an independent MSTI.
- Common root: CIST root.
- Domain root: Root of each IST and MSTI in MST domains. In MST domains, each instance has an independent spanning tree, so the domain roots may be different. The root bridge of instance 0 is the domain root of the domain.
- Domain edge ports: They are located at the edge of an MST domain and they are used to connect ports of different MST domains.
- External path cost: It is the minimum path cost from a port to the common root.
- Internal path cost: It is the minimum path cost from a port to the domain root.
- Master port: It is the domain edge port with the minimum path cost to the common

root in an MST domain. The role of a master port in an MSTI is the same as its role in a CIST.

The election rule of MSTP is similar to that of STP, that is, electing the bridge with the highest priority in the network as the root bridge of CIST by comparing configuration messages. Each MST domain calculates its IST, and MST domains calculate CSTs, and all of the constructs CIST in the entire network. Based on mapping between VLANs and spanning tree instances, each MST domain calculates an independent spanning tree MSTI for each instance.

The CISCO's private spanning tree protocol defines two protocols, i.e. PVST and RPVST. Both of them introduce the concept of instance. One VLAN corresponds to one instance. In different instances, ports may have different port roles and statuses. On this basis, different VLAN packets can be forwarded by their own path.

New definitions and precautions of MSTP in mlag environment:

New definitions and precautions of MSTP in an MLAG environment:

- MLAG-MSTI: Instance MSTI corresponding to MLAG-VLAN;
- root priority: Priority of the root bridge specified by MLAG;
- bridge priority: Priority of the bridge specified by MLAG;
- stp-pseudo: Pseudo-information mode;

Restrictions on configuration of pseudo-information mode:

- The root priority (default value 0) of CIST and all MLAG-MSTIs in the pseudo-information must be higher than the bridge priority (default value 32768) of all bridges in the entire network (including MLAG node itself);
- In addition to ensuring that the partner node is the root bridge (optimal in the entire network), it is required to enable the root guard function on the access port of the MLAG node (all non-Peer-Link ports) (VIST mode does not support root guard yet) to prevent from causing errors in spanning tree calculations due to the receipt of BPDUs of higher priority.
- Bridge-Assurance function is required to be configured on the Peer-Link.
- For instances CIST and MLAG-MSTI, the root-priority of the two nodes should be the same, so that the two nodes appear as the same root bridge for both DHD and SD; in order to make the two nodes present as completely independent network bridges to SD for participation in the spanning tree calculation, the root-priority of the two nodes must be different.

31.2 Spanning Tree Function Configuration

Table 31 Spanning Tree Function Configuration List

Configuration Task	
Configure Basic Functions of a Spanning Tree	Enable the Spanning Tree Function
	Configure MST Domains
	Configure Spanning Tree Log Output Function
Configure Bridge Properties	Configure the Priority of a Bridge
	Configure Hello Time
	Configure Forward Delay
	Configure Max Age
	Configure the Maximum Number of Hops in an MST Domain
Configure Spanning Tree Port Properties	Configure the Priority of a Port
	Configure the Default Path Cost Standard for a Port
	Configure the Path Cost of a Port
	Configure BPDU Packet Length Check
	Configure the Maximum Length Value of BPDU Packets
	Configure the Maximum Transmitting Rate of BPDU Packets
	Configure Source MAC for BPDU Packets
	Configure Timeout Factor of BPDU Packets
	Configure an Edge Port
	Configure Automatic Detection of Edge Port
	Force Automatic Detection of Edge Port
	Configure the Port Link Type

Configuration Task	
Configure the Working Mode of a Spanning Tree	Configure the Working Mode of a Spanning Tree
Configure the Spanning Tree Protection Function	Configure the BPDU Guard Function
	Configure the BPDU Filter Function
	Configure the Flap Guard Function
	Configure the Loop Guard Function
	Configure the Root Guard Function
	Configure the TC Guard Function
	Configure the TC Protection Function

31.2.1 Configure Basic Functions of a Spanning Tree

Configuration Condition

None

Enable the Spanning Tree Function

After the spanning tree function is enabled, devices start to run the spanning tree protocol. The devices exchange BPDU packets to form a stable tree network topology, and network loops are eliminated.

Table 1 Enabling Spanning Tree Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enabling the spanning tree function globally.	**spanning-tree enable**	Mandatory By default, the spanning tree function is disabled globally.

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enabling the spanning tree function on a port.	**spanning-tree enable**	Optional By default, the spanning tree function is enabled on a port.

Configure MST Domains

Dividing an entire network into multiple MST domains helps to shorten the network convergence time. VLAN packets are transmitted through the corresponding MSTIs in MST domains and transmitted through CSTs between MST domains.

Table 31 Configuring MST Domain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the MST domain configuration mode.	**spanning-tree mst configuration**	-
Configure an MST domain name.	**region-name** *region-name*	Mandatory By default, the name of an MST domain is the MAC address of the local device.

Step	Command	Description
Configure the MSTP revision level.	**revision-level** *revision-level*	Mandatory By default, the MSTP revision level is 0.
Configure a VLAN mapping table.	**instance** *instance-id* **vlan** *vlan-list*	Mandatory By default, all VLANs are mapped to instance 0.
Activate MST domain parameter configuration.	**active configuration pending**	Mandatory By default, MST domain parameters do not take effect immediately after modification.

Note

- MST domain parameters do not take effect immediately after they are modified. Instead, you need to run the active configuration pending command to activate the parameters and trigger re-calculation of the spanning tree. To cancel MST domain parameter configuration, use the abort configuration pending command.

Configure Spanning Tree Log Output Function

After the spanning tree log output function is configured, when the port status changes or TC/TCN packets are received, the spanning tree directly outputs prompt logs on the device for users to quickly identify the changes of topology environment.

Table 31 Configuring Spanning Tree Log Output Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the spanning tree log output function	**spanning-tree log portstate**	Mandatory By default, the spanning tree log output function is disabled.

31.2.2 Configure Bridge Properties

Configuration Condition

None

Configure the Priority of a Bridge

The bridge priority and MAC address form the bridge ID. A smaller ID indicates a higher priority. The bridge with the highest priority is elected as the root bridge. One device may have different bridge priority in different spanning tree instances.

Table 31 Configuring Priority of a Bridge

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Priority of a Bridge	**spanning-tree mst instance** *instance-id* **priority** *priority-value*	Mandatory By default, the priority of the bridge in all spanning tree instances is 32768.
Configure the priority of a bridge under vist/rapid-vist mode	**spanning-tree vlan** *vlan-id* **priority** *priority-value*	Mandatory By default, the priority of the bridge in all spanning tree instances is 32768.

Note

- The step of bridge priorities is 4096, that is, the valid values include: 0, 4096, 8192, 12288, 16384, 20480, 24576, 28673, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440.

Configure Hello Time

After the network topology becomes stable, the root bridge sends BPDU packets at the interval of Hello Time to inform other bridges of its role as the root bridge so that the other bridges can recognize its role. The designated bridge maintains the existing spanning tree topology according to the BPDU packet, and it forwards the BPDU packet to other devices. Generally, the designated bridge does not receive BPDU packets in a period of time as long as three times timeout period (3*Hello Time), it regards the link as

faulty. In this way, the spanning tree re-calculates the network topology to obtain a new active path, ensuring the network connectivity.

Table 2 Configuring Hello Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Hello Time	**spanning-tree mst hello-time** *seconds*	Mandatory By default, Hello Time is 2 seconds.
Configure Hello Time under vist/rapid-vist mode	**spanning-tree vlan** *vlan-id* **hello-time** *seconds*	Mandatory By default, Hello Time is 2 seconds.

Note

- Forward Delay, Hello Time, and Max Age must meet the following requirement; otherwise, frequent network flapping may be cause.

  $2 \times (\text{Forward\_Delay} - 1.0\text{seconds}) \geq \text{Max\_Age}$

  $\text{Max\_Age} \geq 2 \times (\text{Hello\_Time} + 1.0\text{seconds})$

Configure Forward Delay

In STP, when the root port or designated port migrates from the Discarding status to the Forwarding status, the topology change cannot be learned by the entire network immediately. To prevent temporary loops, the port migrates to the Learning status in the first Forward Delay, and then waits another Forward Delay to migrate to the Forwarding status.

Table 3 Configuring Forward Delay Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Forward Delay	**spanning-tree mst forward-time** *seconds*	Mandatory

Step	Command	Description
		By default, Forward Delay is 15 seconds.
Configure Forward Delay Time under vist/rapid-vist mode	**spanning-tree vlan** *vlan-id* **forward-time** *seconds*	Mandatory By default, Forward Delay is 15 seconds.

Configure Max Age

Max Age refers to the life cycle of BPDU configuration messages while they are broadcast in a network. When a configuration message is transmitted crossing domains, after it passes through an MST domain, one is added to Message Age in the configuration message. If the device receives a configuration message and finds that the value of Message Age in the configuration message is larger than the value of Max Age, the device discards the configuration message, and the configuration message is no longer used in spanning tree calculation.

Table 4 Configuring Max Age Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Max Age	**spanning-tree mst max-age** *seconds*	Mandatory By default, Max Age is 20 seconds.
Configure Max Age Time under vist/rapid-vist mode	**spanning-tree vlan** *vlan-id* **max-age** *seconds*	Mandatory By default, Max Age is 20 seconds.

Configure the Maximum Number of Hops in an MST Domain

You can limit the size of an MST domain by configuring the maximum number of hops in the MST domain. A larger number of hops in an MST domain mean a larger MST domain. In one MST domain, starting from the domain root, once the configuration message is forwarded by a device, the number of hops is decreased by one. If the number of hops of a configuration message is 0, the device discards the configuration message. Therefore, the device which is beyond the maximum number of hops cannot participate in spanning tree calculation in the domain.

Table 5 Configuring Maximum Number of Hops in an MST Region

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Maximum Number of Hops in an MST Domain	**spanning-tree mst max-hops** *max-hops-value*	Mandatory By default, the maximum number of hops in an MST domain is 20.

31.2.3 Configure Spanning Tree Port Properties

Configuration Condition

None

Configure the Priority of a Port

A port ID consists of port priority and port index. Port ID affects election of the port role. A smaller port ID indicates a higher priority. One port may have different port priority in different spanning tree instances.

Table 6 Configuring Priority of a Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure the Priority of a Port	**spanning-tree mst instance** *instance-id* **port-priority** *priority-value*	Mandatory By default, the priority of the port in all spanning tree instances is 128.
Configure the priority of a port under vist/rapid-vist mode	**spanning-tree vlan** *vlan-id* **port-priority** *priority-value*	Mandatory By default, the priority of the port in all spanning tree instances is 128.

Note

- The step of port priorities is 16, that is, the valid values include: 0, 16, 32, 48, 64, 80, 96, 112, 128, 144, 160, 176, 192, 208, 224, and 240.

Configure the Default Path Cost Standard for a Port

Compared with the path cost calculated based on the IEEE 802.1D-1998 standard, the path cost calculated based on the IEEE 802.1T-2001 is larger. With the increase of the link rate, the path cost value quickly decreases.

Table 7 Configuring Default Path Cost Standard for a Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Default Path Cost Standard for a Port	s**panning-tree pathcost method** { **dot1D-1998 | dot1T-2001** }	Mandatory By default, the IEEE 802.1T-2001 standard is used to calculate the default path cost of the port.

Configure the Path Cost of a Port

The port path cost affects election of the port role. A smaller port path cost means a better link. One port may have different port path cost in different spanning tree instances.

Table 8 Configuring Port Path Cost

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the path cost of a port.	**spanning-tree mst instance** *instance-id* **cost** *cost-value*	Mandatory By default, the path cost is automatically calculated according to the port rate.
Configure the path cost of a port under vist/rapid-vist mode	**spanning-tree vlan** *vlan-id* **cost** *cost-value*	Mandatory By default, the path cost is automatically calculated according to the port rate.

Configure BPDU Packet Length Check

Configure the BPDU packet length check so that the port can check the length of the received BPDU packet to prevent attacks from BPDU packets of illegal length.

Table 9 Configuring BPDU Packet Length Check

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure BPDU Packet Length Check	**spanning-tree bpdu length-check**	Mandatory By default, the BPDU packet length check is disabled.

Configure the Maximum Length Value of BPDU Packets

The maximum length value of a legal BPDU packet when BPDU packet length check is configured.

Table 10 Configuring Maximum BPDU Packet Length

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Maximum Length Value of BPDU Packets	**spanning-tree bpdu max-length** *max-length*	Mandatory By default, the maximum length value is 1500 bytes.

Configure the Maximum Transmitting Rate of BPDU Packets

The maximum transmitting rate of BPDU packets limits the number of BPDU packets that can be transmitted during the Hello Time of a device. This prevents the device from sending too many BPDU packets which may cause frequent spanning tree calculation for other devices.

Table 11 Configuring Maximum BPDU Packet Transmitting Rate

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Maximum Transmitting Rate of BPDU Packets	**spanning-tree transmit hold-count** *hold-count-number*	By default, the port can send 6 BPDU packets at most in Hello Time.

Configure Source MAC Address Check for BPDU Packet

Configure source MAC address check for BPDU packet so that the port can check the source MAC address of the received BPDU packet to prevent attacks from BPDU packets of illegal device.

Table 12 Configuring Source MAC Check of BPDU Packet

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Source MAC for BPDU Packets	**spanning-tree bpdu src-mac-match** *src-mac*	Mandatory By default, the source MAC address check of BPDU packet is disabled on the port.

Configure Timeout Factor of BPDU Packets

In a stable network topology, designated port will send a BPDU packet to neighbored device every HELLO TIME. Usually if the device doesn't receive the BPDU packet from upper devices three times beyond HELLO TIME, it is considered that the network topology changes, which will start a spanning tree re-election.

However in a stable network topology, if the upper device can’t receive the BPDU packet in the case of busy or any other reason, it will start a spanning tree re-election. In this case, you can configure the timeout factor to avoid such calculation.

Table 13 Configuring Timeout Factor of BPDU Packet

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure time factor of BPDU packets	**spanning-tree timer-facor** *times-number*	By default, if the device doesn't receive the BPDU packet from upper devices three times beyond HELLO TIME, it is considered that the network topology changes, which will start a spanning tree re-election. In stacking environment, it is recommended to configure the timeout factor as 6.
Configure time factor of BPDU packet under vist/rapid-vist mode	**spanning-tree vlan** *vlan-id* **timer-facor** *times-number*	By default, if the device doesn't receive the BPDU packet from upper

Step	Command	Description
		devices three times beyond HELLO TIME, it is considered that the network topology changes, which will start a spanning tree re-election. In stacking environment, it is recommended to configure the timeout factor as 6.

Configure an Edge Port

Edge ports are the ports that are directly connected to user terminals. If an edge port is UP/DOWN, it does not cause temporary loops. Therefore, an edge port can quickly migrate from the Discarding status to the Forwarding status without delay time. In addition, if an edge port is UP/DOWN, it does not send TC BPDUs. This prevents unnecessary spanning tree re-calculation.

If an edge port receives BPDU packets, it becomes a non-edge port again. Then, the port can become the edge port again only after it is reset.

Table 14 Configuring Edge Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure an Edge Port	**spanning-tree portfast edgeport**	Mandatory By default, a port is a not an edge port.

Note

- Before an edge port is specified, please make sure that the port is directly connected to the user terminal. Otherwise, after an edge port is configured, a temporary loop may be introduced.

Configure Automatic Detection of Edge Port

Automatic detection of edge port can be configured to automatically identify the port connected to the terminal as an edge port. This can avoid spanning tree recalculation and thus network oscillation when the terminal device goes online and offline.

An edge port will become a non-edge port again after BPDU packets are received.

Table 15 Configuring Automatic Detection of Edge Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Automatic Detection of Edge Port	**spanning-tree portfast autoedge**	Mandatory By default, automatic detection of edge port function is enabled in standalone mode, and disabled in stack mode.

Force Automatic Detection of Edge Port

Affected by the configuration or environment, current port may be identified as an edge port or a non-edge port by mistake. At this moment, users can execute this command to trigger edge port detection so that the port can correctly identify whether it is an edge port.

Table 16 Configuring Function of Forcing Automatic Detection of Edge Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Force Automatic Detection of Edge Port	**spanning-tree portfast autoedge force**	Mandatory

Note

- This command can take effect only when the port has enabled automatic edge port detection.

Configure the Port Link Type

If two devices are directly connected, you can configure the port link type to point-to-point link. The ports of the point-to-point link type can quickly migrate from the Discarding status to the Forwarding status without delay time.

Table 17 Configuring Link Type of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure the Port Link Type	**spanning-tree link-type** { **point-to-point | shared** }	Mandatory By default, the port link type is set according to the port duplex mode. If the port works in the full duplex mode, the port is set to the point-to-point link type. If the port works in the half duplex mode, the port is set to the shared link type.

Note

- The link type of the port should be configured according to the actual physical link. If the actual physical link of the port is not a point-to-point link, configuration as point-to-point link may bring in temporary loops.
- When the local port has a shared link, it does not support automatic identification of edge port. If automatic identification of edge port is conducted for a peer port, the peer port may be identified as an edge port by mistake.

Configure Bridge Assurance Function of the Port

After the Bridge Assurance function is enabled on current port, the port will send BPDUs regardless of the spanning tree role (even if it is AlternatePort or BackupPort). If the port does not receive BPDU from the peer device for a consecutive period of time, the port status will switch to Blocking state and will not participate in the calculation of spanning tree. If BPDUs from the peer device are received later, current port will get back to normal for spanning tree calculation.

Table 18 Configuring Bridge Assurance Function of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure Bridge Assurance function of the port	**spanning-tree bridge-assurance enable**	Mandatory By default, the Bridge Assurance function of the port is disabled.

Note

Restrictions on configuration of Bridge-Assurance:

- It is mutually exclusive with the port's BPDU-Guard, BPDU-Filter, and Port-Fast (adminEdge, autoEdge). If the port is configured with one of these functions, it cannot configure Bridge-Assurance (a print prompt will be given).
- RP and AP in STP mode cannot send BPDUs at will, so the Bridge-Assurance configuration in STP mode is not effective, but it can be configured.

31.2.4 Configure the Working Mode of a Spanning Tree

The working mode of a spanning tree determines the mode in which devices run and determines the encapsulation format of BPDU packets that are sent out. If a port that works in the MSTP mode is found to be connected to a device that runs RSTP, the port automatically migrates to the RSTP mode. If a port that works in the MSTP mode or MSTP mode is found to be connected to a device that runs STP, the port automatically migrates to the STP compatible mode.

Configuration Condition

None

Configure the Working Mode of a Spanning Tree

Table 19 Configuring Working Mode of a Spanning Tree

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Working Mode of a Spanning Tree	**spanning-tree mode** { **stp | rstp | mstp | vist | rapid-vist**}	Mandatory By default, the working mode of spanning tree is MSTP.

31.2.5 Configure the Spanning Tree Protection Function

Configuration Condition

None

Configure the BPDU Guard Function

For an access layer device, the access port is usually directly connected to the user terminal or file server. At this time, the port is set to the edge port to realize fast migration of port statuses. When an edge port receives BPDU packets, it automatically changes to a non-edge port to cause re-generation of the spanning tree. Normally, an edge port does not receive BPDU packets. However, if someone sends faked BPDU packets to attack the device in a malicious manner, network flapping may be caused. The BPDU Guard function is used to prevent such attacks. If an edge port on which the BPDU Guard function is enabled receives BPDU packets, the port is closed.

Table 20 Configuring BPDU Guard Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure the BPDU Guard Function	**spanning-tree bpdu guard**	Mandatory By default, the BPDU Guard function is disabled.

Configure the BPDU Filter Function

After the BPDU Filter function is enabled on an edge port, the port does not send or receive BPDU packets.

Table 21 Configuring BPDU Filter Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the BPDU Filter Function	**spanning-tree bpdu filter**	Mandatory By default, the BPDU Filter function is disabled.

Configure the Flap Guard Function

In a stable topology environment, the root port is usually not changed. However, if the links in the network are not stable or the network experiences attacks with external BPDU packets, frequent switchover of root ports may be caused, and finally network flapping is caused.

The Flap Guard function prevent frequent switchover of root ports. After the Flap Guard function is enabled, if the root port role change frequency of a spanning tree instance exceeds the specified threshold, the root port of the instance enters the Flap Guard status. In this case, the root port is always in the Discarding status, and it starts normal spanning tree calculation only after the recovery time times out.

Table 22 Configuring Flap Guard Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the Flap Guard function	**spanning-tree flap-guard enable**	Mandatory By default, the Flap Guard function is disabled.
Configure the maximum times of change in root port allowed within the detection cycle	**spanning-tree flap-guard max-flaps** *max-flaps-number* **time** *seconds*	Optional By default, after the Flap Guard function is enabled, if a certain instance has 5 times of change in root port roles within 10 seconds, it will be under the Flap Guard status.
Configure the Flap Guard recovery time	**spanning-tree flap-guard recovery-time** *seconds*	Optional By default, Flap Guard can recover within 30 seconds.

Configure the Loop Guard Function

The local device maintains the statuses of the root port and other blocked ports according to the BPDU packets that are periodically sent by the upstream device. In the case of link congestion or unidirectional link failure, the ports fail to receive BPDU packets from the upstream device, the spanning tree message on the port times out. Then, the downstream devices re-elect port roles. The downstream device ports that fail to receive BPDU packets change to designated port, while blocked ports migrate to the Forwarding status, resulting in loops in the switching network.

The Loop Guard function can restrain generation of such loops. After the Loop Guard function is enabled on a port, if the port times out owing to the failure to receive BPDU packets from the upstream device, in re-calculating the port role, the port is set to the Discarding status, and the port does not participate in

spanning tree calculation. If an instance on the port receives BPDU packets again, the port participates in spanning tree calculation again.

Table 23 Configuring Loop Guard Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the Loop Guard Function	**spanning-tree guard** { **loop** | **root** | **none** }	Mandatory By default, the Loop Guard function of the port is disabled.

Note

- For Root Guard and Loop Guard of the port, only one function can be enabled.

Configure the Root Guard Function

The root bridge and backup root bridge of a spanning tree must be in the same domain, especially the CIST root bridge and its backup bridge. In network design, usually the CIST root bridge and its backup bridge are placed in the core domain with high bandwidth. However, owning to incorrect configuration or malicious attacks in the network, the legal root bridge in the network may receive a BPDU packet with a higher priority. In this way, the current legal bridge may lose its role as the root bridge, and improper change of the network topology is caused. The illegal change may lead the traffic that should be transmitted through a high-speed link to a low-speed link, causing network congestion.

The Root Guard function prevents occurrence of such case. If the Root Guard function is enabled on a port, the port can only act as the designated port in all instances. If the port receives a better BPDU configuration message, the port is set to the Discarding status. If it does not receive better BPDU configuration message in a period of time, the port resumes its previous status. It is recommended that you enable the Root Guard function on the specified port of the root bridge.

Table 24 Configuring Root Guard Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the Root Guard Function	**spanning-tree guard** { **loop** | **root** | **none** }	Mandatory By default, the Root Guard function of the port is disabled.

Note

- For Root Guard and Loop Guard of the port, only one function can be enabled.

Configure the TC Guard Function

When a device detects a network topology change, a TC packet will be generated to notify other devices in the environment that the network topology has changed. When the device receives the TC packet, it will refresh the address. When the topology is unstable or a TC packet is manually created to launch an attack,

TC will frequently appear on the network, causing repeated address refresh of the device. This affects calculation of the spanning tree and leads to a high CPU occupancy.

TC Guard can effectively prevent this from happening. After the TC Guard is configured on current port, when the device receives the TC packet, it will no longer process the TC flag therein or spread TC, which can effectively prevent the TC packet from impacting the network.

Table 25 Configuring TC Guard Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the TC Guard Function	**spanning-tree tc-guard enable**	Mandatory By default, the TC Guard function of the port is disabled.

Configure the TC Protection Function

If the network topology changes, to ensure normal forwarding of service data during the topology change process, when devices handle TC packets, they will refresh the MAC addresses. Attacks with faked TC packets may cause the devices to refresh MAC addresses frequently. This affects calculation of the spanning tree and leads to a high CPU occupancy.

The TC protection function prevents occurrence of such case. After the TC protection function is enabled, once a TC packet is received within the TC protection interval, the TC counter counts one. If the TC counter is equal to or larger than the threshold, it enters a suppressed status. Then, the devices do not refresh MAC addresses in handling later TC packets. After the TC protection interval, the suppressed status is changed to the normal status, and the TC counter is cleared and started again.

Table 26 Configuring TC Protection Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the TC protection function	**spanning-tree tc-protection enable**	Optional By default, the TC protection function is enabled.
Configure the time interval of TC protection	**spanning-tree tc-protection interval** *seconds*	Mandatory By default, the time interval of TC protection is 4 seconds.
Configure the threshold value of TC protection	**spanning-tree tc-protection threshold** *threshold-value*	Mandatory By default, the threshold value of TC protection is 1.

31.2.6 Configure the Function of Configuring Pseudo-information of Spanning Tree

Configuration Condition

When the pseudo-information of spanning tree is applied in the MALG environment, on the MLAG virtual node, the conventional priority configuration method of spanning tree will not take effect. The priority of corresponding instance of the MLAG node is modified by configuring pseudo-information of spanning tree. At this moment, the instance priority information of the BPDU sent by MLAG GROUP is the pseudo-information of spanning tree configured. For the two MLAG node devices, it seems the spanning tree calculation for one device. Please note that during configuration, the pseudo-information configuration of the spanning tree on the MLAG master and standby devices should be consistent, and the configured parameters in the pseudo-information configuration mode only take effect in the MLAG environment.

Configure Specified Root Bridge Priority of the Instance

Configure the root bridge priority of the specified spanning tree instance in pseudo-information.

Table 27 Configuring Specified Root Bridge Priority of Instance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure to enter pseudo-information	**spanning-tree pseudo-information**	Mandatory
Configure the root bridge priority of the specified spanning tree instance	**mst instance** *instance-id* root-priority *priority-value*	Mandatory By default, the root bridge priority of each spanning tree instance in the pseudo-information is 0 (i.e. highest priority). *instance-id*: Spanning tree instance ID, value range 0~63 *priority-value*: Configure the root bridge priority of the device in the specified spanning tree instance. The smaller the value, the higher the priority will become.

Note

- The step of root bridge priorities is 4096, that is, the valid values include: 0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440.
- On the MLAG paired device, the two devices must be consistent in terms of the root bridge priorities of all instances configured in the pseudo information.

Configure Specified Bridge Priority of the Instance

Configure the specified bridge priority of the specified spanning tree instance in pseudo-information.

Table 28 Configuring Specified Bridge Priority of Instance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure to enter pseudo-information	**spanning-tree pseudo-information**	Mandatory
Configure the specified bridge priority of the specified spanning tree instance in pseudo-information	**mst instance** *instance-id* **designated-priority** *priority-value*	Mandatory By default, the specified bridge priority of each spanning tree instance in the pseudo-information is configured as 32768. *instance-id*: Spanning tree instance ID, value range 0~63 *priority-value*: Configure the root bridge priority of the device in the specified spanning tree instance. The smaller the value, the higher the priority will become.

Note

- The step of the specified bridge priorities is 4096, that is, the valid values include: 0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440.

Configure the Root Bridge Priority of the Specified VLAN List

Configure the root bridge priority of the device in the specified VLAN list.

Table 29 Configuring Root Bridge Priority of Specified VLAN List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to enter pseudo-information	**spanning-tree pseudo-information**	Mandatory
Configure the root bridge priority of the device in the specified VLAN list	**vist vlan** *vlan-list* **root-priority** *priority-value*	Mandatory By default, the root bridge priority of each VLAN in the pseudo-information is 0 (i.e. highest priority). *priority-value*: Configure the root bridge priority of the device in the specified spanning tree instance. The smaller the value, the higher the priority will become.

Note

- The step of root bridge priorities is 4096, that is, the valid values include: 0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440.
- On the MLAG paired device, the two devices must be consistent in terms of the root bridge priorities of all VLANs configured in the pseudo information.

Configure the Bridge Priority of the Specified VLAN List

Configure the bridge priority of the device in the specified VLAN list.

Table 30 Configuring Bridge Priority of Specified VLAN List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure to enter pseudo-information	**spanning-tree pseudo-information**	Mandatory
Configure bridge priority of the device in the specified VLAN list	**vist vlan** *vlan-list* **designated-priority** *priority-value*	Mandatory By default, the specified bridge priority of each spanning tree instance in the pseudo-information is configured as 32768. *priority-value*: Configure the root bridge priority of the device in the specified spanning tree instance. The smaller the value, the higher the priority will become.

Note

- The step of the specified bridge priorities is 4096, that is, the valid values include: 0, 4096, 8192, 12288, 16384, 20480, 24576, 28672, 32768, 36864, 40960, 45056, 49152, 53248, 57344, and 61440.

31.2.7 Spanning Tree Monitoring and Maintaining

Table 31 Spanning Tree Monitoring and Maintaining

Command	Description
clear spanning-tree detected-protocols	Perform mCheck operation on the global or specified port

Command	Description
clear spanning-tree bpdu statistics [**interface** *interface-name* **| interface link-aggregation** *link-aggregation-id*]	Clear BPDU-related statistical information on the global or specified port
show spanning-tree [**detail**]	Show basic information of the spanning tree
show spanning-tree guard [**current** [**interface** *interface-name* **| interface link-aggregation** *link-aggregation-id*]]	Show configuration and status information of the spanning tree protection function on the port
show spanning-tree { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* } [**detail**]	Show spanning tree status information of the specified port or aggregation group
show spanning-tree mst [**configuration** [**current | pending**] | **detail | instance** *instance-id* [**detail**] | { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* } [**instance** *instance-id*]]	Show spanning tree configuration and status information
show configuration { **current | pending** }	Show related configuration of MST Domain
show spanning-tree vlan *vlan-id* [**detail**]	Show spanning tree status information of the specified vlan in vist/rapid-vist mode

31.3 Spanning Tree Typical Configuration Example

31.3.1 MSTP Typical Application

Network Requirements

- Four devices in the network are in the same MST domain. Device1 and Device2 are convergence layer devices, while Device3 and Device4 are access layer devices.
- To reasonably balance traffic on the links to realize load sharing and redundancy backup, configure packets of VLAN2 to be forwarded following instance 1. The root bridge of instance 1 is Device1. Packets of VLAN3 are forwarded following instance 2. The root bridge of instance 2 is Device2. Packets of VLAN4 are forwarded following instance 0.

Network Topology

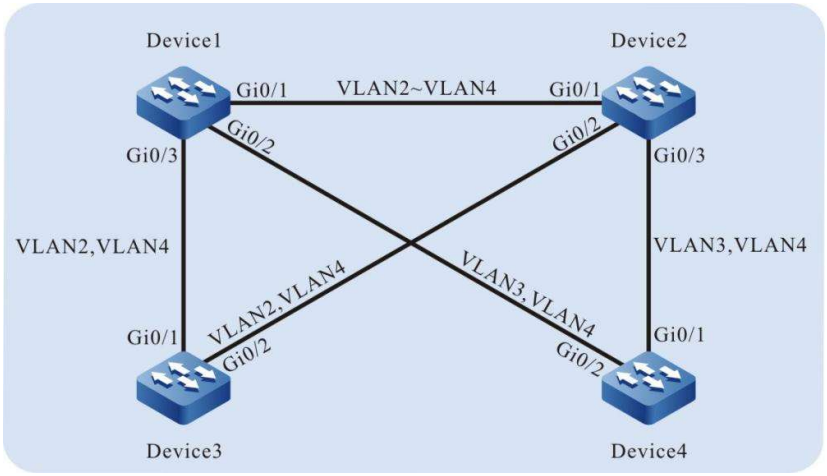


Figure 31 Network Topology for Typical Application of MSTP

Configuration Steps

Step 1: Configure VLANs, and configure the link type of the ports.

#On Device1, create VLAN2-VLAN4, configure the link type of port gigabitethernet0/1 to Trunk and allow services of VLAN2-VLAN4 to pass.

```
Device1(config)#vlan 2-4
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#switchport mode trunk
Device1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2-4
Device1(config-if-gigabitethernet0/1)#exit
```

#On Device1, configure the link type of port gigabitethernet0/2 as Trunk and allow services of VLAN3 and VLAN4 to pass. Configure the link type of port gigabitethernet0/3 as Trunk and allow services of VLAN2 and VLAN4 to pass. (Omitted)

#On Device2, create VLAN2-VLAN4. Configure the link type of ports gigabitethernet0/1-gigabitethernet0/3 to Trunk, configure gigabitethernet0/1 to allow services of VLAN2-VLAN4 to pass, gigabitethernet0/2 to allow services of VLAN2 and VLAN4 to pass, and gigabitethernet0/3 to allow services of VLAN3 and VLAN4 to pass. (Omitted)

#On Device3, create VLAN2 and VLAN4. Configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, allowing the services of VLAN2 and VLAN4 to pass. (Omitted)

#On Device4, create VLAN3 and VLAN4. Configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk and allow services of VLAN3 and VLAN4 to pass. (Omitted)

Step 2: Configure an MST domain.

#On Device1, configure an MST domain. Set the domain name to admin, the revision level to 1, map instance 1 to VLAN2, map instance 2 to VLAN3, and activate the MST domain.

```
Device1#configure terminal
Device1(config)#spanning-tree mst configuration
Device1(config-mst)#region-name admin
Device1(config-mst)#revision-level 1
Device1(config-mst)#instance 1 vlan 2
Device1(config-mst)#instance 2 vlan 3
Device1(config-mst)#active configuration pending
Device1(config-mst)#exit
```

Note

- The MST domain configuration of Device2, Device3, and Device 4 is the same as that of Device1. (Omitted)

#On Device1, configure the priority of MSTI 1 to 0. On Device2, configure the priority of MSTI 2 to 0.

```
Device1(config)#spanning-tree mst instance 1 priority 0
Device2(config)#spanning-tree mst instance 2 priority 0
```

#On Device1, enable the spanning tree globally.

```
Device1(config)#spanning-tree enable
```

Note

- The configuration for enabling the spanning tree globally on Device2, Device3, and Device 4 is the same as that on Device1. (Omitted)

Step 3: Check the result.

#After the network topology is stable, check the calculation result of all spanning tree instances.

```
Device1#show spanning-tree mst
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped: 1,4-4094
 Bridge              address 0000.0000.008b priority 32768
 Region root         address 0000.0000.008b priority 32768
   Designated root       address 0000.0000.008b priority 32768
                    root: 0, rpc: 0, epc: 0, hop: 20
 Operational  hello time 2, forward time 15, max age 20
 Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 6
 Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
 Tc protection: admin true, threshold 3, interval 2s, rxTcCnt 0, status:NORMAL
 Bpdu length-check:  false, bpdu illegal length packets count: 0
 Autoedge swap-check: true
 Swap-delay time: 30
 Configured timer factor: 3
 Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
```

```
        Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- --------------------------
gi0/1                Desg  FWD     20000    128.001 P2P
gi0/2                Desg  FWD     20000   128.002 P2P
gi0/3                Desg  FWD     20000   128.003 P2P
MST Instance 01         vlans mapped: 2
 Bridge ID             address 0000.0000.008b priority 1/0
 Designated root       address 0000.0000.008b priority 1
                  root: 0, rpc: 0, hop: 20
Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
        Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- --------------------------
gi0/1                Desg  FWD     20000   128.001 P2P
gi0/3                Desg  FWD     20000   128.003 P2P
MST Instance 02         vlans mapped: 3
 Bridge ID             address 0000.0000.008b priority 32770/32768
 Designated root       address 0001.7a54.5c96 priority 2
                  root: 32769, rpc: 20000, hop: 19
Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
        Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- --------------------------
gi0/1                Root  FWD     20000   128.001 P2P
gi0/2                Desg  FWD     20000   128.002 P2P
```

#On Device2, query the calculation result of all spanning tree instances. According to the result, port gigabitethernet0/2 of Device2 is blocked in both instance 0 and instance 1.

```
Device2#show spanning-tree mst
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped:  1,4-4094
 Bridge               address 0001.7a54.5c96 priority 32768
 Region root          address 0000.0000.008b priority 32768
   Designated root       address 0000.0000.008b priority 32768
                  root: 32769, rpc: 20000, epc: 0, hop: 19
 Operational  hello time 2, forward time 15, max age 20
 Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 6
 Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
 Tc protection: admin true, threshold 3, interval 2s, rxTcCnt 0, status:NORMAL
 Bpdu length-check: false, bpdu illegal length packets count: 0
 Autoedge swap-check: true
 Swap-delay time: 30
 Configured timer factor: 3
 Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
        Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- --------------------------
gi0/1                Root  FWD     20000   128.001 P2P
gi0/2                Alte  DIS     20000   128.002 P2P
gi0/3                Desg  FWD     20000   128.003 P2P
MST Instance 01         vlans mapped:  2
 Bridge ID             address 0001.7a54.5c96 priority 32769/32768
 Designated root       address 0000.0000.008b priority 1
                  root: 32769, rpc: 20000, hop: 19
Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
        Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- --------------------------
gi0/1                Root  FWD     20000   128.001 P2P
gi0/2                Alte  DIS     20000   128.002 P2P
MST Instance 02         vlans mapped:  3
 Bridge ID             address 0001.7a54.5c96 priority 2/0
 Designated root       address 0001.7a54.5c96 priority 2
                  root: 0, rpc: 0, hop: 20
Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
        Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- --------------------------
gi0/1                Desg  FWD     20000   128.001 P2P
gi0/3                Desg  FWD     20000   128.003 P2P
```

#On Device3, query the calculation result of all spanning tree instances.

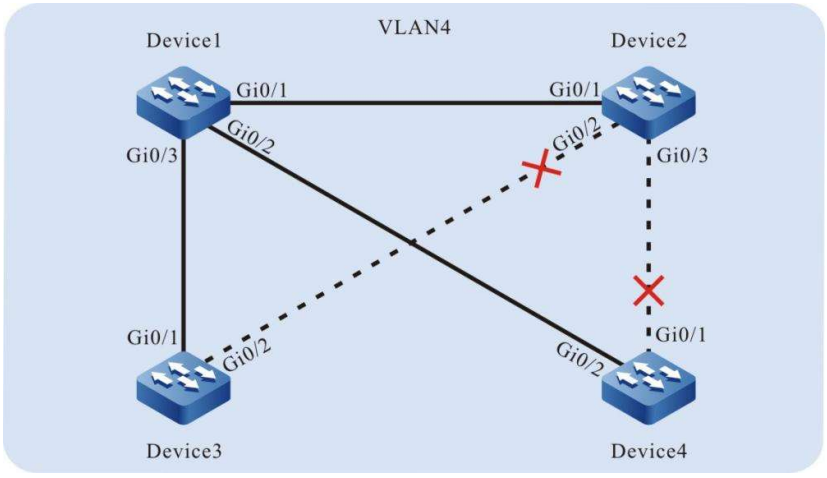
```
Device3#show spanning-tree mst
```

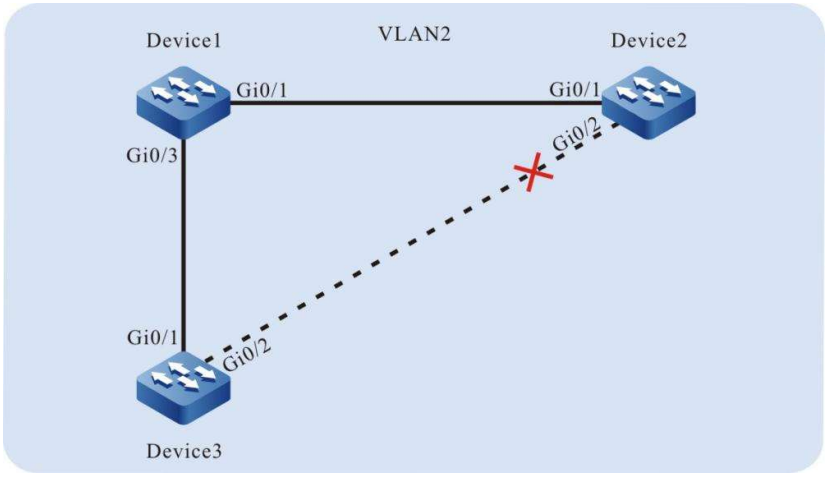
```
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped: 1,4-4094
 Bridge               address 0000.0305.070a priority 32768
 Region root          address 0000.0000.008b priority 32768
   Designated root       address 0000.0000.008b priority 32768
                      root: 32769, rpc: 20000, epc: 0, hop: 19
 Operational  hello time 2, forward time 15, max age 20
 Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 6
 Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
 Tc protection: admin true, threshold 3, interval 2s, rxTcCnt 0, status:NORMAL
 Bpdu length-check: false, bpdu illegal length packets count: 0
 Autoedge swap-check: true
 Swap-delay time: 30
 Configured timer factor: 3
 Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
         Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- ---------------------------
gi0/1                 Root  FWD     20000   128.001 P2P
gi0/2                Desg  FWD     20000   128.002 P2P
MST Instance 01         vlans mapped: 2
 Bridge ID            address 0000.0305.070a priority 32769/32768
 Designated root       address 0000.0000.008b priority 1
                      root: 32769, rpc: 20000, hop: 19
Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
         Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- ---------------------------
gi0/1                Root  FWD      20000   128.001 P2P
gi0/2                Desg  FWD     20000   128.002 P2P
```

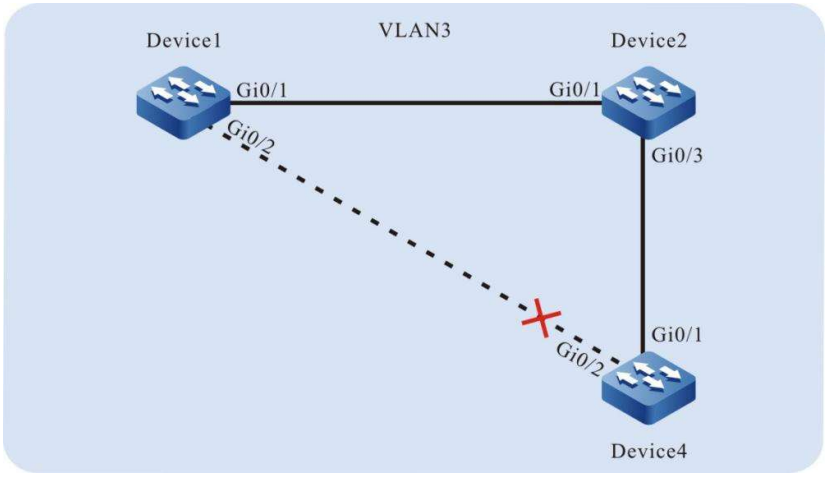
#On Device4, query the calculation result of all spanning tree instances. According to the result, port gigabitethernet0/1 of Device4 is blocked in instance 0, and port gigabitethernet0/2 is blocked in instance 2.

```
Device4#show spanning-tree mst
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped:  1,4-4094
 Bridge               address 0001.7a58.dc0c priority 32768
 Region root          address 0000.0000.008b priority 32768
   Designated root       address 0000.0000.008b priority 32768
                      root: 32769, rpc: 20000, epc: 0, hop: 19
 Operational  hello time 2, forward time 15, max age 20
 Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 6
 Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
 Tc protection: admin true, threshold 3, interval 2s, rxTcCnt 0, status:NORMAL
 Bpdu length-check: false, bpdu illegal length packets count: 0
 Autoedge swap-check: true
 Swap-delay time: 30
 Configured timer factor: 3
 Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
         Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- ---------------------------
gi0/1                Alte  DIS     20000   128.001 P2P
gi0/2                 Root  FWD     20000   128.002 P2P
MST Instance 02         vlans mapped:  3
 Bridge ID            address 0001.7a58.dc0c priority 32770/32768
 Designated root       address 0001.7a54.5c96 priority 2
                      root: 32769, rpc: 20000, hop: 19
Topology Change Count:4, last change occured:0 hour 1 minute 0 second(60 seconds)
         Interface  Role  Sts      Cost  Prio.Nbr Type
-------------------- ----- ---- --------- --------- ---------------------------
gi0/1                 Root  FWD    20000   128.001 P2P
gi0/2                Alte  DIS    20000   128.002 P2P
```

Based on the spanning tree calculation result of the four devices, the tree diagrams corresponding to MSTI 0 (mapped to VLAN4), MSTI 1 (mapped to VLAN2), and MSTI 2 (mapped to VLAN3) are obtained.







31.3.2 Application of Basic MSTP Functions in the MLAG Environment

Network Requirements

- The 4 devices on the network are within the same MST domain, with the network bridge priority of MLAG device being the highest.

Network Topology

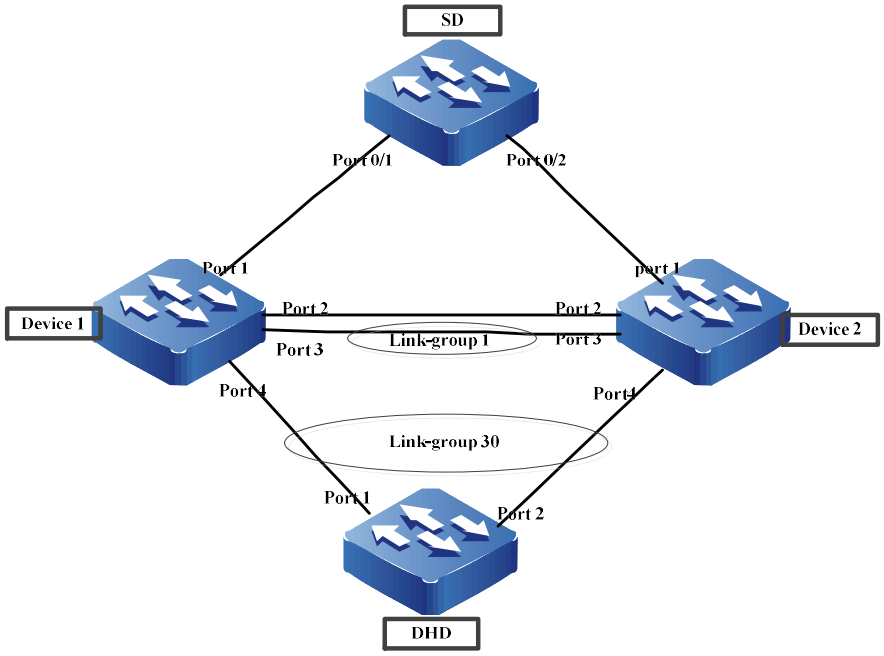


Figure 1 Network Topology for Application of MSTP in MLAG

Configuration Steps

Step 1: Add the interface into the aggregation group and vlan. (Omitted)

Step 2: Configure MLAG domain. (Omitted)

Step 3: Configure MST domain

#On Device1, configure an MST domain. Set the domain name to admin and revision level to 1, and activate the MST domain.

```
Device1#configure terminal
Device1(config)#spanning-tree mst configuration
Device1(config-mst)#region-name admin
Device1(config-mst)#revision-level 1
Device1(config-mst)#active configuration pending
Device1(config-mst)#exit
```

Note

- The MST domain configuration of Device2, SD, and DHD is the same as that of Device1.

(Omitted)

View information about the spanning tree of each device

#Convergence 1 on #DEVICE1 and DEVICE2 is an inline port

```
Device1#show spanning-tree
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped: 1-4094
Bridge                  address 0001.7a95.000b priority 0
Region root             address 0001.7a95.000b priority 0
Designated root         address 0001.7a95.000b priority 0
                        root: 0, rpc: 0, epc: 0, hop: 20
                        We are the root of the spanning tree
Operational  hello time 2, forward time 15, max age 20, message age 0
Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 10
Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
Tc protection: admin true, threshold 2, interval 20s, rxTcCnt 0, status:NORMAL
ARL flush: enabled
Bpdu length-check: false, bpdu illegal length packets count: 0
Autoedge swap-check: true
Swap-delay time: 30
Configured timer factor: 3
Topology Change Count:6, last change occured:118 weeks 5 days(71863322 seconds)
Interface            Role  Sts  Cost       Prio.Nbr  Type
-------------------- ----- ---- ---------- ---------- --------------------------
te0/1              Desg  FWD  20000      128.0036 P2P
link-agg1            Desg  FWD  1950       128.0193 P2P (MLAG peer-link)
link-agg30           Desg  FWD  19500      128.0222 P2P (MLAG 100)

Device2#show spanning-tree
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped: 1-4094
Bridge                  address 0001.7a95.000b priority 0
Region root             address 0001.7a95.000b priority 0
Designated root         address 0001.7a95.000b priority 0
                        root: 0, rpc: 0, epc: 0, hop: 20
                        We are the root of the spanning tree
Operational  hello time 2, forward time 15, max age 20, message age 0
Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 6
Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
Tc protection: admin true, threshold 1, interval 4s, rxTcCnt 0, status:NORMAL
```

```
ARL flush: enabled
Bpdu length-check: false, bpdu illegal length packets count: 0
Autoedge swap-check: true
Swap-delay time: 30
Configured timer factor: 3
Topology Change Count:7, last change occured:118 weeks 4 days(71776558 seconds)
Interface           Role  Sts  Cost       Prio.Nbr  Type
------------------- ----- ---- ---------- ---------- --------------------------
gi0/1               Desg  FWD  20000      128.0332 P2P
link-agg1           IRoot FWD  1950       128.0385 P2P (MLAG peer-link)
link-agg30          Desg  FWD  19500      128.0414 P2P (MLAG 100)
```

#The port spanning tree where SD connects to Device2 is calculated as block, and the mlag-group connected to DHD as Root

```
SD#show spanning-tree
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped: 1-4094
Bridge                  address 0001.7a7a.3c10 priority 32768
Region root             address 0001.7a95.000b priority 0
Designated root         address 0001.7a95.000b priority 0
                        root: 32804, rpc: 20000, epc: 0, hop: 19
Operational  hello time 2, forward time 15, max age 20, message age 0
Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 6
Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
Tc protection: admin true, threshold 1, interval 4s, rxTcCnt 0, status:NORMAL
ARL flush: enabled
Bpdu length-check: false, bpdu illegal length packets count: 0
Autoedge swap-check: true
Swap-delay time: 30
Configured timer factor: 1
Topology Change Count:36, last change occured:118 weeks 5 days(71863036 seconds)
Interface           Role  Sts  Cost       Prio.Nbr  Type
------------------- ----- ---- ---------- ---------- --------------------------
gi0/1               Root  FWD  20000      128.0012 P2P
gi0/2               Alte  DIS  20000      128.0036 P2P

DHD#show spanning-tree
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped: 1-4094
Bridge                  address 0001.7a6a.0148 priority 32768
```

```
Region root            address 0001.7a95.000b priority 0
Designated root        address 0001.7a95.000b priority 0
                    root: 33662, rpc: 18000, epc: 0, hop: 19
Operational  hello time 2, forward time 15, max age 20, message age 0
Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 6
Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
Tc protection: admin true, threshold 1, interval 4s, rxTcCnt 0, status:NORMAL
ARL flush: enabled
Bpdu length-check: false, bpdu illegal length packets count: 0
Autoedge swap-check: true
Swap-delay time: 30
Configured timer factor: 6
Topology Change Count:20, last change occured:118 weeks 5 days(71863409 seconds)
Interface            Role  Sts  Cost       Prio.Nbr  Type
-------------------- ----- ---- --------- ---------- --------------------------
link-agg30           Root  FWD  18000      128.0894 P2P
```

Step 4: Modify the specified bridge priority of Device2 so that the blocked port of SD is calculated as 0/1.

```
Device2#conf t
Device2(config)#spanning-tree pseudo-information
Device2 (config-stp-pseudo)#mst instance 0 designated-priority 4096

SD# show spanning-tree
Spanning-tree enabled protocol mstp
MST Instance 00         vlans mapped: 1-4094
Bridge                address 0001.7a7a.3c10 priority 32768
Region root            address 0001.7a95.000b priority 0
Designated root        address 0001.7a95.000b priority 0
                    root: 32780, rpc: 20000, epc: 0, hop: 19
Operational  hello time 2, forward time 15, max age 20, message age 0
Configured   hello time 2, forward time 15, max age 20, max hops 20, hold count 6
Flap guard : admin false, max count 5, detect period 10s, recovery period 30s
Tc protection: admin true, threshold 1, interval 4s, rxTcCnt 0, status:NORMAL
ARL flush: enabled
Bpdu length-check: false, bpdu illegal length packets count: 0
Autoedge swap-check: true
Swap-delay time: 30
Configured timer factor: 1
Topology Change Count:37, last change occured:118 weeks 5 days(71864200 seconds)
Interface            Role  Sts  Cost       Prio.Nbr  Type
```

```
-------------------- ----- ---- --------- ---------- --------------------------
gi0/1              Root  FWD  20000       128.0012 P2P
gi0/2              Alte  DIS  20000       128.0036 P2P
```

Step 5: Enable BA function on the inline port of Device1 and Device2

```
Device1(config)#interface link-aggregation 1
Device1(config-if-link-aggregation1)#spanning-tree bridge-assurance enable
Device2(config)#interface link-aggregation 1
Device2(config-if-link-aggregation1)#spanning-tree bridge-assurance enable
```

32 Loopback Detection

32.1 Overview

In the Ethernet, if the destination of some packet fails to be recognized, they will be flooded in a VLAN. If a loop exists in the network, the packets circulate and multiply without limit, and finally they will use up the bandwidth. Then, the network fails to provide normal communication.

There are two types of loops, loop between different ports of a device, and loop on one port of a device. The two types of loops can be detected through loopback detection.

After the loopback detection function is enabled, a port sends loopback detection packets at intervals in the VLAN to which it has been added to check whether a loop exists in the network. When a port receives a loopback detection packet that the local device sent, it determines that a loop exists in the network. Then, the port is disabled to prevent the local loop from affecting the entire network.

32.2 Loopback Detection Function Configuration

Table 32 Loopback Detection Function Configuration List

Configuration Task	
Configure basic functions of loopback detection.	Enable the global loopback detection control switch.
	Enable the loopback detection control switch of a port or aggregation group.
Configure basic parameters of loopback detection.	Configure the interval at which loopback detection packets are sent.
	Configure the Error-Disable action on a port.

32.2.1 Configure Basic Functions of Loopback Detection

Configuration Condition

None

Enable the Global Loopback Detection Control Switch

The global loopback detection control switch is used to enable the global loopback detection function. The loopback detection configuration of a port takes effect only after the global loopback detection control switch is enabled.

Table 32 Enabling Global Loopback Detection Control Switch

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the global loopback detection control switch.	**loopback-detection enable**	Mandatory By default, the global loopback detection control switch is disabled.

Enable the Loopback Detection Control Switch of a Port or Aggregation Group

After the loopback detection function is enabled, a port sends loopback detection packets at intervals in the VLAN to which it has been added to check whether a loop exists in the network.

Table 1 Enabling Loopback Detection Control Switch of Ethernet Port or Aggregation Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2/3 Ethernet interface configuration mode	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		configuration takes effect only on current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enable the loopback detection control switch of a port or aggregation group.	**loopback-detection enable**	Mandatory By default, the loopback detection control switch of a port or aggregation group is disabled.

Note

- In loopback detection configuration task, you must enable the global loopback detection control switch before the loopback detection configuration on a port takes effect.

32.2.2 Configure Basic Parameters of Loopback Detection

Configuration Condition

None

Configure the Interval at Which Loopback Detection Packets Are Sent

In a loopback detection, loopback detection packets are sent periodically to detect loops in the network. You can modify the interval at which loopback detection packets are sent according to the actual network requirement.

Table 32 Configuring Sending Interval of Loopback Detection Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2/3 Ethernet interface configuration mode	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the interval at which loopback detection packets are sent.	**loopback-detection enable interval-time** *interval-time-value*	Mandatory By default, the interval at which loopback detection packets are sent is 30 seconds.

Configure the Error-Disable Action on a Port

If a port allows the Error-Disable action, the port is controlled. After a port detects a loop, it performs the Error-Disable action to close the port so as to eliminate the loop. If the port is not in the controlled status, the port only prints loop prompt message instead of closing the port. In this case, the loop has not been eliminated.

Table 2 Configuring Error-disable Action on Ethernet Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2/3 Ethernet interface configuration mode	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure whether the port allows the Error-Disable function.	**loopback-detection enable control**	Mandatory By default, after a port detects a loop, it performs the Error-Disable action.

32.2.3 Loopback Detection Monitoring and Maintaining

Table 32 Loopback Monitoring and Maintaining

Command	Description
show loopback-detection [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Displays the configuration information of all ports or a specified port in loopback detection.

32.3 Typical Configuration Example of Loopback Detection

32.3.1 Configure Remote Loopback Detection

Network Requirements

- Device1 and Device2 are directly connected, and Device2 has two ports which form a self-loop.
- On Device1, loopback detection has been enabled.
- After Device1 detects a loop, it closes the interconnected port to eliminate the loop.

Network Topology

Figure 32 Network Topology for Configuring Remote Loopback Detection Function

Layer-2 Ethernet Interface Configuration Steps

Step 1: Configure the link type of VLAN and layer-2 Ethernet interface.

#Create VLAN2 on Device1.

```
Device1#configure terminal
Device1(config)#vlan 2
Device1(config-vlan2)#exit
```

#Configure the link type of layer-2 Ethernet interface gigabitethernet0/1 on Device1 as Trunk, allowing the services of VLAN2 to pass.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#switchport mode trunk
Device1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device1(config-if-gigabitethernet0/1)#exit
```

#Create VLAN2 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#Configure the link type of layer-2 Ethernet interfaces gigabitethernet0/1, gigabitethernet0/2 and gigabitethernet0/3 on Device2 as Trunk, allowing the services of VLAN2 to pass and the layer-2 Ethernet interfaces gigabitethernet0/2 and gigabitethernet0/3 to disable the spanning tree.

```
Device2(config)#interface gigabitethernet 0/1-0/3
Device2(config-if-range)#switchport mode trunk
Device2(config-if-range)#no switchport trunk allowed vlan 1
Device2(config-if-range)#switchport trunk allowed vlan add 2
Device2(config-if-range)#exit
Device2(config)#interface gigabitethernet 0/2-0/3
Device2(config-if-range)#no spanning-tree enable
Device2(config-if-range)#exit
```

Step 2: Enable the loopback detection function.

#On Device1, globally enable the loopback detection function.

```
Device1(config)#loopback-detection enable
```

#On Device1, view the loopback detection status.

```
Device1#show loopback-detection
----------------------------------------------------------------
Global loopback-detection : ENABLE
------------------- -------- ------- ------------ -------
Interface           Loopback  Time(s) State        Control
------------------- -------- ------- ------------ -------
gi0/1               DISABLE   30      NORMAL       TRUE
gi0/2               DISABLE   30      NORMAL       TRUE
```

#Enable the loopback detection function on the layer-2 Ethernet interface gigabitethernet0/1 of Device1.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#loopback-detection enable
Device1(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#On Device1, view the loopback detection status.

```
After a loop is detected:
Device1#show loopback-detection
----------------------------------------------------------------
Global loopback-detection : ENABLE
------------------- -------- ------- ------------ -------
Interface           Loopback  Time(s) State        Control
------------------- -------- ------- ------------ -------
gi0/1               ENABLE    30      ERR-DISABLE  TRUE
gi0/2               DISABLE   30      NORMAL       TRUE
```

#After Device1 detects a loop, the layer-2 Ethernet interface gigabitethernet0/1 performs close operation, and the following prompt messages are output on the device.

```
Jul 30 2014 03:30:30: %LOOP-BACK-DETECTED : loop-back send tag packet in vlan2 on gigabitethernet0/1, detected in vlan2
from gigabitethernet0/1
Jul 30 2014   03:30:30: %LINK-INTERFACE_DOWN-4: interface gigabitethernet0/1, changed state to down
Jul 30 2014 03:30:30: %LINEPROTO-5-UPDOWN : gigabitethernet0/1 link-status changed to err-disable
```

#Check the status of layer-2 Ethernet interface gigabitethernet0/1 on Device1. The link status of layer-2 Ethernet interface gigabitethernet0/1 becomes Down.

```
Device1#show interface gigabitethernet 0/1
gigabitethernet0/1 configuration information
    Description     :
    Status          : Enabled
      Link          : Down  (Err-disabled)
    Set Speed       : Auto
```

```
Act Speed       : Unknown
Set Duplex      : Auto
Act Duplex      : Unknown
Set Flow Control : Off
Act Flow Control : Off
Mdix            : Auto
Mtu             : 1824
Port mode       : LAN
Port ability    : 10M HD,10M FD,100M HD,100M FD,1000M FD
Link Delay      : No Delay
Storm Control   : Unicast Disabled
Storm Control   : Broadcast Disabled
Storm Control   : Multicast Disabled
Storm Action    : None
        Port Type       : Nni
Pvid            : 1
Set Medium      : Copper
Act Medium      : Copper
Mac Address     : 0000.0000.008b
```

Layer-3 Ethernet Interface Configuration Steps

Step 1: Configure the link type of VLAN and layer-2 Ethernet interface.

#Create VLAN2 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#Configure the link type of layer-2 Ethernet interfaces gigabitethernet0/1, gigabitethernet0/2 and gigabitethernet0/3 on Device2 as Trunk, allowing the services of VLAN2 to pass and the layer-2 Ethernet interfaces gigabitethernet0/2 and gigabitethernet0/3 to disable the spanning tree.

```
Device2(config)#interface gigabitethernet 0/1-0/3
Device2(config-if-range)#switchport mode trunk
Device2(config-if-range)#no switchport trunk allowed vlan 1
Device2(config-if-range)#switchport trunk allowed vlan add 2
Device2(config-if-range)#switchport trunk pvid vlan 2
Device2(config-if-range)#exit
Device2(config)#interface gigabitethernet 0/2-0/3
Device2(config-if-range)#no spanning-tree enable
Device2(config-if-range)#exit
```

Step 2: Enable the loopback detection function.

#On Device1, globally enable the loopback detection function.

```
Device1(config)#loopback-detection enable
```

#On Device1, view the loopback detection status.

```
Device1#show loopback-detection
------------------------------------------------------------
Global loopback-detection : ENABLE
------------------- -------- ------- ------------ -------
Interface           Loopback  Time(s) State        Control
------------------- -------- ------- ------------ -------
gi0/1               DISABLE   30      NORMAL       TRUE
gi0/2               DISABLE   30      NORMAL       TRUE
```

#On Device1, configure the layer-2 Ethernet interface gigabitethernet0/1 as layer-3 Ethernet interface.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#no switchport

#Enable the loopback detection function on the layer-3 Ethernet interface gigabitethernet0/1 of Device1
Device1(config-if-gigabitethernet0/1)#loopback-detection enable
Device1(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#On Device1, view the loopback detection status.

After a loop is detected:

```
Device1#show loopback-detection
------------------------------------------------------------------
Global loopback-detection : ENABLE
------------------- -------- ------- ------------ -------
Interface           Loopback  Time(s) State        Control
------------------- -------- ------- ------------ -------
gi0/1               ENABLE    30      ERR-DISABLE  TRUE
gi0/2               DISABLE   30      NORMAL       TRUE
```

#After Device1 detects a loop, the layer-3 Ethernet interface gigabitethernet0/1 performs close operation, and the following prompt messages are output on the device.

```
Jul 31 2014 11:29:30: %LOOP-BACK-DETECTED : loop-back send packet on gigabitethernet0/1, detected from gigabitethernet0/1
Jul 31 2014 11:29:30: %LINEPROTO-5-UPDOWN : gigabitethernet0/1 link-status changed to err-disable
Jul 31 2014 11:29:30: %LINK-INTERFACE_DOWN-3: Interface gigabitethernet0/1, changed state to down.
Jul 31 2014 11:29:30: %LINK-LINEPROTO_DOWN-3: Line protocol on interface gigabitethernet0/1, changed state to down.
```

#Check the status of layer-3 Ethernet interface gigabitethernet0/1 on Device1. The status of layer-3 Ethernet interface becomes err-disabled.

```
Device1#show interface gigabitethernet 0/1 status err-disabled

Interface              Status         Reason
------------------------------------------------------------------
gi0/1                  err-disabled   loopback-detect
```

32.3.2 Configure Local Loopback Detection

Network Requirements

- Device1 and Device2 form a loop through two links, and all the ports in the loop is in one VLAN.
- On Device1, loopback detection has been enabled.
- After Device1 detects a loop, it closes the interconnected layer-2 port to eliminate the loop.

Network Topology

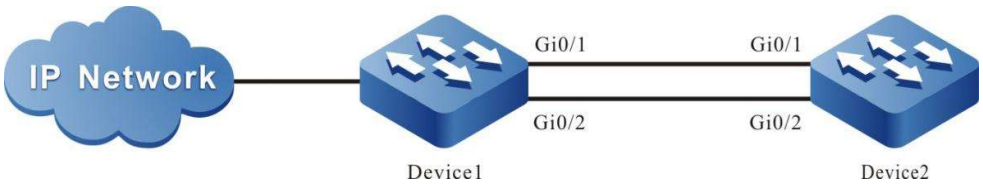


Figure 32 Network Topology for Configuration of Local Port Loopback Detection Function

Layer-2 Ethernet Interface Configuration Steps

Step 1: Configure the link type of VLAN and layer-2 Ethernet interface.

#Create VLAN2 on Device1.

```
Device1#configure terminal
Device1(config)#vlan 2
Device1(config-vlan2)#exit
```

#Configure the link type of layer-2 Ethernet interfaces gigabitethernet0/1 and gigabitethernet0/2 on Device1 as Trunk, allowing the services of VLAN2 to pass.

```
Device1(config)# interface gigabitethernet 0/1-0/2
Device1(config-if-range)#switchport mode trunk
Device1(config-if-range)#switchport trunk allowed vlan add 2
Device1(config-if-range)#exit
```

#Create VLAN2 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#Configure the link type of layer-2 Ethernet interfaces gigabitethernet0/1 and gigabitethernet0/2 as Trunk, allowing the services of VLAN2 to pass and closing the spanning tree.

```
Device2(config)# interface gigabitethernet 0/1-0/2
Device2(config-if-range)#switchport mode trunk
Device2(config-if-range)#no switchport trunk allowed vlan 1
Device2(config-if-range)#switchport trunk allowed vlan add 2
Device2(config-if-range)#no spanning-tree enable
Device2(config-if-range)#exit
```

Step 2: Enable the loopback detection function.

#On Device1, globally enable the loopback detection function.

```
Device1(config)#loopback-detection enable
```

#On Device1, view the loopback detection status.

```
Device1#show loopback-detection
------------------------------------------------------------------
Global loopback-detection : ENABLE
------------------- -------- ------- ------------ -------
Interface           Loopback  Time(s) State        Control
------------------- -------- ------- ------------ -------
gi0/1               DISABLE   30      NORMAL       TRUE
gi0/2               DISABLE   30      NORMAL       TRUE
```

#Enable the loopback detection function on the layer-2 Ethernet interface gigabitethernet0/1 of Device1.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#loopback-detection enable
Device1(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#On Device1, view the loopback detection status.

```
After a loop is detected:
Device1#show loopback-detection
------------------------------------------------------------
Global loopback-detection : ENABLE
-------------------- -------- ------- ------------ -------
Interface            Loopback  Time(s) State        Control
-------------------- -------- ------- ------------ -------
gi0/1                ENABLE    30      ERR-DISABLE   TRUE
gi0/2                DISABLE   30      NORMAL        TRUE
```

#After Device1 detects a loop, the layer-2 Ethernet interface gigabitethernet0/1 performs close operation, and the following prompt messages are output on the device.

```
Jul 30 2014 03:29:59: %LOOP-BACK-DETECTED : loop-back send tag packet in vlan2 on gigabitethernet0/1, detected in vlan2
from gigabitethernet0/2
Jul 30 2014  03:29:59: %LINK-INTERFACE_DOWN-4: interface gigabitethernet0/1, changed state to down
Jul 30 2014 03:29:59: %LINEPROTO-5-UPDOWN : gigabitethernet0/1 link-status changed to err-disable
```

#Check the status of layer-2 Ethernet interface gigabitethernet0/1 on Device1. The link status of layer-2 Ethernet interface gigabitethernet0/1 becomes Down.

```
Device1#show interface gigabitethernet 0/1
gigabitethernet0/1 configuration information
    Description     :
    Status          : Enabled
      Link          : Down  (Err-disabled)
    Set Speed       : Auto
    Act Speed       : Unknown
    Set Duplex      : Auto
    Act Duplex      : Unknown
    Set Flow Control : Off
    Act Flow Control : Off
    Mdix            : Auto
    Mtu             : 1824
    Port mode       : LAN
    Port ability    : 10M HD,10M FD,100M HD,100M FD,1000M FD
    Link Delay      : No Delay
    Storm Control   : Unicast Disabled
    Storm Control   : Broadcast Disabled
    Storm Control   : Multicast Disabled
    Storm Action    : None
          Port Type       : Nni
    Pvid            : 1
    Set Medium      : Copper
    Act Medium      : Copper
     Mac Address    : 0000.0000.008b
```

Caution

- When gigabitethernet 0/1 or gigabitethernet 0/2 of Device1 is a layer-3 Ethernet interface, there

is no loop in the networking environment.

33 Error-Disable Management

33.1 Overview

The Error-Disable function is an error detection and fault recovery mechanism on ports.

Exceptions on ports may degrade the performance of the entire network or bring down the entire network. The Error-Disable function can limit the abnormality within a single device or part of the network, preventing the abnormality from affecting other normal ports and preventing the abnormality from spreading.

If an exception is detected on an open port, the port is automatically closed so that the port will not forward packets. That is, if an error condition is triggered on the port, the port is automatically disabled. This is called the Error-Disable management function, and the port status is called the Error-Disabled status.

Currently, the following functions are supported: storm suppression, port security, link flapping, DHCP rate limit, BPDU Guard, ARP detection, L2 protocol tunnel, loopback detection, OAM, and Monitor Link.

If an exception is detected on a port through the above functions, the port is automatically closed, and it is set to the Error-Disabled status. However, this status cannot continue. After the fault is eliminated, the port needs to be enabled again, and the Error-Disabled status of the port needs to be cleared so that the port can continue to forward packets. Here the automatic recovery mechanism of the Error-Disable management function is involved.

33.2 Error-Disable Management Function Configuration

Table 33 Error-disable Management Function Configuration List

Configuration Task	
Configure Error-Disable basic functions.	Configure Error-Disable error detection.
	Configure Error-Disable automatic recovery.

Configuration Task	
Configure Error-Disable automatic recovery.	Configure the interval for Error-Disable automatic discovery.

33.2.1 Configure Error-Disable Basic Functions

Configuration Condition

None

Configure Error-Disable Error Detection

After the Error-Disable detection of the specification function is configured, if an exception is detected on the port, the system automatically close the port and set the port to the Error-Disabled status.

Table 33 Configuring Error-disable Error Detection

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Error-Disable error detection.	**errdisable detect cause** { **all** | **bpduguard** | **dai** | **dhcp-snooping** | **monitor-link | torm-control | link-flap | l2pt | oam | port-security | loopback-detect** | **transceiver-power-high** | **transceiver-power-low** }	Mandatory By default, all the listed functions allowed to close the port and set it as Error-Disabled.

33.2.2 Configure Error-Disable Automatic Recovery

Configure Error-Disable Automatic Recovery

The Error-Disable error detection mechanism enables specified functions to close a port. To quickly recover the port so that it can continue to forward packets, an automatic recovery mechanism is provided. With the mechanism, the port is automatically re-enabled after a specified interval.

Table 33 Configuring Automatic Recovery of Error-disable

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Error-Disable automatic recovery.	**errdisable recovery cause** { **all** | **bpduguard** | **dai** | **dhcp-snooping** | **eips-udld** | **l2pt | link-flap** | **loopback-detect** | **oam | port-security** | **storm-control** | **transceiver-power-high** | **transceiver-power-low** | **ulfd** }	Mandatory By default, a port cannot be automatically enabled, and the Error-Disabled status set by the listed functions cannot be automatically cleared. However, by default, a port can be automatically enabled and the Error-Disabled status can be automatically cleared if its status is set by the Link-Flap function.

Configure the Interval for Error-Disable Automatic Discovery

You can configure the interval for a port to automatically recover normal after it port is closed by the Error-Disable error detection mechanism.

Table 33 Configuring Time Interval for Automatic Discovery of Error-disable

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the interval for Error-Disable automatic discovery.	**errdisable recovery interval** *interval-value*	Mandatory By default, the interval at which a port is enabled and its Error-Disabled status is cleared is 300 seconds.

33.2.3 Error-Disable Management Monitoring and Maintaining

Table 33 Error-disable Management Monitoring and Maintaining

Command	Description
show errdisable detect	Displays whether it is allowed that all the listed functions close a port and set the port to the Error-Disabled status.
show errdisable recovery	Displays whether a port can be automatically enabled, and whether the Error-Disabled status set by the listed functions can be cleared automatically.
show { **interface** *interface-list* | **interface link-aggregation** *link-aggregation-id* } **status err-disabled**	Displays the information about Error-Disabled status setting of a specified port or aggregation group.

33.3 Typical Configuration Example of Error-Disable Management

33.3.1 Combination of Error-Disable and Storm Suppression

Network Requirements

- PC accesses IP Network through Device. On Device, the storm suppression and Error-Disable functions have been enabled.
- If a port of a device receives a large number of broadcast packets and then disabled, Error-Disable can re-enable the port according to the policy.

Network Topology

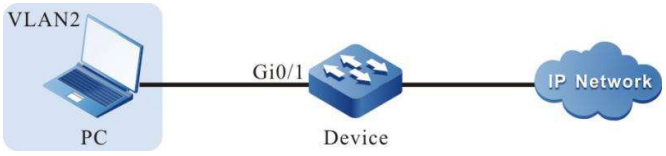


Figure 33 Network Topology for Combination of Error-disable and Storm Suppression

Configuration Steps

Step 1: Configure the link type of VLAN and port.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 of the Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 2: Configure the storm suppression function

#Enable the storm suppression function on port gigabitethernet0/1 of the Device, and adopt the pps limitation mode to suppress broadcast packets. The suppression rate is 20pps. When a storm occurs, the port is shutdown.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#storm-control action shutdown
Device(config-if-gigabitethernet0/1)#storm-control broadcast pps 200
Device(config-if-gigabitethernet0/1)#exit
```

Step 3: Configure Error-disable function.

#Enable the storm suppression recovery function in Error-disable, and configure the recovery time as 30 seconds.

```
Device(config)#errdisable recovery cause storm-control
Device(config)#errdisable recovery interval 30
```

Step 4: Check the result.

#View related configurations of Error-disable.

```
Device#show errdisable recovery

Error disable auto recovery config
interval:30 seconds
ErrDisable Reason   Timer Status
---------------     ------------
bpduguard             Disabled
dai                   Disabled
dhcp-snooping         Disabled
eips-udld             Disabled
l2pt                  Disabled
link-flap             Enabled
loopback-detect       Disabled
oam                   Disabled
port-security         Disabled
storm-control         Enabled
ulfd                  Disabled
transceiver-power-low  Disabled
transceiver-power-high Disabled
```

#When the PC sends plenty of broadcast packets, the port gigabitethernet0/1 will be closed and the following prompt messages will be printed.

```
Nov 24 2014 15:37:13: %STORM_CONTROL-3: A storm detected on interface gigabitethernet0/1, ActionType:shutdown,
StormType: broadcast storm
```

Nov 24 2014 15:37:13: %PORTMGR-LINEPROTO_DOWN-3: Line protocol on interface gigabitethernet0/1, changed state to down

#View the status of port gigabitethernet0/1.

```
Device#show interface gigabitethernet 0/1

gigabitethernet0/1 configuration information
    Description     :
    Status          : Enabled
    Link            : Down (Err-disabled)
    Set Speed       : Auto
    Act Speed       : Unknown
    Set Duplex      : Auto
    Act Duplex      : Unknown
    Set Flow Control : Off
    Act Flow Control : Off
    Mdix            : Auto
    Mtu             : 1824
    Port mode       : LAN
    Port ability    : 10M FD, 100M FD,1000M FD
    Link Delay      : No Delay
    Storm Control   : Unicast Pps 1500
    Storm Control   : Broadcast Pps 20
    Storm Control   : Multicast Pps 1500
    Storm Action    : Shutdown
    Port Type       : Nni
    Pvid            : 2
    Set Medium      : Copper
    Act Medium      : Copper
    Mac Address     : 0001.7a54.5ca5
```

#After 30 seconds, the port gigabitethernet0/1 will be enabled, and the following prompt messages will be printed.

```
Nov 24 2014 15:37:43: %PORTMGR-AUTO_RECOVERY-5: auto recovery timer expired on interface gigabitethernet0/1,
module: STROM CONTROL ACTION.
Nov 24 2014 15:37:45: %PORTMGR-LINEPROTO_UP-5: Line protocol on interface gigabitethernet0/1, changed state to up.
```

#View the status of port gigabitethernet0/1.

```
Device#show interface gigabitethernet 0/1

gigabitethernet0/1 configuration information
    Description     :
    Status          : Enabled
    Link            : Up
    Set Speed       : Auto
    Act Speed       : 1000
    Set Duplex      : Auto
    Act Duplex      : Full
    Set Flow Control : Off
    Act Flow Control : Off
    Mdix            : Auto
    Mtu             : 1824
    Port mode       : LAN
    Port ability    : 10M FD, 100M FD,1000M FD
    Link Delay      : No Delay
    Storm Control   : Unicast Pps 1500
    Storm Control   : Broadcast Pps 20
    Storm Control   : Multicast Pps 1500
```

```
Storm Action     : Shutdown
Port Type        : Nni
Pvid             : 2
Set Medium       : Copper
Act Medium       : Copper
Mac Address      : 0001.7a54.5ca5
```

34 GVRP

34.1 Overview

GVRP (GARP VLAN Registration protocol) is an application protocol defined by GARP. It dynamically maintains the VLAN information in the switch based on the GARP protocol mechanism. All switches that support GVRP features can receive VLAN registration information from other switches and dynamically update local VLAN registration information, including current VLAN on the switch and which ports are included in these VLANs. Besides, these switches that support GVRP features can spread local VLAN registration information to other switches so that the VLAN configurations of all devices supporting GVRP features in the same switching network are consistent in interoperability. The VLAN registration information spread through GVRP includes both local static VLAN information manually configured and dynamic VLAN information from other switches. It should be noted that the Leave message of GVRP cannot eliminate the local VLAN manually configured as it has a higher priority than GVRP operation.

GVRP realizes the dynamic registration, maintenance and cancellation of VLAN port member information. If there is no VLAN, a VLAN will be dynamically created; if the number of VLAN port members is 0, the VLAN will be dynamically deleted, i.e. the port will be dynamically added to the VLAN or deleted from the VLAN, realizing dynamic configuration of the VLAN on the switch.

GVRP can dynamically configure VLANs so that it's unnecessary to configure all VLANs of all devices. Instead, only some devices, especially edge devices, and some special VLANs are configured. Other devices will be automatically configured through GVRP. Nowadays, enterprises always have a large network and many VLANs. The GVRP function greatly reduces the workload of administrators in configuration, as well as the possibility of manual errors. Besides, it can automatically configure VLANs when the network topology changes to ensure the connectivity between VLANs.

34.2 GVRP Function Configuration

Table 12-1 GVRP Function Configuration List

Configuration Task	
Enable GVRP function	Globally enable the GVRP function

Configuration Task	
Configure GVRP port	Configure the port as trunk and the VLAN allowed to pass
	Configure the port to enable GVRP function
	Configure GVRP mode for the port

34.2.1 Enable GVRP Function

Configuration Condition:

None

Globally Enable GVRP Function

Globally enable GVRP function through configuration.

Table 12-2 Globally Enabling GVRP Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure gvrp enable	**gvrp enable**	Mandatory

34.2.2 Configure GVRP Port

Configuration Condition:

None

Configure GVRP Port

Add configuration on the port where GVRP needs to be enabled, including GVRP mode and the VLAN allowed to pass.

Table 12-3 Enabling GVRP Function for a Port

Step	Command	Description
Enter the global configuration mode.	configure terminal	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the port as trunk	switchport mode trunk	Mandatory
Allow the port to allow all VLANs	switchport trunk allowed vlan all	Mandatory
Configure the port to enable GVRP	gvrp enable	Mandatory

35 VLAN Isolation

35.1 Overview

In the users' access network, in order to realize mutual isolation between different user groups, different user groups need to be divided into different VLANs. When users in the same user group intend to be isolated from other users, they can use the port isolation technology. But if this technology is used, the administrator needs to know the location of the port of the users' access network. It will lead to inconvenient configuration, management and maintenance. VLAN isolation technology can solve this problem. The administrator simply needs to configure VLAN isolation for the VLAN where the user group is located. Then, users in the user group are isolated from each other. By configuring the uplink port of VLAN isolation, users in the user group can access public network through the uplink port. This technology provides a safer and more flexible solution for networking.

35.2 VLAN Isolation Function Configuration

Table 35 VLAN Global Function Configuration List

Configuration Task	
Configure VLAN isolation	Enable the VLAN isolation function
	Configure the uplink port of VLAN isolation

35.2.1 Configure VLAN Isolation

Configuration Condition

None

Enable the VLAN Isolation Function

By enabling the VLAN isolation function, you can realize mutual isolation between the member ports in VLAN.

Table 35 Enabling Global VLAN Isolation

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Enable the VLAN isolation function	**vlanIsolat enable**	Mandatory By default, the VLAN isolation function is disabled.

Configure the Uplink Port of VLAN Isolation

After the uplink ports of VLAN isolation are configured, the downlink ports in the VLAN are still isolated from each other. However, intercommunications between uplink ports and downlink ports are possible.

Table 35 Configuring Uplink Port of VLAN Global Isolation

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the uplink port of VLAN global isolation	**vlanIsolate uplink-port vlan** *vlan-id*	Mandatory By default, no uplink port of VLAN isolation is configured.

Note

- After the VLAN global isolation function is disabled, the configured uplink port of VLAN isolation is automatically cancelled, VLAN isolation is enabled, and all ports in the VLAN are downlink ports by default.

35.2.2 VLAN Isolation Monitoring and Maintaining

Table 35 VLAN Global Isolation Monitoring and Maintaining

Command	Description
show vlan-isolate([vlan *vlan-id* **])**	Show the information of VLAN isolation

36 MLAG

36.1 Overview

MLAG is a mechanism which achieves cross-device link aggregation. It combines one device with two other paired devices for ross-device link aggregation to form a dual-active system.

As a weakly correlated horizontal virtualization technology, MLAG has the following advantages in addition to increasing bandwidth, providing link reliability, and load sharing:

- Higher reliability: MLAG improves the link reliability from single-board level to device level. For common cross-board link aggregation, if one board fails, the entire aggregation link can still work normally; for MLAG cross-device link aggregation, if one device fails, the entire aggregation link can still work normally.
- Simplified networking: MLAG, as a horizontal virtualization technology, logically virtualizes two paired devices that are double-homed into one device. MLAG provides a layer-2 topology without loops and realizes redundant backup. Therefore, the access side doesn't need spanning tree protocol, which greatly simplifies the process of networking and configuration.
- Independent upgrading: Two paired devices can be upgraded separately to ensure that one device is working normally. This has no impact on the ongoing business.

Definitions of MLAG-related concepts:

- MLAG (Multi-Chassis Link Aggregation Group) domain: Composed of two MLAG partner nodes, it forms a dual-active system.

- MLAG partner nodes: For the MLAG partner nodes, one serves as \MASTER),and the other as SLAVE.
- Peer-Link: A direct aggregation link between MLAG partner nodes, used to exchange MLAG protocol packets and transmit some data traffic.
- Keepalive: Keepalive detection between MLAG partner nodes, performed through L3 link. It determines whether one of the MLAG partner nodes is still alive when the Peer-Link fails.
- PTS (Peer-Link Transport Server): A reliable packet transmission service based on Peer-Link.
- DHD (Double-Homed Device): A device (or server) which is double-homed to the MLAG dual-active system. DHD itself may be a MLAG dual-active system.
- SD (Single-Homed Device): A device (or server) that is single-homed to the MLAG dual-active system.
- MLAG-Port: The cross-device aggregation group between DHD and MLAG dual-active system.
- MLAG Member Port: The member port in the cross-device aggregation group between DHD and MLAG dual-active system.
- Orphan-Port: The single-homed port on the MLAG partner nodes, including the single-homed aggregation group. Orphan-Port may or may not belong to MLag-VLAN.
- MLAG-VLAN: The VLAN where Peer-Link is added. Generally, the VLAN to which MLAG port belongs should be added into MLAG-VLAN.
- Non-MLAG-VLAN: The VLAN that doesn't contain Peer-Link. Generally, non-MLAG-VLAN doesn't contain MLAG port.
- MLAG-VLANIF: VLANIF interface corresponding to MLAG-VLAN.
- Non-MLAG-VLANIF: VLANIF interface corresponding to non-MLAG-VLAN.
- Unpaired: After the Peer-Link port is disconnected, if the Keepalive is normal, it is believed that an Unpaired failure has occurred. This will cause the MLAG port and MLAG-VLANIF on the SLAVE node to Suspend so that the uplink and downlink traffic is forwarded through the MASTER node.
- Up-Delay: When the MLAG partner nodes restart or Peer-Link failure recovers, the MLAG port will be set as UP after a period of delay.
- Auto-Recovery: After a period of time, when the MLAG node of local port believes that it is completely disconnected from the MLAG node of peer port (as a matter of fact, the MLAG node of peer port may have device failure or still be alive), MLAG node of local port deems itself as the only node and becomes a master node to forward traffic.
- Dual-Master: If both Peer-Link and Keepalive fail, when the SLAVE node believes that it is completely disconnected from the MASTER node, the SLAVE node will be upgraded to

a MASTER node, and the original MASTER node still exists. Then, there are two MASTER nodes, i.e. Dual -Master. There may be abnormal traffic forwarding in Dual-Master state.

- Control protocol packet (also called PEERING packet): The protocol packet exchanged between MLAG nodes, used for node pairing, role election, etc. It is sent and received via UDP.
- Data synchronization packet (also called SYNC packet): The synchronization packet exchanged between MLAG nodes, used for transmission of control information of each service, relay service protocol packet, synchronization service entries, etc. It is sent and received via TCP after the SYNC packet encapsulates the PTS header.
- Control VLAN: The layer-3 VLAN (interface vlan) used to transmit PTS synchronization packets. Only Peer-Link can be added into this VLAN. Other ports cannot be added into this VLAN.
- Suspend: Here it means shutdown, i.e. the shutdown of MLAG aggregation group or MLAG-VLANIF interface.

36.2 MLAG Function Configuration

Table 36 MLAG Function Configuration List

Configuration Task	
Create MLAG domain	Create MLAG domain
Configure MLAG parameters	Configure the automatic recovery delay time after the node is restarted
	Specify local VLAN interface
	Configure MLAG node ID
	Configure the role priority of MLAG node
	Specify peer IP address

	Configure preemption mode
	Configure the MAC address of MLAG system
	Configure the priority of MLAG system
	Configure the delay time and interval time of UP state
Configure Keepalive parameters	Configure the source and destination addresses of Keepalive packet
	Set the sending interval and receiving timeout of Keepalive packet
	Set the silent period of Keepalive
Configure Peer-Link	Configure the layer-2 aggregation interface as a Peer-Link port
Configure MLAG port	Configure MLAG port
Configure Orphan-Port	Configure the Orphan-Port of the SLAVE node to be set as shutdown when the Peer-Link fails but the Keepalive is normal

Note

- MLAG function, supporting software learning instead of hardware learning.

36.2.1 Create MLAG Domain

In MLAG partner nodes, the MLAG domain ID must be consistent.

Configuration Condition

Before creating MLAG domain, ensure that:

- On the MLAG partner nodes, there are no other MLAG domains.

Create MLAG Domain

Create MLAG domain.

Table 36 Creating MLAG Domain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create MLAG domain	**mlag domain** *domain-id*	Mandatory By default, no MLAG domain is created, and the value range of domain ID is 1~255.

36.2.2 Configure MLAG parameters

Configuration Condition

Before configuring MLAG parameters, ensure that:

- Create MLAG domain.

Configure the Automatic Recovery Delay time After the Node is Restarted

After the device is started, start the automatic recovery timer with the configured automatic recovery delay time. If no Keepalive or Peering packet is received until the timer times out, and the Peer-Link is always Down, it is believed that there is no peer node, and this node becomes the MASTER.

Table 36 Configuring Automatic Recovery Delay Time After Restarting of Node

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the MLAG domain configuration mode	**mlag domain** *domain-id*	-

Configure the automatic recovery delay time after the node is restarted	**auto-recovery reload-delay** *delay_value*	Optional By default, the automatic recovery delay time is 240 seconds. It ranges from 240 to 3600 seconds.

Configure MLAG node ID

In the same MLAG domain, the MLAG node IDs are different and unique.

Table 36 Configuring MLAG Node ID

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the MLAG domain configuration mode	**mlag domain** *domain-id*	-
Configure MLAG node ID	**node id** *id-number*	Mandatory By default, no MLAG node ID is configured. Its range is 1 and 2.

Configure the Role Priority of MLAG Node

The node role priority is used for master-slave role election between two nodes in the same MLAG domain. The smaller the value, the higher the priority. The one with a higher priority becomes the Master device. If the nodes have the same priority, compare the bridge MAC addresses of the two devices. The one with a smaller bridge MAC address becomes the Master device.

Table 36 Configuring MLAG Node Role Priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Enter the MLAG domain configuration mode	**mlag domain** *domain-id*	-
Configure the role priority of MLAG node	**node role-priority** *priority-value*	Optional By default, the MLAG node priority is 100. Its range is 1~ 254.

Configure Preemption Mode

If the preemption mode is configured, when the master-slave role is elected, the previous role of the node will be ignored. The node role will be determined according to the node priority and the MAC comparison result: the lower the node priority value, the higher the priority, and the one with higher priority becomes the Master device; if the nodes have the same priority, compare the bridge MAC addresses of the two devices (the one with a smaller bridge MAC address becomes the Master device).

Table 1 Configuring Preemption Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the MLAG domain configuration mode	**mlag domain** *domain-id*	-
Configure preemption mode	**role preempt**	Optional By default, no preemption mode is configured.

Configure the MAC Address of MLAG System

In order to enable the access device to deem the two nodes in MLAG domain as one device, the MAC addresses of the MLAG system of the two nodes must be the same.

Table 2 Configuring MAC Address of MLAG System

Step	Command	Description

Enter the global configuration mode.	**configure terminal**	-
Enter the MLAG domain configuration mode	**mlag domain** *domain-id*	-
Configure the MAC address of MLAG system	**system-mac** *mac_address*	Optional By default, the MAC address of MLAG system is not configured. The MAC addresses of MLAG systems of the two nodes are the same and automatically generated according to the domain id.

Configure the Priority of MLAG System

In order to enable the access device to deem the two nodes in MLAG domain as one device, the MLAG system priority of the two nodes must be the same.

Table 3 Configuring MLAG System Priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the MLAG domain configuration mode	**mlag domain** *domain-id*	-
Configure the priority of MLAG system	**system-priority** *priority_value*	Optional By default, the MLAG system priority is 32768. Its range is 1~ 65535.

Configure the Delay Time and Interval Time of UP State

When the device is added into the MLAG domain as a SLAVE node, the MLAG interface will be set as UP state after the period of UP state delay. During the period of UP state delay, the MAC address table, ARP table and other information must be synchronized. Therefore, if there are many entries, the local timer can be properly extended to avoid packet loss.

Table 4 Configuring Delay Time and Interval Time of UP State

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter the MLAG domain configuration mode	mlag domain domain-id	-
Configure the delay time and interval time of UP state	up-delay delay_seconds [interval interval_mseconds]	Optional By default, the delay time and interval time of UP state are 90 seconds and 1000 milliseconds, and they range from 1 to 3600 seconds and from 1 to 300000 milliseconds respectively.

Configure MLAG Graceful Restart

After graceful restart is enabled, the local node will notify the peer node to delay the keep-alive time of control protocol and Keepalive. This can avoid traffic interruption due to the timeout of peer node when the MLAG of local node is restarted. It is recommended that this command be configured only before MLAG is restarted. Under normal conditions, configuring this command will make the peer node insensitive to network changes.

By default, MLAG graceful restart is disabled.

Table 36 Configuring MLAG Graceful Restart

Step	Command	Description
Enter the privilege configuration mode	**enable**	-

Configure MLAG graceful restart and the keep-alive time of peer port control protocol and Keepalive after the restart	**mlag graceful-restart [holding-time seconds]**	- Optional By default, the keep-alive time is 300 seconds. Its range is 200-20000 seconds.

Configure Reserved Interface

Configure the VLAN interface of the SLAVE node to be set as shutdown when the Peer-Link fails but the Keepalive is normal.

By default, no reserved interface is configured.

Table 36 Configuring Reserved Interface

Step	Command	Description
Enter the interface configuration mode	**interface vlan [vlan-id]**	-
Configure reserved interface	**mlag unpaired reserved**	Optional The vlan corresponding to the interface must be MLAG-VLAN. This command is not required for non-MLAG-VLANIF interface as it will not be configured as shutdown.

36.2.3 Configure Keepalive Parameters

Configuration Condition

Before configuring Keepalive parameters, ensure that:

- Create MLAG domain.

Configure the Source and Destination Addresses of Keepalive Packet

To enable the MLAG system to be correctly established, the source and destination addresses of Keepalive packets must be configured, and it is reachable between two nodes at layer 3.

The VLAN corresponding to the layer-3 interface where the source IP address of Keepalive packet belongs shall not be included in the VLAN of Peer-Link port.

Table 36 Configuring Source and Destination Addresses of Keepalive Packet

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter the MLAG domain configuration mode	mlag domain domain-id	-
Configure the source and destination addresses of Keepalive packet	keepalive ip destination ipv4_address source ipv4_address [udp-port udp-number] [vrf vrf_name]	Mandatory By default, udp-port is 53910, VRF name global, and udp-port range 1~65535. VRF name supports 31 characters at most.

Configure the Sending Interval and Receiving Timeout of Keepalive Packet

After the Keepalive receiving timeout timer is enabled, if the next Keepalive packet is not received before this timer expires, it is deemed LOST.

Table 5 Configuring Sending Interval and Receiving Timeout Period of Keepalive Packet

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter the MLAG domain configuration mode	mlag domain domain-id	-
Configure the sending interval and receiving timeout of Keepalive packet	keepalive interval mseconds [timeout seconds]	Optional By default, the sending interval and receiving timeout of Keepalive packet are 1000 milliseconds and 6s, and they range from 100 to 10000 milliseconds and from 1

		to 20 seconds respectively.

Configure the Silent Period of Keepalive

After the Peer-Link link becomes DOWN, the SLAVE node enters the silent period. The Keepalive packets received during the silent period will be ignored and will not be processed until the silent period expires. The silent period can be set to allow the Keepalive packets on the link to be received and sent completely so as to avoid false detection caused by packet delay.

Table 6 Configuring Keepalive Silent Period

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter the MLAG domain configuration mode	mlag domain domain-id	-
Configure the silent period of Keepalive	keepalive quiet-time mseconds	Optional By default, the Keepalive silent period is 3000 milliseconds. Its range is 1~15000 milliseconds.

36.2.4 Configure Peer-Link

Configuration Condition

Before configuring Peer-Link, ensure that:

- Create MLAG domain.

Configure the Layer-2 Aggregation Interface as a Peer-Link Port

As a direct aggregation link between two MLAG devices, Peer-Link can be used to exchange MLAG protocol packets and transmit some data traffic.

Table 7 Configuring Layer-2 Aggregation Interface as a Peer-Link Port

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter the layer-2 aggregation interface configuration mode	interface link-aggregation link-aggregation-id	-
Configure the layer-2 aggregation interface as a Peer-Link port	mlag peer-link	Mandatory By default, no Peer-Link port is configured.

36.2.5 Configure MLAG Port

Configuration Condition

Before configuring MLAG port, ensure that:

- Create MLAG domain.

Configure MLAG Port

In order to improve reliability and avoid loops in the process of configuration, on the two MLAG partner nodes, configure the same MLAG port ID for the aggregation groups that are connected to the same aggregation group on the DHD to form a cross-device link aggregation group.

Table 8 Configuring MLAG Port

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter the layer-2 aggregation interface configuration mode	interface link-aggregation link-aggregation-id	-
Configure MLAG port	mlag group mlag-id	Mandatory By default, no MLAG port is configured. The MLAG port ID ranges from 1 to 1000.

Note

- It is recommended that the link aggregation group be configured as a dynamic aggregation group.

36.2.6 Configure Orphan-Port

Configuration Condition

Before configuring Orphan-Port, ensure that:

- Create MLAG domain.

Configure the Orphan-Port of the SLAVE Node to Be Set as Shutdown when the Peer-Link Fails but the Keepalive Is Normal

By default, when the Peer-Link fails but the Keepalive is normal, all the MLAG ports of the SLAVE node will be configured as shutdown, but the Orphan-Port will not be configured as such state. To configure some Orphan-Ports as shutdown, this command needs to be configured for these ports.

Table 9 Configuring the Mode of Orphan-Port of SLAVE Node as Shutdown When the Peer-Link Fails but the Keepalive is Normal

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Layer-2 Ethernet interface configuration mode	interface interface-name	At least one option must be selected.
Enter the layer-2 aggregation interface configuration mode	interface link-aggregation link-aggregation-id	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on current port. After you enter the layer-2 aggregation interface configuration mode,

		the subsequent configuration takes effect only within current aggregation group.
Configure the Orphan-Port of the SLAVE node to be set as shutdown when the Peer-Link fails but the Keepalive is normal	mlag unpaired orphan-port suspend	Optional By default, this command is not configured.

36.2.7 MLAG Monitoring and Maintaining

Table 10 MLAG Monitoring and Maintaining

Command	Description
clear mlag packet keepalive statistics [tx | **rx]**	Clear statistical information of MLAG Keepalive packets
clear mlag packet peering statistics [tx | **rx]**	Clear statistical information of MLAG Peering packets
clear mlag packet pts statistics [application *app-id***] [tx** | **rx]**	Clear statistical information of MLAG PTS packets
clear mlag packet sync statistics [tx | **rx]**	Clear statistical information of MLAG Sync packets
show mlag pts application	Show information of all MLAG services
show mlag brief	Show summary information of MLAG
show mlag group [*mlag-id***]**	Show information of MLAG aggregation group
show mlag keepalive	Show information of MLAG Keepalive
show mlag node	Show information of MLAG node
show mlag packet pts [application [*app-id***]] statistics**	Show statistical information of PTS packets sending and receiving of MLAG's all services or specified services

Command	Description
show mlag packet keepalive statistics	Show statistical information of MLAG Keepalive packets
show mlag packet peering statistics	Show statistical information of MLAG paired packets
show mlag packet sync statistics	Show statistical information of MLAG synchronous packets
show mlag suspend	Show the Suspended interface
show mlag up-delay	Show the interface waiting for timeout of up-delay timer

36.3 Typical Example of Configuration of MLAG

36.3.1 Configure Basic Functions of MLAG

Network Requirements

- All devices are within the same layer-2 network.

Network Topology

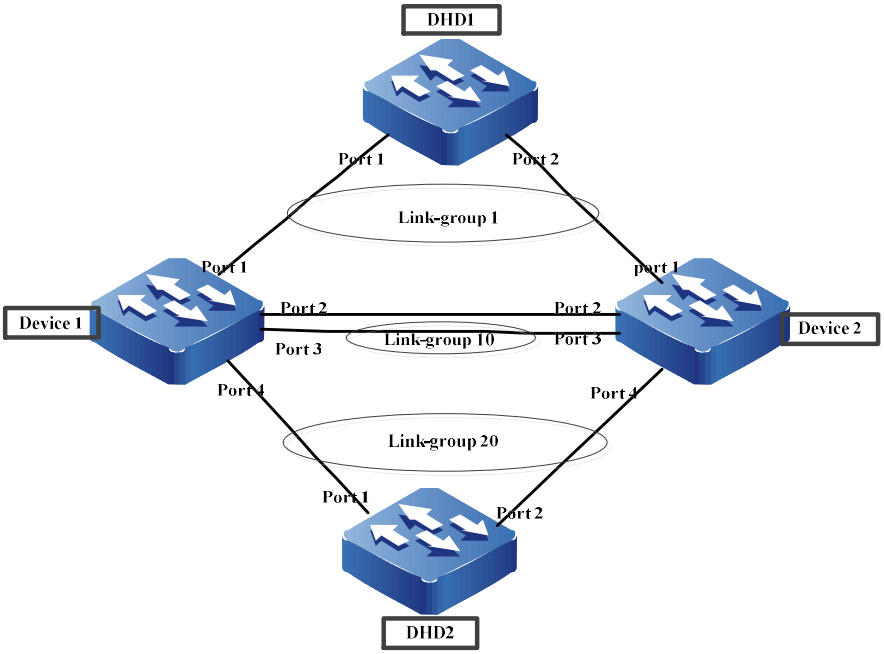


Figure 36 Configuring Basic Functions of MLAG

Configuration Steps

Step 1: Add the interface into the aggregation group and vlan. (The addition of interface into the aggregation group is omitted)

#Configure Device1. Add the interface into the peerlink aggregation group, peerlink aggregation into vlan, and keepalive port into vlan.

Device1#configure terminal

Device1(config)#vlan 2-4093

Please wait ……

Done.

Device1(config)# link-aggregation 10 mode lacp

Device1(config)# interface port3

Device1(config-if-port3)# link-aggregation 10 active

Device1(config-if-port3)#exit

Device1(config)# interface link-aggregation 10

Device1(config-link-aggregation10)# switchport mode trunk

Device1(config-link-aggregation10)# switchport trunk allowed vlan add 2-4093

Device1(config-link-aggregation10)# no switchport trunk allowed vlan 1

Device1(config-link-aggregation10)# switchport trunk pvid vlan 2

Device1(config-link-aggregation10)#exit

Device1(config)# interface port2

Device1(config-if-port2)# switchport access vlan 4094

Device1(config-if-port2)#exit

#Configure Device2. Add the interface into the peerlink aggregation group, peerlink aggregation into vlan, and keepalive port into vlan.

Device2#configure terminal

Device2 (config)#vlan 2-4093

Please wait ……

Done.

Device2 (config)# link-aggregation 10 mode lacp

Device2 (config)# interface port3

Device2 (config-if-port3)# link-aggregation 10 active

Device2 (config-if-port3)#exit

Device2 (config)# interface link-aggregation 10

Device2 (config-link-aggregation10)# switchport mode trunk

Device2 (config-link-aggregation10)# switchport trunk allowed vlan add 2-4093

Device2 (config-link-aggregation10)# no switchport trunk allowed vlan 1

Device2 (config-link-aggregation10)# switchport trunk pvid vlan 2

Device2 (config-link-aggregation10)#exit

Device2 (config)# interface port2

Device2 (config-if-port2)# switchport access vlan 4094

Device2 (config-if-port2)#exit

Step 2: Configure MLAG domain.

#Configure Device1. Configure MLAG domain instance.

Device1#configure terminal

Device1(config)#mlag domain 1

Device1(config-mlag-domain)#node id 1

Device1(config-mlag-domain)#keepalive ip destination 30.0.0.10 source 30.0.0.20

Device1(config-mlag-domain)#exit

#Configure Device2. Configure MLAG domain instance.

Device2#configure terminal

Device2(config)#mlag domain 1

Device2(config-mlag-domain)#node id 2

Device2(config-mlag-domain)#keepalive ip destination 30.0.0.20 source 30.0.0.10

Device2(config-mlag-domain)#exit

Note:

The domain IDs of the two MLAG nodes must be the same;

The node IDs of the two MLAG nodes must be different;

Step 3: Configure the keepalive ip interface.

#Configure Device1. Configure keepalive ip interface.

Device1(config)#interface vlan 4094

Device1(config-if-vlan4094)#ip address 30.0.0.20 24

Device1(config-if-vlan4094)#exit

Device1(config)#

#Configure Device2. Configure keepalive ip interface.

Device2(config)#interface vlan 4094

Device2(config-if-vlan4094)#ip address 30.0.0.10 24

Device2(config-if-vlan4094)#exit

Device2(config)#

Step 4: Configure MLAG group and peer-link group.

#Configure Device1. Configure MLAG group and peer-link group.

```
Device1(config)#interface link-aggregation 1
Device1(config-link-aggregation1)#mlag group 1
Device1(config-link-aggregation1)#exit
Device1(config)#
Device1(config)# interface link-aggregation 10
Device1(config-link-aggregation10)#mlag peer-link
Device1(config-link-aggregation1)#exit
Device1(config)#
Device1(config)# interface link-aggregation 20
Device1(config-link-aggregation20)#mlag group 20
Device1(config-link-aggregation20)#exit
Device1(config)#
```

#Configure Device2. Configure MLAG group and peer-link group.

```
Device2(config)# interface link-aggregation 1
Device2(config-link-aggregation1)#mlag group 1
Device2(config-link-aggregation1)#exit
Device2(config)#
Device2(config)# interface link-aggregation 10
Device2(config-link-aggregation10)#mlag peer-link
Device2(config-link-aggregation1)#exit
Device2(config)#
Device2(config)# interface link-aggregation 20
Device2(config-link-aggregation20)#mlag group 20
Device2(config-link-aggregation20)#exit
Device2(config)#
```

#View the MLAG information on Device1

Device1#sho mlag brief

MLAG domain id : 1

Role FSM status : SLAVE

Peering FSM status : ESTABLISHED

Keepalive FSM status : ALIVE

PTS Service : ON

Up-delay : 90sec

Graceful-restart : Disabled

Number of mlags configured : 2

Peer-Link Link-status Data-status Active-vlans

---------- ---------- ---------- --------

link-aggregation 10 UP UP 2-4093

Node ID Role System-MAC System-Priority

------- ---- ------- --------------- ----------

Self 1 SLAVE 0001.7a95.000b 32768

Remote 2 MASTER 0001.7a95.000b 32768

Device1#

Device1#show mlag group

Number of mlags configured : 2

mlag-id: 1 (link-aggregation1)

--Link status: UP

--Data status: UP

--Active mlag vlans: 2-4093

--Redirect FSM state: UNREDIRECT

--Isolate FSM state: ISOLATE

--Block FSM state: UNBLOCK

--Remote interface: link-aggregation 1

--Remote link status: UP

--Remote data status: UP

mlag-id: 20 (link-aggregation 20)

--Link status: UP

--Data status: UP

--Active mlag vlans: 2-4093

--Redirect FSM state: UNREDIRECT

--Isolate FSM state: ISOLATE

--Block FSM state: UNBLOCK

--Remote interface: link-aggregation 20

--Remote link status: UP

--Remote data status: UP

Device1#

37 ARP

37.1 Overview

Address Resolution Protocol (ARP) provides dynamic mapping from IP addresses to MAC addresses. The Ethernet frames to be transmitted in the Ethernet can be encapsulated properly only after MAC addresses are specified. The ARP protocol is used to obtain MAC addresses that correspond to IP addresses.

37.2 ARP Function Configuration

Table 37-1 ARP Function Configuration List

Configuration Task	
Configure Basic Functions of ARP	Configure static ARP
	Configure local ARP advertisement
	Configure the maximum number of dynamic ARP entries
	Configure the dynamic ARP aging time
	Enable dynamic ARP learning
	Enable Dynamic ARP Learning
	Configure ARP Receive Queue Depth
	Configure ARP Proxy
	Enable ARP fast response

37.2.1 Configure Basic Functions of ARP

Configuration Condition

None

Configure Static ARP

Configuring static ARP means that the user manually specifies the mapping relationship between IP addresses and MAC addresses.

Table 37-2 Configuring Static ARP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure static ARP	**arp** [**vrf** *vrf-name*] { *ip-address* | *host-name* } *mac-address* [**alias** [**advertise**] | **advertise** [**alias**]] [**vlan** *vlan-id* {{ **interface** *if-name*} | { **link-aggregation** *link-aggregation-id* }}]	Mandatory

Note

- When the configured static ARP entry contains an alias option, if an ARP request for this IP address is received, the MAC address in the static ARP entry is used for response.
- When the configured static ARP entry contains an advertise option, the static ARP will be regularly advertised when the static ARP advertisement is enabled.
- When static ARP is bound to a specific port or aggregation group, the static ARP takes effect only on that port or aggregation group.

Configure Local ARP Advertisement

ARP request packets are broadcast packets. When there are a large number of ARP requests in the network, it is easy to cause a broadcast storm in the network, which can result in normal ARP request packets being overwhelmed and ARP unable to be learned. In this case, you can reduce the possibility of broadcast storms by configuring the local ARP advertisement feature to reduce ARP requests.

Table 37-3 Configuring Local ARP Advertisement

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure local ARP advertisement	**arp local-announce enable**	Mandatory
Configure local ARP advertisement interval.	**arp local-announce interval** *seconds*	Optional The default value is 10 seconds.
Configure local ARP advertisement rate.	**arp local-announce rate** *speed*	Optional The default value is 1 packet per second.

Configure Maximum Number of Dynamic ARP Entries

The maximum number of dynamic ARP entries is configured to avoid dynamically learned ARP from taking up too many system resources.

Table 37-4 Configuring the Maximum Number of Dynamic ARP Entries

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the maximum number of dynamic ARP entries	**arp limited** *max-entries*	Mandatory The default maximum number of entries is 2000.

Configure Dynamic ARP Aging Time

There is a survival period, or aging time, for dynamically learned ARPs. During the aging time, the device will send ARP requests periodically, reset the aging time if an ARP response is received, and delete the dynamic ARP table entry when the aging time expires.

Table 37-5 Configuring Dynamic ARP Aging Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the dynamic ARP aging time	**arp timeout** { *second* | **disable** }	Mandatory The default aging time is 1200 seconds.

Enable Dynamic ARP Learning

By default, a dynamic ARP learning is enabled on a device. To prevent dynamic learning from occupying too many system resources, you can disable the dynamic ARP learning function. After dynamic ARP learning is disabled, after the local device receives an ARP request for the MAC address of the local device, it sends an ARP response but does not generate any related ARP entry. An ARP entry is generated only when the local device requests for the MAC address of a peer device.

Table 37-6 Enabling Dynamic ARP Learning

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable Dynamic ARP Learning	**arp learn-active**	Mandatory By default, the dynamic ARP passive learning function is enabled.

Enable Interface Dynamic ARP Learning

An interface can perform dynamic ARP learning by default. To increase reliability and security, users can disable the interface dynamic ARP learning function and use static ARP, which can effectively prevent ARP spoofing.

Table 7 Enabling Dynamic ARP Learning Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the interface configuration mode	**interface** *interface-name*	-
Enable dynamic ARP learning	**arp dynamic-learn**	Mandatory By default, the dynamic ARP learning function is enabled.

Configure ARP Receive Queue Depth

The ARP packets received by the device will be first cached to the ARP receive queue. The system will read the packets from the queue in order and then handle the packets. When the cached ARP packets reach the queue depth, the subsequently received APR packets will be dropped. The user can adjust the ARP receive queue depth based on the network ARP emergency.

Table 8 Configuring ARP Packet Receive Queue Length

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure ARP Receive Queue Depth	**arp queue-length** *length*	Mandatory The default ARP packet receive queue depth is 200.

Configure ARP Proxy

An ARP request is sent by the host of one network to another network, and the intermediate device between the two networks can respond to the ARP request. This process is called ARP proxy.

Table 9 Configuring ARP Proxy

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-

Step	Command	Description
Configure ARP Proxy	**ip proxy-arp**	Mandatory By default, the ARP proxy function is enabled.

Configure ARP Fast Response

By default, after receiving the ARP packets, the device will send the packets to the MPU to learn and respond. After enabling the ARP fast response function, the device can give fast responses to the packets in the LPU.

Table 37-10 Configuring ARP Fast Response

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure ARP Fast Response	**arp fast-response**	Mandatory By default, the global ARP fast response function is disabled.

37.2.2 ARP Monitoring and Maintaining

Table 11 ARP Monitoring and Maintaining

Command	Description
show arp [**vrf** *vrf-name*]	View ARP table
show arp attack-detection	View information about suspected hosts of ARP attacks
show arp statistic	View ARP statistics

37.3 Typical Configuration Example of ARP

37.3.1 Configure ARP Proxy

Network Requirements

- Device is directly connected to PC1 and PC2 respectively. The network number of the LAN where PC1 and PC2 are located is the same, both are 10.0.0.0/16.
- The MAC address of Device's interface VLAN2 is 0001.7a13.0102.
- Through the ARP proxy of Device, PC1 is able to ping through to PC2, and PC1 can learn the MAC address of PC2.

Network Topology

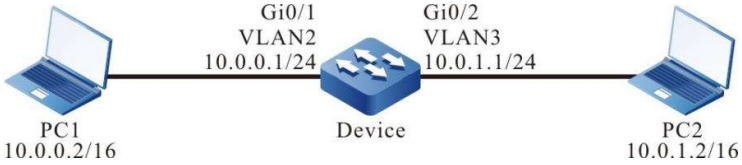


Figure 37-1 Network Topology for Configuring ARP Proxy

Configuration Steps

Step 1: Configure Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Check the result.

PC1 ping PC2 at the address 10.0.1.2.

```
C:\Documents and Settings>ping 10.0.1.2

Pinging 10.0.1.2 with 32 bytes of data:

Reply from 10.0.1.2: bytes=32 time<1ms TTL=255
Reply from 10.0.1.2: bytes=32 time<1ms TTL=255
Reply from 10.0.1.2: bytes=32 time<1ms TTL=255
Reply from 10.0.1.2: bytes=32 time<1ms TTL=255

Ping statistics for 10.0.1.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
```

```
Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

View Device's ARP table entries.

```
Device#show arp
Protocol  Address     Age (min) Hardware Addr   Type   Interface   Swithport
Internet  10.0.0.1    -         0001.7a13.0102  ARPA   vlan2       ---
Internet  10.0.0.2    1         B8AC.6F2D.4498  ARPA   vlan2
gigabitethernet0/1
Internet  10.0.1.1    -         0001.7a13.0103  ARPA   vlan3       ---
Internet  10.0.1.2    1         4437.e603.0d63  ARPA   vlan3       gigabitethernet0/2
```

View the ARP table entries of PC1.

```
C:\Documents and Settings>arp -a

Interface: 10.0.0.2 --- 0x5
  Internet Address      Physical Address      Type
  10.0.0.1              00-01-7a-13-01-02     dynamic
  10.0.1.2              00-01-7a-13-01-02     dynamic
```

PC1 is able to ping through to PC2, and PC1 can learn the MAC address of PC2.

Note

- The device has ARP proxy enabled by default.

37.3.2 Configure Static ARP

Network Requirements

- Device is directly connected to the PC.
- The MAC address of the PC is 4437.e603.0d63.
- Bind the IP address and MAC address of PC on Device.
- PC is able to ping through to the address of the interface VLAN2 of Device.

Network Topology

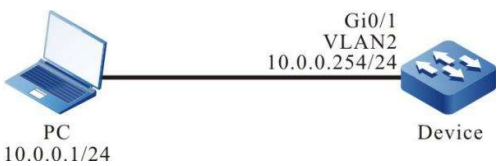


Figure 37-2 Network Topology for Configuring Static ARP

Configuration Steps

Step 1: Configure VLAN, and add ports to the corresponding VLAN. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Bind the IP address and MAC address of PC on Device.

#Configure Device.

Bind the IP address and MAC address of PC to Device.

```
Device(config)#arp 10.0.0.1 4437.e603.0d63
```

Step 4: Check the result.

View Device's ARP table entries.

```
Device1#show arp
Protocol  Address     Age (min) Hardware Addr   Type   Interface  Switchport
Internet  10.0.0.1    -         4437.e603.0d63  ARPA   vlan2      gigabitethernet0/1
Internet  10.0.0.254  -         0001.7a13.0102  ARPA   vlan2      ---
```

#The PC is able to ping through to the address of the interface VLAN2 of Device 10.0.0.254.

```
C:\Documents and Settings>ping 10.0.0.254

Pinging 10.0.0.254 with 32 bytes of data:

Reply from 10.0.0.254: bytes=32 time<1ms TTL=255
Reply from 10.0.0.254: bytes=32 time<1ms TTL=255
Reply from 10.0.0.254: bytes=32 time<1ms TTL=255
Reply from 10.0.0.254: bytes=32 time<1ms TTL=255

Ping statistics for 10.0.0.254:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

#The PC is able to ping through to the address of the interface VLAN2 of Device 10.0.0.254.

38 IP Basics

38.1 Overview

The Internet Protocol (IP) is based on data packets. It is used in data exchange between computer networks. The protocols that are supported by the device include: IP, Internet Control Message Protocol (ICMP), Transfer Control Protocol (TCP), User Datagram Protocol (UDP), and Socket.

Among them, IP packets are the base of the TCP/IP protocol stack. The IP layer is responsible for addressing, fragmentation, reassembly, and protocol information partitioning. As the network layer protocol, the IP protocol performs route addressing and control packet transmission.

The UDP protocol and the UDP protocol is set up based on the IP protocol. They provide connection-based reliable data transmission services and non-connection-based unreliable data transmission services respectively.

ICMP is mainly used to provide network detection services. It also provides an error report if the network layer or transmission layer protocol becomes abnormal, and it informs the related device of the abnormality to facilitate network control management.

38.2 IP Basic Function Configuration

Table 38-1 IP Basic Function Configuration List

Configuration Task	
Configure an IP address.	Configure an IP address for an interface.
	Configure an unnumbered IP address for an interface.
Configure basic functions of the IP protocol.	Configure the depth of the IP packet receiving queue.
	Configure the Time To Live (TTL) of transmitted IP packets.

Configuration Task	
	Configure timeout for packet reassembly.
	Enable IP packet receiving verification and check.
	Configure transmitted IP packets to calculate a checksum.
	Enable IP routing cache.
Configure basic functions of the ICMP protocol.	Enable global ICMP redirection.
	Enable global ICMP redirection.
	Enable ICMP destination unreachable.
Configure basic functions of the TCP protocol.	Configure the size of the TCP receiving cache.
	Configure the size of the TCP transmitting cache.
	Configure the maximum number of TCP retransmissions.
	Configure the maximum length of TCP packets.
	Configure the maximum TCP round-trip time.
	Configure the TCP connection idle time.
	Configure TCP connection setup waiting time.
	Configure the maximum number of TCP keep-alive times.
	Enable the TCP timestamp.
	Enable TCP selective retransmission.
Configure basic functions of the UDP protocol.	Configure TTL of UDP packets.
	Configure the size of the UDP receiving cache.
	Configure the size of the UDP transmitting cache.

Configuration Task	
	Enable UDP verification and check.
	Fill in UDP packet checksum.

38.2.1 Configure an IP Address

An IP address is a 32-bit number which uniquely identifies a network device that runs the IP protocol on the Internet.

An IP address consists of the following two parts:

- Network number (Net-id): It identifies the network in which the device is located.
- Host number (Host-id): It specifies the host number in the device network.

To facilitate IP address management, IP addresses are categorized into five classes, and each IP address class has its own functions. IP addresses of classes A to C are used for address allocation, IP addresses of class D is used in multicast applications, and IP addresses of class E are used for test purpose. The following table shows the IP addresses classes and their ranges.

Table 38-2 IP Address Classes and Their Ranges

Address Type	Available Network Address Range	Description
A	1.0.0.0 ~ 127.0.0.0	Network number 127 is used for loopback interfaces.
B	128.0.0.0 ~ 191.255.0.0	-
C	192.0.0.0 ~ 223.255.255.0	-
D	224.0.0.0 ~ 239.255.255.255	Class D addresses are used for multicast.
E	240.0.0.0 ~ 255.255.255.254	Class E addresses are used for test purpose.

With the development of the Internet, IP address resources have gradually been consumed up. Address allocation based on classes causes address waste, so the concept of "subnet" is introduced. "Subnet" takes some host numbers in the IP addresses as subnet numbers. In this way, a large network is divided into multiple subnets. This facilitates network planning and deployment.

The three address segments, 10.0.0.0-10.255.255.255, 172.16.0.0-172.16.255.255, and 192.168.0.0-192.168.255.255 are private and reserved addresses, and they cannot be allocated to the public network.

This section describes how to configure an interface IP address and how to configure an unnumbered interface IP address.

Configuration Condition

None

Configure an IP Address for an Interface

An IP address can only be configured for an interface that supports the IP protocol. One interface can only be configured with one primary IP address but it can be configured with multiple secondary IP addresses.

Table 38-3 Configuring an IP Address for an Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure an IP address for an interface.	**ip address** *ip-address* { *network-mask* | *mask-len* } [**secondary**]	Mandatory

Note

- One interface can only be configured with one primary IP address, therefore, the newly configured primary IP address replaces the original primary IP address.
- Before an interface is configured with secondary IP addresses, the interface must be configured a primary IP address. An interface can be configured with a maximum of 100 secondary IP addresses.
- The IP addresses of different interfaces must not in the same network segment, but the primary and secondary IP addresses of one interface can be in the same network segment.

Configure an Unnumbered IP Address for an Interface

Unnumbered IP addresses save IP addresses. In the case of unnumbered IP addresses, the IP addresses of other interfaces can be borrowed instead of allocated independently. If an unnumbered interface

generates an IP packet, the source IP address of the packet is the primary IP address of a borrowed interface. In configuring an unnumbered IP address for an interface, the interface to be borrowed must be specified, so that the IP address of the interface can be borrowed.

Table 38-4 Configuring an Unnumbered IP Address for an Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure an unnumbered IP address for an interface.	**ip unnumbered** *reference-interface*	Mandatory

Note

- The borrowed interface must be configured with the primary IP address, and the interface must not be configured with an unnumbered IP address.
- The primary IP address of an interface can be borrowed by multiple interfaces, but only the primary IP address of the interface can be borrowed.

38.2.2 Configure Basic Functions of the IP Protocol

In the TCP/IP protocol stack, the IP protocol is the network layer core protocol that is responsible for network interconnection. The IP protocol is a connectionless protocol. Before transmitting data, you need not set up a connection. The IP protocol tries best to deliver packets, but is does not ensure that all packets can reach the destination orderly.

Configuration Condition

None

Configure the Depth of the IP Packet Receiving Queue

The IP packets received by a device are first cached in the IP packet receiving queue of an interface. The system reads packets orderly in the queue for processing. If the cached IP packets reach the specified queue depth, the later IP packets are discarded. You can adjust the depth of the IP packet receiving queue according to burst of IP packets in the network.

Table 38-5 Configuring the Depth of the IP Packet Receiving Queue

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the depth of the IP packet receiving queue to a specified value.	**ip option queue-length** *queue-size*	Mandatory By default, the depth of the IP packet receiving queue is 200.
Configure the depth of the IP packet receiving queue to the default value.	**default ip option queue-length**	Optional

Configure the Time To Live (TTL) of Transmitted IP Packets

The header of an IP packet contains the Time-To-Live (TTL) field, which is decreased by 1 once the IP packet passes a routing device. When the TTL is zero, the device discards the IP packet. By default, the TTL of IP packets transmitted by the device is 255, that is, the packet can only be transmitted for up to 255 times. If you want to limit the number of packet forwarding times, adjust the TTL value for the transmitted IP packets.

Table 38-38 Configuring the TTL of Transmitted IP Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the TTL of transmitted IP packets to a specified value.	**ip option default-ttl** *ttl-value*	Mandatory By default, the TTL of transmitted IP packets is 255.
Configure the TTL of transmitted IP packets to a default value.	**default ip option default-ttl**	Optional

Configure Timeout for Packet Reassembly

If an IP packet is fragmented during the transmission, after the fragments reach the destination, they need to be reassembled to form a complete IP packet. Before all fragments are received, the received fragments are cached temporarily. If reassembly times out before all fragments reach the destination, the received fragments are discarded.

Table 6-7 Configuring Timeout for Packet Reassembly

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configuring timeout for packet reassembly to a specified value.	**ip option fragment-ttl** *ttl-value*	Mandatory By default, the timeout for packet reassembly is 60, and the unit is 0.5 second.
Configuring timeout for packet reassembly to the default value.	**default ip option fragment-ttl**	Optional

Note

- The unit for timeout of packet reassembly is 0.5 second.

Enable IP Packet Receiving Verification and Check

You can enable this function to verify and check the received IP packets. If the checksum is incorrect, the packet will be discarded.

Table 38-38 Enabling IP Packet Verification and Check

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable IP packet receiving verification and check.	**ip option recv-checksum**	Mandatory By default, the function is enabled.

Step	Command	Description
Configure the method for verifying and checking the received IP packets to the default value.	**default ip option recv-checksum**	Optional

Enable IP Routing Cache

After a packet is sent from socket to the IP layer, if the destination address is the same as the previous packet and the route is valid, the packet directly use the route in the cache without the need of searching for another route.

Table 38-8 Enabling IP Routing Cache

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable IP routing cache.	**ip upper-cache**	Mandatory By default, the IP routing cache function is enabled.

38.2.3 Configure Basic Functions of the ICMP Protocol

In the TCP/IP protocol stack, ICMP is mainly used to provide network detection services. It also provides an error report if the network layer or transmission layer protocol becomes abnormal, and it informs the related device of the abnormality to facilitate network control management.

Configuration Condition

None

Enable Global ICMP Redirection

After a device receives an IP packet to be forwarded, if it is found that the receiving interface of the packet and the transmitting interface of the packet are the same through route selection, the device forwards the packet and sends back an ICMP redirection packet to the source end, requesting the source end to reselect the correct next hop for transmission of later packets. By default, a device can send ICMP redirection packets. In some special cases, you can prohibit a device from sending ICMP redirection packets.

Table 38-9 Enabling Global ICMP Redirection

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable global ICMP redirection.	**ip redirect**	Mandatory By default, the global ICMP redirection function is enabled.

Enable Global ICMP Redirection

In sending ICMP redirection packets, if you need to send ICMP redirection packets, you need to enable the ICMP redirection function on the interface.

Table 38-10 Enabling Global ICMP Redirection

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Enable global ICMP redirection.	**ip redirects**	Mandatory By default, the ICMP redirection function is enabled on an interface.

Note

- You can send ICMP redirection packets only when the ICMP redirection function is enabled globally and on the interface.

Enable Global ICMP Destination Unreachable

After a device receives IP data packets, if the destination is unreachable, the packet is discarded and the ICMP destination unreachable error packet is sent back to the source end.

- If route selection of a forwarded IP packet fails, the "network unreachable" ICMP error packet is sent back to the source end.

Table 38-11 Enabling ICMP Destination Unreachable

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable ICMP Destination Unreachable	**ip network unreachables reply**	Optional By default, the ICMP destination unreachable function is disabled.

Enable ICMP Destination Unreachable

After a device receives IP data packets, if the destination is unreachable, the packet is discarded and the ICMP destination unreachable error packet is sent back to the source end.

- If route selection of a forwarded IP packet fails, the host unreachable ICMP error packet is sent back to the source end.
- For an IP packet that can be forwarded, if you need to fragment the IP packet but a Don't Fragment (DF) bit is set in the packet, an ICMP error packet indicating that "segmentation is required but a DF bit is set" is sent to the source end.
- For an IP packet whose destination address is the local device, if the device does not support the upper-layer protocol of the device, it sends a "protocol unreachable" ICMP error packet to the source end.
- For an IP packet whose destination address is the local device, if the transport layer port of the packet of the packet does not match the port that the device process monitors, the device sends back a "port unreachable" ICMP error packet to the source end.

If a device encounters a malicious attack by a large number of ICMP destination unreachable packets, the device performance is degraded, and network traffic is increased. To prevent such case, you can disable the function of sending ICMP destination unreachable packets.

Table 38-12 Enabling ICMP Destination Unreachable

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the interface configuration mode	**interface** *interface-name*	-
Enable ICMP destination unreachable.	**ip unreachables**	Optional By default, the ICMP destination unreachable function is enabled.

38.2.4 Configure Basic Functions of the TCP Protocol

In the TCP/IP protocol stack, TCP is a connection-oriented transport layer protocol. Before sending data through the TCP protocol, you must first set up a connection. The TCP protocol provides congestion control and ensures reliable data transmission.

Configuration Condition

None

Configure Size of TCP Receiving cache

In some special network environment, you can configure both the size of receiving cache and the size of transmitting cache of a TCP connection so that the network can reach the optimal performance. If the TCP connection receiving cache is not configured, the size of the receiving cache is the default value.

Table 13 Configuring Size of TCP Receiving Cache

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the size of the TCP receiving cache.	**ip tcp recvbuffers** *buff-size*	Mandatory By default, the size of the receiving cache is 8192 bytes.

Configure Size of TCP Transmitting Cache

In some special network environment, you can configure both the size of receiving cache and the size of transmitting cache of a TCP connection so that the network can reach the optimal performance. If the TCP connection transmitting cache is not configured, the size of the transmitting cache is the default value.

Table 14 Configuring Size of TCP Transmitting Cache

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the size of the TCP transmitting cache.	**ip tcp sendbuffers** *buff-size*	Optional By default, the size of the transmitting cache is 8192 bytes.

Configure the Maximum Number of TCP Retransmissions

After the server sends a SYN-ACK packet, if it does not receive a response packet from the client, the server retransmits the packet. If the number of retransmissions exceeds the maximum number of retransmissions defined by the system, the system disconnects the TCP connection.

Table 15 Configuring the Maximum Number of TCP Retransmissions

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the maximum number of TCP retransmissions.	**ip tcp retransmits** *retransmits-count*	Mandatory By default, the maximum number of TCP retransmissions is 3.

Configure the Maximum Length of TCP Packets

The maximum length of TCP packets is the maximum length of data blocks that are sent by the transmitting end of a TCP connection to the receiving end. When a connection is set up, the smaller maximum packet length of the two ends is used as the maximum packet length in sending TCP packets by the two ends. If a TCP packet exceeds the maximum packet length, the transmitting ends fragments the packet before sending it.

Table 16 Configuring the Maximum Length of TCP Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the maximum length of TCP packets.	**ip tcp segment-size** *seg-size*	Optional By default, the maximum length of TCP packets is 512 bytes.

Configure the Maximum TCP Round-trip Time

The TCP round trip time refers to the time between the timepoint at which the transmitting end sends a TCP packet and the timepoint at which the transmitting end receives the response packet. The maximum TCP round-trip time that is configured during TCP connection setup is taken as the initial value of the TCP round-trip time. The later TCP round-trip time is calculated according to the actual round-trip time. By default, the maximum TCP round-trip time is 3 seconds.

Table 17 Configuring the Maximum TCP Round-Trip Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the maximum TCP round-trip time.	**ip tcp round-trip** *round-trip-time*	Mandatory By default, the maximum TCP round-trip time is 3 seconds.

Configure TCP Connection Idle time

After a TCP connection is set up, if no data is exchanged, the TCP connection idle time times out. Then TCP performs a keep-alive test. After the maximum number of keep-alive times is reached, the TCP connection is disconnected. By default, the TCP connection idle time is 2 hours.

Table 18 Configuring TCP Connection Idle Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the TCP connection idle time.	**ip tcp idle-timeout** *idle-time*	Mandatory By default, the TCP connection idle time is 14400, and the unit is 0.5 second.

Note

- The unit of the TCP connection idle time is 0.5 second.

Configure TCP Connection Setup Waiting Time

The setup of a TCP connection requires three handshakes. After a TCP client sends a connection request packet, it waits for the response from the TCP server before completing connection setup. After the time for waiting for connection setup timeout before a response is received, connection setup is terminated. By default, the time for waiting for setting up a TCP connection is 75 seconds.

Table 19 Configuring TCP Connection Setup Waiting Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TCP connection setup waiting time.	**ip tcp init-timeout** *init-time*	Mandatory By default, the time for waiting for setting up a TCP connection is 150 seconds, and the unit is 0.5 second.

Note

- The unit of the TCP connection setup waiting time is 0.5 second.

Configure the Maximum Number of TCP Keep-alive Times

If no data is exchanged on a TCP connection for TCP connection idle time, a TCP keep-alive packet is sent for keep-alive test. If the keep-alive test fails, a keep-alive test is performed again. If the maximum number of TCP keep-alive times exceeds the threshold, the TCP connection will be disconnected. By default, the maximum number of TCP keep-alive times is 3.

Table 20 Configuring the Maximum Number of TCP Keep-Alive Times

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the maximum number of TCP keep-alive times.	**ip tcp keep-count** *keep-count*	Mandatory By default, the maximum number of TCP keep-alive times is 3.

Enable TCP Timestamp

TCP automatically calculates the packet round-trip time according to the serial number of the request packet and that of the response packet. However, the calculation is not accurate. Use of TCP timestamps can revise the problem. The transmitting end adds a timestamp into a packet, and the receiving end sends back the timestamp in the response packet. The transmitting end calculates the packet round-trip time according to the returned timestamp. By default, the function is disabled.

Table 21 Enabling TCP Timestamp

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the TCP timestamp.	**ip tcp timestamp**	Mandatory By default, the function is disabled.

Enable TCP Selective Retransmission.

After TCP sends a series of packets, if the transmission of one packet fails, the series of packets need to be retransmitted. After TCP selective transmission is enabled, then only the packet that fails to be transmitted needs to be retransmitted. By default, the function is disabled.

Table 22 Enabling TCP Selective Retransmission

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TCP selective retransmission.	**ip tcp selective-ack**	Mandatory By default, the function is disabled.

38.2.5 Configure TCP Protocol Anti-Attack Function

The TCP server receives a large number of SYN packets but the peer end does not respond to the SYN-ACK response from the server. This can cause the server's memory to be consumed heavily, taking up the server's syn queue and causing the TCP server unable to service normal requests. Such attacks can be avoided by configuring TCP anti-attack function.

Configuration Condition

None

Enable TCP Syncache Function

This function does not rush to allocate the TCB when a SYN data packet is received, but first responds with a SYN ACK packet and stores this half-open connection information in a dedicated HASH table (Cache) until a correct response ACK packet is received before allocating the TCB.

Table 23 Enabling TCP Syncache Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TCP syncache function	**ip tcp syncache**	Mandatory By default, the function is disabled.

Enable TCP Syncookies Function

This function does not use any storage resources at all, it uses a special algorithm to generate Sequence Number. The algorithm takes into account fixed information including the other party's IP, port, its own IP and port, and other fixed information of its own, such as MSS, time, etc. After receiving the other party's ACK packet, the algorithm will recalculate it to see if it is the same as the other party's response packet (Sequence Number-1), so as to decide whether to allocate TCB resources.

Table 24 Enabling TCP Syncookies Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the TCP syncookies function.	**ip tcp syncookies**	Mandatory By default, the function is disabled.

38.2.6 Configure Basic Functions of the UDP Protocol

In the TCP/IP protocol stack, UDP is a connectionless-oriented transport layer protocol. Before sending data through the TCP protocol, you need not set up a connection. The UDP protocol provides unreliable data transmission without congestion control.

Configuration Condition

None

Configure TTL of UDP Packets

Configuring TTL of UDP packets means to fill in the TTL value in the IP header of UDP packets. The header of an IP packet contains the Time-To-Live (TTL) field, which is decreased by 1 once the IP packet passes a routing device. When the TTL is zero, the device discards the IP packet. By default, the TTL value of the IP packet of a UDP packet is 64.

Table 25 Configuring TTL of UDP Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TTL of UDP packets.	**ip udp default-ttl** *time-to-live*	Mandatory

Step	Command	Description
		By default, the TTL value of the IP packet of a UDP packet is 64.

Configure Size of UDP Receiving Cache

In some special network environment, you can configure both the size of receiving cache and the size of transmitting cache of a UDP connection so that the network can reach the optimal performance. If the UDP connection receiving cache is not configured, the size of the receiving cache is the default value, 41600 bytes.

Table 26 Configuring Size of UDP Receiving Cache

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the size of the UDP receiving cache.	**ip udp recvbuffers** *buffer-size*	Mandatory By default, the size of the UDP receiving cache is 41600 bytes.

Configure Size of UDP Transmitting Cache

In some special network environment, you can configure both the size of receiving cache and the size of transmitting cache of a UDP connection so that the network can reach the optimal performance. If the UDP connection transmitting cache is not configured, the size of the transmitting cache is the default value, 9216 bytes.

Table 27 Configuring Size of UDP Sending Cache

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the size of the UDP transmitting cache.	**ip udp sendbuffers** *buffer-size*	Mandatory

Step	Command	Description
		By default, the size of the UDP transmitting cache is 9216 bytes.

Enable UDP Verification and Check

To prevent errors that occur during transmission of UDP packets, after UDP packets are received, UDP verification and check need to be performed. The system compares the UDP packet verification field calculated by the receiving end and the UDP packet header checksum field. If the two values are different, the system determines that a transmission error has occurred, and then discards the packet. By default, the function is enabled.

Table 28 Enabling UDP Verification and Check

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable UDP verification and check.	**ip udp recv-checksum**	Mandatory By default, the function is enabled.

Fill in UDP Packet Checksum

To prevent UDP packets from encountering transmission errors, in transmitting UDP packets, the transmitting end fills in the UDP packet checksum to be calculated into the UDP packet header checksum field for the receiving end to perform checksum check. By default, the function is enabled.

Table 29 Filling in UDP Packet Checksum

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to fill in packet checksum in transmitting UDP packets.	**ip udp send-checksum**	Mandatory By default, the function is enabled.

38.2.7 IP Basics Monitoring and Maintaining

Table 30 IP Basics Monitoring and Maintaining

Command	Description
clear ip icmpstat	Clears ICMP protocol statistics.
clear ip statistics	Clears IP protocol statistics.
clear ip tcp syncache statistics	Clears TCP protocol syncache statistics.
clear ip tcpstat	Clears TCP protocol statistics.
clear ip udpstat	Clears UDP protocol statistics.
show ip icmpstat	Displaying ICMP protocol statistics.
show ip interface [*interface-name* **| brief**]	Displaying the interface IP address.
show ip sockets	Displaying the Socket details.
show ip statistics	Displaying IP protocol statistics.
show ip tcpstat	Displaying TCP protocol statistics.
show ip tcp syncache statistics	Displaying TCP syncache statistics.
show ip udpstat	Displaying UDP protocol statistics.
show ip tcp syncache detail	Displaying TCP protocol syncache entry details.
show tcp tcb [**detail**]	Displaying TCP protocol control block details.

39 DHCP

39.1 Overview

It is hard to manage a large network. For example, in a network in which IP addresses are manually allocated, IP address conflicts are common. The only way of solving the problem is to dynamically allocate IP addresses to the hosts. The Dynamic Host Configuration Protocol (DHCP) allocates IP address to requesting hosts from an IP address pool. DHCP also provides other information, such as gateway IP and DNS server address. DHCP reduces the workload of the administrator in recording and tracking manually allocated IP addresses.

DHCP is a protocol that is based on UDP broadcast. The process for a DHCP client to obtain an IP address and other configuration information from a DHCP server contains four phases:

DISCOVER phase. When the DHCP client accesses the network for the first time, it sends a DHCP DISCOVER packet with the source address 0.0.0.0 and destination address 255.255.255.255 to the network.

OFFER phase. After the DHCP server receives the DHCP DISCOVER broadcast packet sent by the client, it selects an IP address from the corresponding IP address pool according to the policy, and sends the IP address and other parameters to the client in a DHCP OFFER packet.

REQUEST phase. If the DHCP client receives response messages from multiple DHCP servers on the network, it selects one DHCP OFFER (usually the one that arrives first). Then it sends a DHCP REQUEST packet to the network, telling all DHCP servers the IP address of which server it will accept.

ACK phase. After the DHCP server receives the DHCP REQUEST packet from the DHCP server, it sends a DHCP ACK message containing the provided IP address and other configuration to the DHCP client, telling the DHCP client that the DHCP client can use the provided IP address.

The IP address that the DHCP server allocates to the DHCP client has a lease. After the lease expires, the server will take back the allocated IP address. When the lease term of the IP address of the DHCP client has passed half time, the DHCP client sends a DHCP REQUEST packet to the DHCP server requesting to update its IP address lease. If the DHCP server allows the DHCP client to use its IP address, the DHCP server responds with a DHCP ACK packet, requesting the DHCP client to update the lease. If the DHCP server does not allow the DHCP client to continue to use the IP address, the DHCP server responds with a DHCP NAK packet.

During dynamic IP address acquisition, request packets are sent in broadcast mode; therefore, DHCP is applied only when the DHCP client and server are in the same subnet. If multiple subnets exist in a network and the hosts of the subnets need to obtain configuration information such as IP address through the DHCP server, the hosts of the subnets communicate with the DHCP server through a DHCP relay to obtain IP addresses and other configuration information.

39.2 DHCP Function Configuration

Table 39 DHCP Function Configuration List

Configuration Task	
Configure a DHCP Address Pool	Creating the DHCP address pool to allow VRF attributes specification.
	Configure an IP address range.
	Configure a DNS server address.
	Configure the default route.
	Configure the lease of an IP address.
	Bind an IP address and a MAC address.
	Configure user-defined options.
	Configure the IP address pool of a specified vender.
Configure other parameters of a DHCP server.	Configure DHCP server.
	Configure the ranges of reserved IP addresses.
	Configure the DHCP ping probe parameters.
	Configure DHCP data logging function.
Configure the functions of a DHCP client.	Configure a DHCP client.
	Configure vendor ID.
	Configure DHCP routing distance.
	Configure DHCP option 60 function.

	Configure the DHCP client not to request the default route option.
Configure the Function of a DHCP Relay	Configure interface DHCP relay.
	Configure functions of Option 82.
	Configure interface DHCP relay packets source address.
	Configure a DHCP server address.

39.2.1 Configure a DHCP Address Pool

Configuration Condition

None

Create a DHCP Address Pool

A DHCP server needs to select and allocate IP addresses and other parameters from a DHCP address pool. Therefore, a DHCP address pool must be created for the DHCP server.

Table 1 Creating a DHCP Address Pool

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create a DHCP address pool and enter the DHCP configuration mode.	**ip dhcp pool** *pool-name* **[vrf** *vrf-name* **]**	Mandatory By default, no DHCP address pool has been created by the system.

Note

- Address pools fall into two types: Network and Range. The two types of address pools can be configured respectively through the network and range commands.

Configure an IP Address Range

On a DHCP server, each DHCP address pool must be configured with an IP address range to allocate IP addresses to DHCP clients.

Table 2 Configuring an IP Address Range

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCP configuration mode.	**ip dhcp pool** *pool-name* **[vrf** *vrf-name* **]**	-
Configure an IP address range for an address pool of the Network type.	**network** *ip-address* [*network-mask* **|** *mask-len*]	Optional By default, an IP address range is not configured for an address pool.
Configure an IP address range for an address pool of the Range type.	**range** *low-ip-addres high-ip-address* [*network-mask*	*mask-len*]	Optional By default, an IP address range is not configured for an address pool.

Note

- After an IP address range is configured for an address pool by using the network or range command, if you run the network or range command again, the new IP address range configuration overwrites the existing configuration.
- Change the type of the address pool from network to range (or vice versa). If the address range of the new configuration and the address range of the old configuration intersect, the command line will prompt the user whether to perform this operation, if yes, all address configurations (static binding, vendor sub-pool) and dynamic leases under the address pool will be deleted; if the actual effective address range of the new configuration covers the actual effective address range of the old configuration, the address pool will keep all the address configurations under the address pool (static binding, vendor sub-pool), and delete the ip range and dynamic lease of the vendor sub-pool configuration.

Configure a DNS Server Address

On a DHCP server, you can configure the DNS server address respectively for each DHCP address pool. When a DHCP server allocates an IP address for a DHCP client, it also sends the DNS server address to the client.

When the DHCP client starts dynamic domain name resolution, it queries the DNS server.

Table 3 Configuring a DNS Server Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCP configuration mode.	**ip dhcp pool** *pool-name* **[vrf** *vrf-name* **]**	-
Configure a DNS server address.	**dns-server** { *ip-address*&<1-8> | **autoconfig** }	Mandatory By default, the DNS server address is not configured.

Configure Default Route

On a DHCP server, you can specify the address of a gateway corresponding to clients for each DHCP address pool. When the server allocates an IP address to a client, it also sends the gateway address to the client.

When a DHCP client accesses a server or host that is not in the network segment, its data is forwarded through the gateway.

Table 4 Configuring Default Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCP configuration mode.	**ip dhcp pool** *pool-name* **[vrf** *vrf-name* **]**	-
Configure the default route.	**default-router** *ip-address*&<1-8>	Mandatory By default, no default route is configured.

Configure Lease Term of an IP Address

The IP address that the DHCP server allocates to the DHCP client has a lease. After the lease expires, the server will take back the allocated IP address. If the DHCP client wants to continue to use the IP address, it must have the IP address lease updated.

On the DHCP server, you can configure an IP address lease for each DHCP address pool.

Table 5 Configuring Lease Term of an IP Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCP configuration mode.	**ip dhcp pool** *pool-name* **[vrf** *vrf-name* **]**	-
Configure the lease of an IP address.	**lease** *days* [*hours* [*minutes*]]	Mandatory By default, the value of *days* is 1, the value of *hours* is 6, and the value of *minutes* is 0.

Bind IP Address and MAC Address

After IP addresses and MAC addresses are bound, when the client with a specified MAC address sends an IP address request to the DHCP server, the DHCP server allocates the IP address that is bound to the IP address to the client. In this way, as long as the MAC address of the client is not changed (e.g., by replacing the network interface card), the client will obtain the same IP address from the server each time.

Table 6 Binding IP Addresses and MAC Addresses

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCP configuration mode.	**ip dhcp pool** *pool-name* **[vrf** *vrf-name* **]**	-
Bind an IP address and a MAC address.	**bind** { *ip-address mac-address* | **automatic**}	Mandatory By default, no IP address and MAC address binding is configured.

Configure User-Defined Options

For some options, RFC does not give specifications; therefore, you can define these options according to the actual requirement.

Table 7 Configuring User-Defined Options

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCP configuration mode.	**ip dhcp pool** *pool-name* **[vrf** *vrf-name* **]**	-
Configure user-defined options.	**option** *option-code* { **ascii** *ascii-string* | **hex** *hex-string* | **ip** *ip-address*&<1-8> }	Mandatory By default, user-defined options are not configured.

Configure a DHCP Vendor Address Pool

When the client requests an IP address, it may carry the option 60, which specifies the vendor ID. Users can specify different IP address segments for different vendors.

Table 8 Configuring a DHCP Vendor Address Pool

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCP configuration mode.	**ip dhcp pool** *pool-name* **[vrf** *vrf-name* **]**	-
Configure the vendor address pool and enter DHCP vendor address pool configuration mode.	**vendor-class-identifier** *vendor_id*	By default, no vendor address pool is configured.
Configure the vendor address pool range.	**ip range** *low-ip-address high-ip-address*	No range is configured by default.
Configure the contents of option 43 to be returned by the specified vendor.	**option 43** { **ascii** *ascii-string* | **hex** *hex-string* | **ip** *ip-address*&<1-8> }	No configured by default.

39.2.2 Configure Other Parameters of a DHCP Server

Configuration Condition

None

Configure a DHCP Server

After configuring the interface to work in DHCP server mode, when the interface receives DHCP request packets from DHCP clients, the DHCP server allocates IP addresses and other network parameters for the clients.

Table 9 Configuring a DHCP Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the functions of the DHCP server.	**ip dhcp server**	Mandatory By default, no DHCP server function is configured.

Configure Ranges of Reserved IP Addresses

In the DHCP address pool, some IP addresses are reserved for specific devices, and some conflict with the IP addresses of other hosts on the network. These IP addresses cannot be used for dynamic allocation.

Table 10 Configuring Range of Reserved IP Addresses

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the ranges of reserved IP addresses.	**ip dhcp excluded-address** *low-ip-address* [*high-ip-address*] [**vrf** *vrf-name*]	Mandatory By default, the range of reserved IP addresses is not configured.

		The IP addresses in the reserved IP address range will not be allocated.

Configure DHCP Ping Probe Parameters

To prevent an IP address conflict, before dynamically allocating an IP address to a DHCP client, a DHCP server must detect the IP address. The detection operation is performed with the ping operation. The DHCP server determines whether an IP address conflict exists by checking and whether an ICMP echo response packet is received within the specified time.

Table 11 Configuring DHCP Ping Probe Parameters

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the DHCP ping probe parameters.	**ip dhcp ping** { **packets** *packet-num* | **timeout** *milliseconds* }	Mandatory By default, the number of ping packets is 1, and the timeout time is 500 ms.

Configure DHCP Data Logging Function

When the data log function of a DHCP server is enabled, the address pool allocation on the DHCP server will be recorded to the data log.

Table 12 Configuring DHCP Service Switch

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the DHCP server data logging service switch.	**ip dhcp logging security-data**	Mandatory By default, the data logging function is not enabled.

39.2.3 Configure Functions of a DHCP Client

Configuration Condition

None

Configure a DHCP Client

A DHCP client interface obtains an IP address and other parameters through DHCP.

Table 13 Configuring a DHCP Client

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the DHCP client to obtain an IP address.	**ip address dhcp** [**request-ip-address** *ip-address*]	Mandatory By default, the DHCP client is not configured to obtain an IP address.

Configure DHCP Routing Distance

Each protocol in the IP routing table has an administrative distance, or routing distance, that controls routing. Routing distance is used to make routing decisions for the same network segment routes from different protocols, and routes with small routing distance take precedence.

Table 14 Configuring DHCP Routing Distance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure DHCP routing distance.	**ip dhcp route-distance** *distance*	Mandatory By default, the DHCP routing distance is 254.

Configure the Option 60 Function

The content of DHCP option 60 is vendor ID, and the option 60 content can be carried during DHCP client request. The server can set the IP address allocation policy based on this option.

Table 15 Configuring DHCP Option 60 Function

Step	Command	Description

Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the option 60 function.	**ip dhcp vendor-class-identifier {disable | content** *hex-string}*	The option 60 content is carried by default.

Configure the DHCP Client not to Request the Default Route Option

In the process of requesting IP address, the DHCP client, will request the default route by default, users can specify the DHCP client not to request default route so as to configure the route by themselves.

Table 16 Configuring the DHCP Client Not to Request the Default Route Option

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the DHCP client not to request the default route option.	**ip dhcp router-option disable**	Mandatory By default, the DHCP client will request the default route option.

39.2.4 Configure the Function of a DHCP Relay

Configuration Condition

None

Configure a DHCP Relay

If multiple subnets exist in a network and the hosts of the subnets need to obtain configuration information such as IP address through the DHCP server, the hosts of the subnets communicate with the DHCP server through a DHCP relay to obtain IP addresses and other configuration information. If an interface is configured to work in DHCP relay mode, after the interface receives DHCP packets from a DHCP client, it relays the packet to the specified DHCP server. The DHCP server then allocates an IP address.

Table 17 Configuring a DHCP Relay

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the Function of a DHCP Relay	**ip dhcp relay**	Mandatory By default, the DHCP relay function is not configured.

Configure the Function of Option 82

Option 82 is a relay information option, which records the location of a DHCP client. If the DHCP relay is enabled to support Option 82 through configuration, a DHCP relay receives a request packet sent by a DHCP client to a DHCP server and the request packet does not contain the Option 82 option, it adds Option 82 into the request packet and sends the packet to the DHCP server. If the DHCP relay is enabled to support Option 82 through configuration and the request packet carries Option 82, it will proceed to the next step according to the action configured by the **ip dhcp relay information strategy** command, and then forward the packet to the server. If the DHCP relay receives a DHCP response packet which contains Option 82, it deletes Option 82 and forwards the packet to the DHCP client.

Table 18 Configuring the Option 82 Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the DHCP relay to support Option 82	**ip dhcp relay information option**	Mandatory By default, the DHCP relay is not enabled to support Option 82.
Configure the processing policy when a DHCP relay receives a request packet with Option 82 from a client.	**ip dhcp relay information strategy{drop | keep | replace}**	Optional Use the REPLACE action for packets carrying Option 82.

Configure functions of Option 82.	**ip dhcp relay information option | remote-id** { **ascii** *ascii-string* | **hex** *hex-string* }/ **circuit-id** { **ascii** *ascii-string* | **hex** *hex-string* } }	Mandatory By default, the Option 82 function is not configured.

Configure DHCP Relay Packets Source Address

The source address used by DHPC relay when forwarding DHCP client-originated packets to a DHCP server is, by default, the output interface address of the route to the DHCP server. In some environments, the DHCP server cannot communicate with this address, therefore users are allowed to configure the source address of the packets forwarded by the DHCP relay to the DHCP server and the giaddr field in the packets via the **ip dhcp relay source-address** command. Also users are allowed to configure the DHCP relay source address as the address of the interface that receives DHCP client packets via the **ip dhcp relay source-address relay-address** command.

Table 19 Configuring DHCP Relay Packets Source Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure DHCP Relay Packets Source Address	**ip dhcp relay source-address relay-address**	Mandatory By default, the DHCP relay packets source address is the output interface address of the route to the DHCP server.
Enter the interface configuration mode	**interface** *interface-name*	-
Configure DHCP Relay Packets Source Address	**ip dhcp relay source-address** *ip-address*	Mandatory By default, the DHCP relay packets source address is the output interface address of the route to the DHCP server.

Note

- The source address of the **ip dhcp relay source-address** *ip-address* configuration must be the interface address of this device, and the interface address must belong to the same vrf as the relay interface, otherwise the relay packets will fail to be sent.
- If the **ip dhcp relay source-address** *ip-address* command is configured in interface mode and the **ip dhcp relay source-address relay-address** command is configured in global mode, the former has a higher priority than the latter, and the DHCP relay will fill the configured *ip-address* with the source address of DHCP relay packets sent to the DHCP server.

Configure a DHCP Server Address

After the interface receives DHCP packets from a DHCP client, it relays the packet to the specified DHCP server. The DHCP server then allocates an IP address.

Table 20 Configuring a DHCP Server Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure a DHCP server address.	**ip dhcp relay server-address** *ip-address*	Mandatory By default, no DHCP server address is configured.

39.2.5 DHCP Monitoring and Maintaining

Table 21 DHCP Monitoring and Maintaining

Command	Description
clear ip dhcp pool *pool-name* { **lease** | **conflict [***ip-address***]** }	Clears dynamic lease information from the address pool or address information with conflicting addresses.

clear ip dhcp server interface [*interface-name* **] statistics**	Clears the key statistics when the DHCP server interacts with clients or relays for packets.
clear ip dhcp relay statistics	Clears the statistics on the DHCP relay device.
show ip dhcp server interface *interface-name* **[statistics]**	Displaying the address pool information associated with the specified interface or displaying the key statistics when the DHCP server engages in packet interactions with clients or relays under the specified interface.
show ip dhcp pool *pool-name* **{ summary | ping_list | offer_list | excluded_list | conflict_list | lease | binding }**	Displaying the summary information of the specified address pool or the information of the address that is doing ping check or the address that has sent the OFFER packet and is waiting for the DHCP client to respond to the REQUEST packet or the information of the excluded address in the address pool or the information of the address that has address conflict in the address pool or the information of dynamic lease in the address pool or the information of static binding in the address pool.
show ip dhcp pool *pool-name* **specific { ip-address** *ip-address* **| mac-address** *mac-address* **}**	Displaying information about the specified IP address or mac address in the address pool.
show ip dhcp relay [interface *interface-name* **]**	Displaying the packet statistics on the DHCP relay device.

39.3 Typical Configuration Example of DHCP

39.3.1 Configure a DHCP Server to Statically Allocate IP Addresses

Network Requirements

- Device2 acts as a DHCP server to allocate IP addresses, gateway IP addresses, and DNS server IP addresses in a static manner.
- The DHCP server allocates an IP address to PC in MAC binding mode.

Network Topology

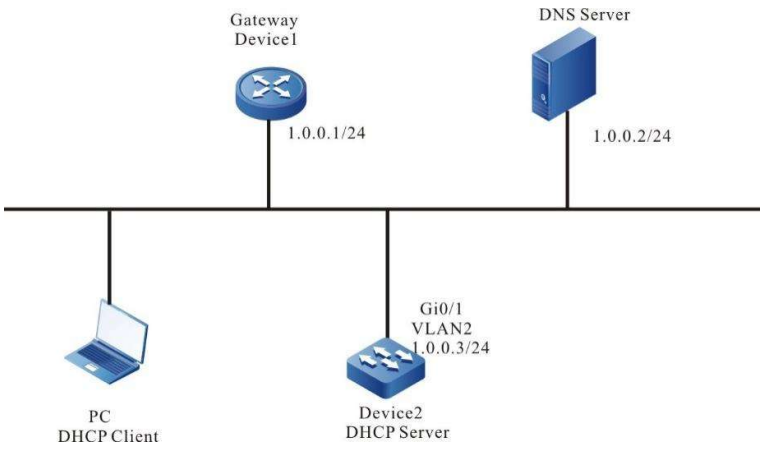


Figure 39 Network Topology for Configuring DHCP Server to Statically Allocate IP Addresses

Configuration Steps

Step 1: Configure Device2 interface IP addresses and enable it to work in DHCP server mode.

```
Device2#configure terminal
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ip address 1.0.0.3
255.255.255.0
Device2(config-if-vlan2)#ip dhcp server
Device2(config-if-vlan2)#exit
```

Step 2: Configure statically bound address pools and parameters.

#Configure the address pool mac-binding, and allocate an IP address to PC in static MAC binding mode.

```
Device2(config)#ip dhcp pool mac-binding
Device2(dhcp-config)#range 1.0.0.4 1.0.0.254
255.255.255.0
Device2(dhcp-config)#bind 1.0.0.11 00e0.00c1.013d
Device2(dhcp-config)#default-router 1.0.0.1
Device2(dhcp-config)#dns-server 1.0.0.2
Device2(dhcp-config)#exit
```

Step 3: Check the result.

#On Device2, use the show ip dhcp server interface vlan2 command to check the address pool associated with the interface.

```
Device2(config)#exit
Device2#show ip dhcp server interface vlan2
DHCP server status information:
DHCP server is enabled on interface: vlan2
Vrf : global
DHCP server pool information:
Available directly-connected pool:
Interface IP      Pool name          Pool Range         Pool utilization
-----------    ------------------  -------------------  ----------------
 1.0.0.3/24      mac-binding      1.0.0.4 – 1.0.0.254        0.00%
```

#On Device2, use the show show ip dhcp pool mac-binding binding command to check the IP addresses allocated

to the PC.

```
Device2#show ip dhcp pool mac-binding binding
IP Address     MAC Address        Vendor Id    Type
Time Left(s)
------------ ----------------- ------------- -------- ----------
---
1.0.0.11       00e0.00c1.013d      Global    Binding
NA
```

#On Device2, use the show show ip dhcp pool mac-binding lease command to check the addresses allocated to the PC.

```
Device#show ip dhcp pool danymic-pool2 lease
IP Address       MAC Address        Vendor Id
Type    Time Left(s)
------------ ------------------ -------------------- -------- ----
---------
1.0.0.11       00e0.00c1.013d       Global        Lease
107980
```

On the PC, check whether the obtained IP addresses, gateway IP addresses, and DNS server IP addresses are correct.

39.3.2 Configure a DHCP Server to Dynamically Allocate IP Addresses

Network Requirements

- Two interface VLANs of Device, VLAN2 and VLAN3, are respectively configured with IP addresses in the 1.0.0.3/24 and 2.0.0.3/24 network segments.
- The DHCP server Device dynamically allocates IP addresses in the 1.0.0.0/24 and

2.0.0.0.0/24 network segments to the two clients in the directly-connected physical network.

- The addresses in network segment 1.0.0.0/24 have a one-day lease, the gateway address is 1.0.0.3, the DNS server address is 2.0.0.4. The addresses in network segment 2.0.0.0/24 have a three-day lease, the gateway address is 2.0.0.3, and the DNS server address is 2.0.0.4.
- The first 10 IP addresses in network segments 1.0.0.0/24 and 2.0.0.0/24 are reserved and cannot be allocated.

Network Topology

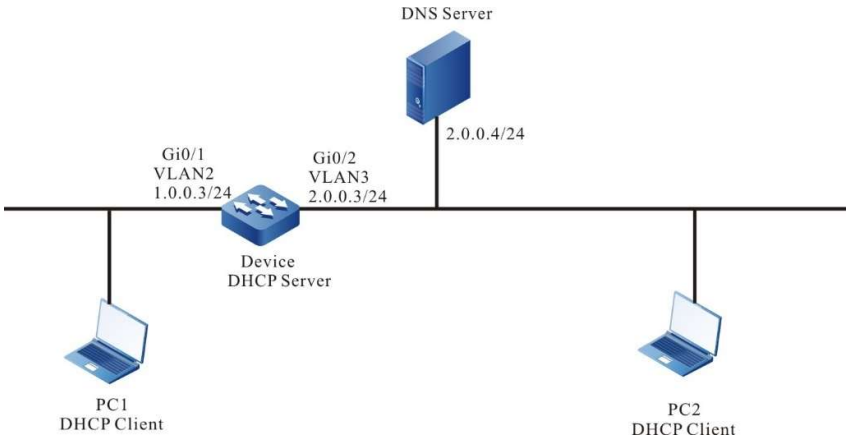


Figure 1 Network Topology for Configuring DHCP to Dynamically Allocate IP Addresses

Configuration Steps

Step 1: Configure Device interface IP addresses and enable it to work in DHCP server mode.

```
Device(config)#interface vlan2
Device(config-if- vlan2)#ip address 1.0.0.3
255.255.255.0
Device(config-if- vlan2)#ip dhcp server
Device(config-if- vlan2)#exit
Device(config)#interface vlan3
Device(config-if- vlan3)#ip address 2.0.0.3
255.255.255.0
Device(config-if- vlan3)#ip dhcp server
Device(config-if- vlan3)#exit
```

Step 2: On the DHCP server Device, configure two dynamic address pools and their parameters.

#Configure the first 10 IP addresses in the two address pools to be reserved.

```
Device(config)#ip dhcp excluded-address 1.0.0.1
1.0.0.10
Device(config)#ip dhcp excluded-address 2.0.0.1
2.0.0.10
```

#Configure address pool dynamic-pool1 and its parameters (including address range, gateway, DNS, address lease, and local domain name).

```
Device(config)#ip dhcp pool dynamic-pool1
Device(dhcp-config)#network 1.0.0.0 255.255.255.0
Device(dhcp-config)#default-router 1.0.0.3
Device(dhcp-config)#dns-server 2.0.0.4
Device(dhcp-config)#lease 1 0 0
Device(dhcp-config)#exit
```

#Configure address pool dynamic-pool2 and its parameters (including address range, gateway, DNS address, address lease, Wins server address, and local domain name).

```
Device(config)#ip dhcp pool dynamic-pool2
Device(dhcp-config)#network 2.0.0.0 255.255.255.0
Device(dhcp-config)#default-router 2.0.0.3
Device(dhcp-config)#dns-server 2.0.0.4
Device(dhcp-config)#lease 3 0 0
Device(dhcp-config)#exit
```

Step 3: Check the result.

#View information about the server-associated address pool on Device.

```
Device(config)#exit
Device#show ip dhcp server interface vlan2
DHCP server status information:
DHCP server is enabled on interface: vlan2
Vrf : global
DHCP server pool information:
Available directly-connected pool:
Interface IP      Pool name          Pool Range        Pool utilization
-----------    ------------------  -------------------   ----------------
1.0.0.3/24      dynamic-pool1      1.0.0.0 – 1.0.0.255       0.00%
Device#show ip dhcp server interface vlan3
DHCP server status information:
DHCP server is enabled on interface: vlan3
Vrf : global
DHCP server pool information:
Available directly-connected pool:
Interface IP      Pool name          Pool Range        Pool utilization
-----------    ------------------  -------------------     ----------------
1.0.0.3/24      dynamic-pool2      2.0.0.0 – 2.0.0.255       0.00%
```

#On Device, query the IP addresses allocated to clients.

```
Device#show ip dhcp pool danymic-pool1 lease

IP Address        MAC Address        Vendor Id
Type    Time Left(s)

------------    ----------------  ----------------    --------  ----
---------

1.0.0.11          0001.7a6a.0268        Global       Lease
86390

Device#show ip dhcp pool danymic-pool2 lease

IP Address        MAC Address        Vendor Id
Type    Time Left(s)

------------  ------------------    --------------    --------  ----
---------

2.0.0.11          0001.7a6a.0269        Global       Lease
259194
```

#On Device, query the IP address pool allocation statistics.

```
Device#show ip dhcp pool dynamic-pool1 summary

Pool: dynamic-pool1

Pool Configuration  : 1.0.0.0  255.255.255.0

Pool Range          : 1.0.0.0  1.0.0.255

Pool Utilization    : 0.39%

VRF                 : global

DNS Server          : 2.0.0.4

Default Router      : 1.0.0.3

Lease Time          : 1 Days 0 Hours 0 Minutes

Free Addresses      : 243

Static Bind         : 0

Lease Count         : 1

PingList            : 0

OfferList           : 0

ConflictList        : 0

ExcludeList         : 12


Device#show ip dhcp pool dynamic-pool2 summary

Pool: dynamic-pool2

Pool Configuration  : 2.0.0.0  255.255.255.0

Pool Range          : 2.0.0.0  2.0.0.255

Pool Utilization    : 0.39%

VRF                 : global

DNS Server          : 2.0.0.4

Default Router      : 2.0.0.3

Lease Time          : 3 Days 0 Hours 0 Minutes

Free Addresses      : 243
```

```
Static Bind        : 0
Lease Count        : 1
PingList           : 0
OfferList          : 0
ConflictList       : 0
ExcludeList        : 12
```

On the DHCP clients, query whether the IP addresses have been obtained properly.

Caution

- The IP addresses in the address pool must be within the network segment range of the interface that provides the service.

39.3.3 Configure a DHCP Relay

Network Requirements

- Device1 is the DHCP server and Device2 interface is enabled for DHCP relay function.
- The DHCP server serves clients in the 1.0.0.0/24 network segment, and the first 10 IP addresses are reserved.
- DHCP client obtains IP address through DHCP relay.

Network Topology

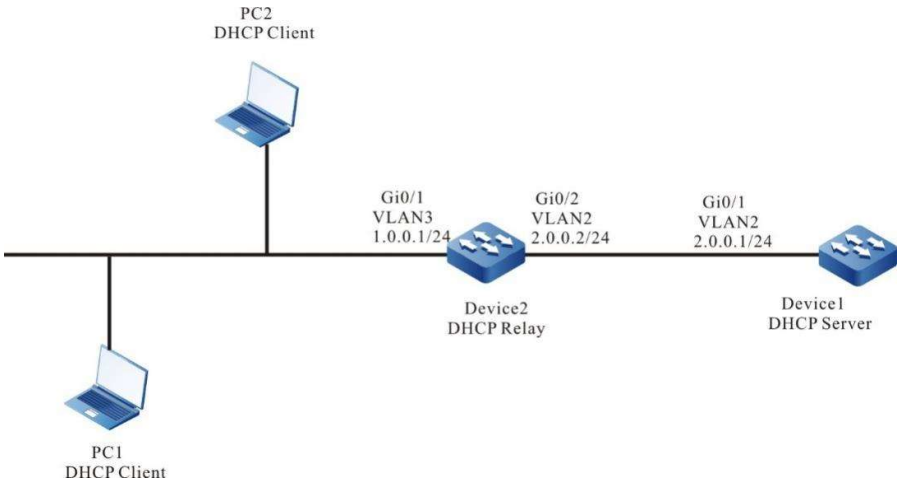


Figure 2Network Topology for Configuring DHCP Relay

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. Configure IP addresses for the ports. (Omitted)

Step 2: Configure the IP address pool and the reserved IP addresses of Device1, and enable it to work in the DHCP server mode.

#Configure the DHCP server.

```
Device1(config)#interface vlan2
Device1(config-if-vlan2)#ip dhcp server
Device1(config-if-vlan2)#exit
```

#Configure IP addresses which are from 1.0.0.1 to 1.0.0.10 not to be allocated.

```
Device1#configure terminal
Device1(config)#ip dhcp excluded-address 1.0.0.1
1.0.0.10
```

#Configure IP address pool dynamic-pool for Device1.

```
Device1(config)#ip dhcp pool dynamic-pool
Device1(dhcp-config)#network 1.0.0.0 255.255.255.0
Device1(dhcp-config)#default-router 1.0.0.1
Device1(dhcp-config)#lease 1 0 0
Device1(dhcp-config)#exit
```

#Configure a static route to network segment 1.0.0.0/24.

```
Device1(config)#ip route 1.0.0.0 255.255.255.0 2.0.0.2
```

Step 3: On the vlan3 interface of Device2, configure the IP address of the DHCP server to be 2.0.0.1, and enable the interface to work in relay mode.

```
Device2(config)#interface vlan3
Device2(config-if-vlan3)#ip dhcp relay
Device2(config-if-vlan3)#ip dhcp relay server-addres
2.0.0.1
Device2(config-if-vlan3)#exit
```

Step 4: Check the result.

#On Device1, check the IP addresses that have been allocated.

```
Device1#show ip dhcp pool dynamic-pool lease
IP Address      MAC Address       Vendor Id      Type   Time Left(s)
------------    --------------    ---------------  --------   -----------
1.0.0.11        0001.7a6a.0268        Global       Lease      86387
```

Use the show ip dhcp pool dynamic-pool lease command to query the IP addresses that have been allocated to clients.

The result shows that a client has obtained the IP address 1.0.0.11.

39.3.4 Configure the DHCP Relay to Support Option 82.

Network Requirements

- On the DHCP relay device, Option 82 is enabled.
- Specify the content of Option 82 sub-option Remote ID as 0102030405.
- The DHCP relay Device2 adds Option 82 in a request packet and forwards the request to DHCP server. The DHCP server then allocates IP addresses in the 1.0.0.0/24 network segment to the client.

Network Topology

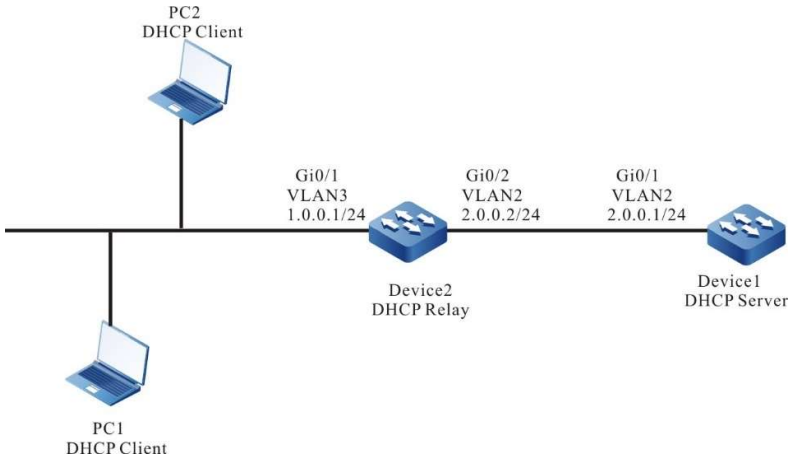


Figure 3 Network Topology for Configuring DHCP Relay to Support Option 82

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. Configure IP addresses for the ports. (Omitted)

Step 2: Configure the DHCP server.

```
Device1# configure terminal
Device1(config)#interface vlan2
Device1(config-if-vlan2)#ip dhcp server
Device1(config-if-vlan2)#exit
Device1(config)#ip dhcp pool dynamic-pool
Device1(dhcp-config)#network 1.0.0.0 255.255.255.0
Device1(dhcp-config)#default-router 1.0.0.1
Device1(dhcp-config)#exit
```

#Configure a static route to network segment 1.0.0.0/24.

```
Device1(config)#ip route 1.0.0.0 255.255.255.0 2.0.0.2
```

Step 3: Configure the DHCP relay Device2 and Option 82 parameters.

#Configure the IP address of the DHCP relay server to 2.0.0.1.

```
Device2(config)#interface vlan3
Device2(config-if-vlan3)#ip dhcp relay
Device2(config-if-vlan3)#ip dhcp relay server-address
2.0.0.1
```

#Enable Option 82, and configure the sub-option Remote-ID to 0102030405.

```
Device2(config)#ip dhcp relay information option
Device2(config)#ip dhcp relay information remote-id
hex 0102030405
```

Step 4: Check the result.

#On Device1, query the IP addresses allocated to clients.

```
Device1#show ip dhcp pool danymic-pool1 lease
IP Address      MAC Address       Vendor Id
Type   Time Left(s)
------------ ------------------ ------------------- -------- ----
---------
1.0.0.2       0001.7a6a.0268       Global       Lease
107992
```

On the DHCP client, query the IP address that the network adapter has obtained from network segment 1.0.0.0/24.

Packet capture on the DHCP server end can verify that the padding value of the remite-id of option 82 in the discover packets received by the server is

0102030405.

Note

- After Option 82 is enabled, it sub-option Circuit ID is filled with the receiving interface index and the system ID of the relay device.

40 DNS

40.1 Overview

Domain Name System (DNS) is a distributed database that maps domain names and IP addresses. It provides conversion between domain names and IP addresses. With the use of DNS, when users access the Internet, they can use easy-to-memory and meaningful domain names. Then the domain name server in the network resolves the domain names into correct IP addresses. DNS is categorized into static DNS and dynamic DNS.

Static domain name resolution is conducted through a static DNS table. In the static DNS table, domain names and IP addresses are mapped, and some frequently used domain names are added. When a client requests for the IP address of a domain name, the DNS server first searches static DNS table for the corresponding IP address. This improves the efficiency of domain name resolution.

Dynamic domain name resolution is implemented by querying the DNS. A DNS client sends a domain name resolution request to a DNS server. After the DNS server receives the domain name resolution request, it first determines whether the requested domain name is located in its authorized management sub-domain. If yes, it searches the database for the required IP address and then sends the query result to the client. If the domain name is not in the authorized management sub-domain, the DNS server starts a recursive resolution with other DNS server, and then it sends the resolution result to the client. Alternatively, it specifies the address of the next DNS server in the response packet to the DNS client. Then, the client sends another domain name resolution request to the domain name server. This is so called iterative resolution mode.

40.2 DNS Function Configuration

Table 40 DNS Function Configuration List

Configuration Task	
Configure DNS cache specifications.	Configure the maximum number of static cache.
	Configure the maximum number of dynamic cache.

Configuration Task	
Configure the DNS client function.	Configure static domain name resolution.
	Configure dynamic domain name resolution.
Configure DNS probe function.	Configure domain name list.
	Detect domain name resolution.

40.2.1 Configure DNS Cache Specifications

Configuration Condition

None

Configure DNS Specifications

Modify the maximum number of entries supported by DNS specification, if the current specification is M,the current number is n; the configured specification is N; the two scenarios are as follows

1. For static specification, if N > M or n < N < M; the configuration takes effect immediately; if N < n; the configuration is prompted to have failed.

2. For dynamic specification, if N > M or n < N < M; the configuration takes effect immediately; if N < n; the configuration takes effect, wait for the aging of dynamic DNS.

Table 40 List for Configuring Privileged Mode Authentication Methods

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the maximum number of configurable specifications supported by static dns.	**dns static max-count** *number*	Optional By default, the maximum number supported by static cache is 64.
Configure the maximum number supported by	**dns dynamic max-count** *number*	Optional By default, the maximum number supported by dynamic cache is 10k.

Step	Command	Description
dynamic dns for configuration.		

40.2.2 Configure the DNS Client Function

Configuration Condition

None

Configure Static Domain Name Resolution

Configuring static domain name resolution is to configure a domain name to map an IPv4 address and an IPv6 address.

Table 1 Configuring Static Domain Name Resolution

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure a domain name and its corresponding IPv4 address.	**ip host** [**vrf** *vrf-name*] *domain-name ip-address*	Mandatory By default, no domain name and its corresponding IPv4 address are configured.
Configure a domain name and its corresponding IPv6 address.	**ipv6 host** [**vrf** *vrf-name*] *domain-name ipv6-address*	Mandatory By default, no domain name and its corresponding IPv6 address are configured.

Configure Dynamic Domain Name Resolution

In configuring dynamic domain name resolution, you need to configure the IP address of a domain name server. Then, domain resolution requests can be sent to the proper domain server for resolution.

Users can pre-configure a domain suffix. Then, when using a domain name, they can input only part of the domain name, and the system automatically adds pre-configured domain suffix for resolution.

Table 2 Configuring Dynamic Domain Name Resolution

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure a domain suffix.	**ip domain-name** [**vrf** *vrf-name*] *domain-name*	Mandatory By default, no domain suffix is configured.
Configure a DNS server address.	**ip name-server** [**vrf** *vrf-name*] *ip-address*	Mandatory By default, the DNS server address is not configured.

40.2.3 Configure DNS Probe Function

Configuration Condition

None

Configure Domain Name List

By configuring the domain name list, you can add some commonly used domain names to the domain name list and save them, and when you need to use them, you can directly specify the name of the domain name list.

Table 3 Configuring Domain Name List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create a domain list and enter domain list configuration mode.	**dns domain-list** *list-name*	Mandatory By default, no domain name list is configured.
Configure domain name.	**domain** *domain-name*	Mandatory By default, no domain name is configured from

Step	Command	Description
		the domain name list.

Detect Domain Name Resolution

By detecting domain name resolution, you can check whether the DNS server can correctly resolve the specified domain name.

Table 4 Detecting Domain Name Resolution

Step	Command	Description
Detect domain name resolution.	**dns query** [**vrf** *vrf-name*] *ip-address* [**name** *domain-name* **| name-list** *list-name*] [**timeout** *time*]	Mandatory By default, domain name resolution is not detected.

40.2.4 DNS Monitoring and Maintaining

Table 5 DNS Monitoring and Maintaining

Command	Description
debug dns {all | config | event | mpos | packet | timer}	Turn on the DNS debugging information switch.
show dns domain-list [*list-name*]	Displaying domain name list.
show hosts	Displaying domain name resolution table entries.
show name-server [vrf *vrf-name***]**	Displaying DNS server information.

40.3 Typical Configuration Example of DNS

40.3.1 Configure Static Domain Name Resolution

Network Requirements

- Device and PC are interconnected, and the route is reachable.

- The host name of PC is host.xxyyzz.com, and the IP address is 1.0.0.2/24.
- On Device, access the host host.xxyyzz.com through static domain name resolution.

Network Topology

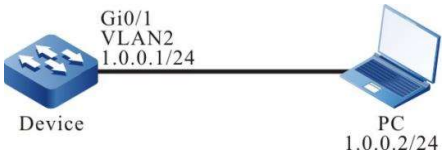


Figure 40 Network Topology for Configuring Static Domain Name Resolution

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure a static domain name.

#On Device, configure the host name host.xxyyzz.com to correspond to IP address 1.0.0.2.

```
Device#configure terminal
Device(config)#ip host host.xxyyzz.com  1.0.0.2
Device(config)#exit
```

Step 4: Check the result.

#On Device, ping host host.xxyyzz.com. Device obtains the IP address 1.0.0.2 that corresponds to the host name through local domain name resolution.

```
Device#ping host.xxyyzz.com

Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to 1.0.0.2 , timeout is 2 seconds:
!!!!!
Success rate is 100% (5/5). Round-trip min/avg/max = 0/6/16 ms.
```

Note

- In pinging a host name, the IPv6 address corresponding to the host name is first resolved, and then the IPv4 address.

40.3.2 Configure Dynamic Domain Name Resolution

Network Requirements

- The IP address of the DNS server is 1.0.0.3/24, the IP address of Device is 1.0.0.1/24, and the IP address of PC is 1.0.0.2/24.
- The DNS server, Device, and PC are interconnected through a LAN, and the route is reachable. On the DNS server, the DNS record of host.xxyyzz.com and 1.0.0.2 exists.
- Device access PC through dynamic resolution of host.xxyyzz.com through the DNS server.

Network Topology

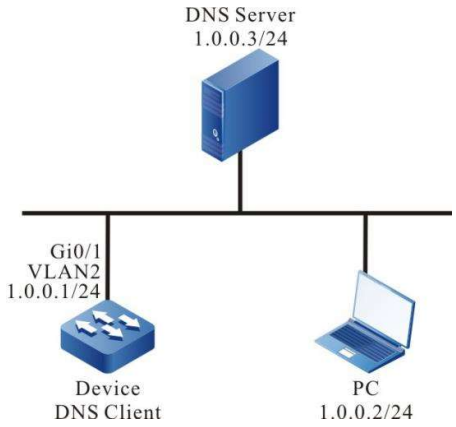


Figure 1 Network Topology for Configuring Dynamic Domain Name Resolution

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure the DNS server. (Omitted)

Step 4: Configure the DNS client.

#Specify a DNS server for the client, and the IP address is 1.0.0.3.

```
Device#configure terminal
Device(config)#ip name-server 1.0.0.3
Device(config)#exit
```

Step 5: Check the result.

#On Device, ping host host.xxyyzz.com. Device obtains the IP address 1.0.0.2 that corresponds to the host name through the DNS server.

```
Device#ping host.xxyyzz.com

Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to 1.0.0.2 , timeout is 2 seconds:
!!!!!
Success rate is 100% (5/5). Round-trip min/avg/max = 0/6/16 ms.
```

41 IPv6 Basics

41.1 Overview

IPv6 (Internet Protocol Version 6) is the second generation standard protocol for network layer protocols, also known as IPng (IP Next Generation), which is a set of specifications designed by the IETF (Internet Engineering Task Force) and is an upgraded version of IPv4.

L3 Interface ND Proxy

The L3 interface ND proxy is used to enable communication between different network segments connected via two interfaces. Normally, the device will not respond to NS requests whose target is not the corresponding network segment of the packet-receiving interface, so different network segments cannot communicate directly. When the ND proxy function is enabled for a L3 interface, the device is also able to answer NA if it receives NS requests from that interface that belongs to another interface network segment. This allows hosts belonging to different network segments to establish neighbor table entries and communicate normally with each other. The typical application scenario is small and large network segment networking.

41.2 IPv6 Basic Function Configuration

Table 41 IPv6 Basic Function Configuration List

Configuration Task	
Configure IPv6 address.	Configure IPv6 addresses for the ports.
Configure the basic functions of IPv6.	Enable IPv6 unicast forwarding function.
	Enable interface IPv6 function.
	Configure IPv6 packet hop limit value.
	Configure IPv6 MTU for the interface.
Configure IPv6 Neighbor Discovery Protocol.	Configure IPv6 Static Neighbors.
	Configure the aging time of IPv6 neighbor table entries in STALE state.
	Configure the retransmission interval of NS packets.
	Configure the attempts to send an NS packet during the IPv6 duplicate address detection.
	Configure the relevant parameters of RA packets.
	Enables the interface to send redirected packets.
Configure to enable the ND fast response function.	Configure to enable the ND fast response function.
Configure L3 interface ND proxy function.	Configure to enable ND proxy function for L3 interface.
Configure ICMPv6 functions.	Configure ICMPv6 error packets transmitting rate.
	Enable transmission of ICMPv6 destination unreachable packets.
Configure TCP anti-attack function for IPv6.	Enable TCP syncache function.
	Enable TCP syncookies function.

41.2.1 Configure IPv6 Addresses for the Ports

The most significant difference between IPv6 and IPv4 is: the length of IP addresses increases from 32 bits to 128 bits. IPv6 addresses are represented as a series of 16-bit hexadecimal numbers separated by a colon (:). Each IPv6 address is divided into 8 groups, with each group of 16 bits represented by 4 hexadecimal numbers, separated by colons between the groups, e.g. 2000:0000:240F:0000:0000:0CB0:123A:15AB.

To simplify the representation of IPv6 addresses, the "0" in an IPv6 address can be handled in the following way:

- The leading "0" in each group can be omitted, i.e. the above address can be expressed as 2000:0:240F:0:0:CB0:123A:15AB.
- If the address contains two or more consecutive groups that are all zeros, a double colon "::" can be used instead, i.e. the above address can be expressed as 2000:0:240F::CB0:123A:15AB.
- The double colon "::" can only be used once in an IPv6 address, otherwise when the device transforms "::" to 0 to recover the 128-bit address, it will not be able to determine the number of zeros "::" represented.

An IPv6 address consists of two parts: the address prefix and the interface identifier. The address prefix is equivalent to the network number field in an IPv4 address and the interface identifier is equivalent to the host number field in an IPv4 address.

The IPv6 address prefix is expressed as: IPv6 address/prefix length. The IPv6 address is either of the forms listed earlier, and the prefix length is a decimal number indicating the number of bits precede the IPv6 address as the address prefix.

There are three types of IPv6 addresses: unicast addresses, multicast addresses, and anycast addresses.

- Unicast address: Used to uniquely identify an interface, similar to the unicast address of IPv4. Data packets sent to a unicast address will be delivered to the interface identified by this address.
- Multicast address: Used to identify a group of interfaces, similar to the multicast address of IPv4. Data packets sent to a multicast address are delivered to all interfaces identified by this address.
- Anycast address: Used to identify a group of interfaces. A packet destined for an anycast address will only be delivered to one interface in that group. According to the routing protocol, the interface that receives the packet is the interface closest to the source.

The IPv6 address type is specified by the first few bits of the address, called the format prefix. The correspondence between the main address types and the format prefix is shown in Table 5-2.

Table 41 Correspondence between IPv6 Address Types and Format Prefixes

Address Type		Format prefix (binary)	Prefix identifier
Unicast address	Unallocated address	00...0 (128 bits)	::/128
	Loopback address	00...1 (128 bits)	::1/128
	Link-local address	1111111010	FE80::/10
	Site-local address	1111111011	FEC0::/10
	Global unicast address	Other forms	-
Multicast address		11111111	FF00::/8
Anycast address		Allocate from the unicast address space, using the unicast address format.	

There can be various types of IPv6 unicast addresses, including global unicast addresses, link-local addresses, and site-local addresses.

- Global unicast addresses are equivalent to IPv4 public network addresses and are provided to network service providers. This type of address allows aggregation of routing prefixes, thus limiting the number of global routing table entries.
- The link-local address is used for communication between nodes on the link-local in the Neighbor Discovery Protocol and Stateless Auto-configuration. Data packets that use link-local addresses as source or destination addresses are not forwarded to other links.
- The site-local address is similar to the private address in IPv4. Data packets that use the site-local address as the source or destination address are not forwarded to other sites outside this site.
- Loopback address: The unicast address 0:0:0:0:0:0:0:1 (simplified as ::1) is called a loopback address and cannot be allocated to any physical interface. It serves the same purpose as the loopback address in IPv4, which is used by the node to send IPv6 packets to itself.
- Unallocated address: The address "::" is called an unallocated address and cannot be allocated to any node. Until a node obtains a valid IPv6 address, it can fill in the source address field of a sent IPv6 packet, but it cannot be used as the destination address in an IPv6 packet.

The special-purpose multicast addresses reserved for IPv6 are shown in Table 5-3.

Table 41 List of IPv6 Special Purpose Multicast Addresses

Address	Use
FF01::1	Indicates the multicast address of all nodes in the local range of the node.
FF02::1	Indicates the multicast address of all nodes in the local range of the link.
FF01::2	Indicates the multicast address of all routers in the local range of the node.
FF02::2	Indicates the multicast address of all routers in the local range of the link.
FF05::2	Indicates the multicast address of all routers in the local range of the site.

Configuration Condition

None

Configure IPv6 Addresses for the Ports

Table 1 Configuring Interface IPv6 Addresses

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure IPv6 addresses for the ports.	**ipv6 address** { *linklocal-address* **link-local** | *prefix-address* [**anycast** | **eui-64**] | **autoconfig** }	Mandatory By default, the interface is not configured with IPv6 address.

Note

- The interface can be configured with multiple IPv6 addresses.
- After the interface is configured with an IPv6 address, the IPv6 function is automatically enabled.

41.2.2 Configure Basic Functions of IPv6

Configuration Condition

None

Enable IPv6 Unicast Forwarding Function

By default, the IPv6 unicast forwarding function is enabled. In some specific cases, users can turn off the IPv6 unicast forwarding feature, and when the feature is turned off, no IPv6 packets are forwarded.

Table 41 Enabling IPv6 Unicast Forwarding

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable IPv6 unicast forwarding function.	**ipv6 unicast-routing**	Mandatory By default, the IPv6 unicast forwarding function is enabled.

Enable Interface IPv6 Function

Before making IPv6-related configurations on the interface, you must enable the IPv6 function first, otherwise it may cause some configurations fail to take effect.

Table 2 Enabling Interface IPv6 Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-

Enable interface IPv6 function.	**ipv6 enable**	Mandatory By default, the interface IPv6 function is disabled.

Configure IPv6 Packet Hop Limit Value

The IPv6 packet header contains the Hop Limit field, which serves the same purpose as the TTL field in the IPv4 header, indicating the number of times the packet can be forwarded by the router in the network.

The value of the hop limit in the header of IPv6 packet generated by the device can be configured by a command.

Table 41 Configuring IPv6 Packet Hop Limit Value

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IPv6 packet hop limit value.	**ipv6 hop-limit** *value*	Mandatory By default, the number of hops a device can send IPv6 packets is limited to 64.

Configure IPv6 MTU for an Interface

Table 3 Configuring IPv6 MTU for an Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure IPv6 MTU for the interface.	**ipv6 mtu** *value*	Mandatory By default, the IPv6 MTU of an interface is not configured.

41.2.3 Configure IPv6 Neighbor Discovery Protocol

The IPv6 Neighbor Discovery (ND: Neighbor Discovery) protocol includes the following functions: address resolution, neighbor un-reachability detection, duplicate address detection, router discovery/prefix discovery, address auto-configuration, and redirection.

The types of ICMPv6 packet used by the ND protocol and their functions are shown in Table 5-9 below.

Table 4 ICMPv6 Packet Types Used by ND Protocol and Their Functions

Types of ICMPv6 Packets	Type No.	effect
Router Solicitation packet (RS)	133	After the node starts, it sends a request to the router via RS packet to request the prefix and other configuration information for the automatic configuration of the node.
Router Advertisement packet (RA)	134	Responding to a RS packet Under the condition that RA packets are not suppressed, the router periodically sends RA packets, which include prefix information options and flag bits information.
Neighbor Solicitation packet (NS)	135	Obtain the link layer address of a neighbor. Verify if the neighbor is reachable. Perform duplicate address detection.
Neighbor Advertisement packet (NA)	136	Respond to NS packets. The node actively sends out NA packets when the link layer changes to notify neighbor nodes of the changes in this node.
Redirect packets (Redirect).	137	When certain conditions are met, the default gateway redirects the host to reselect the correct next-hop address for subsequent packets by sending a redirect packet to the source host.

- Address resolution

Obtain the link layer address of neighboring nodes on the same link, which is achieved by NS packets and NA packets.

- Neighbor Un-reachability Detection

After obtaining the link layer address of the neighbor node, the NS packets and NA packets can be used to verify the reachability of the neighbor node.

1) The node sends an NS packet, where the destination address is the IPv6 address of a neighbor node.

2) If an acknowledgment packet is received from a neighbor node, the neighbor is considered reachable; otherwise, the neighbor is considered unreachable.

- Duplicate Address Detection

When a node acquires an IPv6 address, it needs to use the duplicate address detection function to determine whether the address is already in use by another node.

- Router Discovery/Prefix Discovery and Address Auto-Configuration

Router discovery/prefix discovery means that the node obtains the prefixes of neighbor routers and their networks, as well as other configuration parameters, from the RA packets it receives.

Address stateless autoconfiguration means that the node automatically configures IPv6 addresses based on the information obtained by router discovery/prefix discovery.

Router discovery/prefix discovery is achieved through RS packets and RA packets.

- Redirection

When a host starts up, it may have only one default route to the default gateway in its routing table. When certain conditions are met, the default gateway sends an ICMPv6 redirect packet to the source host, notifying the host to choose a better next-hop for subsequent packets.

Configuration Condition

None

Configure IPv6 Static Neighbors

Resolving the IPv6 addresses of neighbor nodes to link layer addresses can be achieved either through the address resolution function in the IPv6 ND protocol or by manually configuring static neighbors.

An IPv6 neighbor is uniquely identified by the IPv6 address of the neighbor node and the L3 interface connected to this neighbor node.

Table 5 Configuring IPv6 Static Neighbors

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IPv6 Static Neighbors.	**ipv6 neighbor** *ipv6-address interface-name mac-address*	Mandatory By default, no IPv6 static neighbor is configured.

Configure the Aging Time of IPv6 Neighbor Table Entries in STALE State

IPv6 neighbor table entries have five reachability states: INCOMPLETE, REACHABLE, STALE, DELAY and PROBE, where the STALE state indicates that it does not know whether the neighbor is reachable or not. The neighbor table entries in the STALE state have an aging time, which will migrate to the DELAY state when reach their aging time.

Table 6 Configuring the Aging Time of IPv6 Neighbor Entries in STALE State

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Aging Time of IPv6 Neighbor Table Entries in STALE State	**ipv6 neighbor stale-aging** *aging-time*	Optional By default, the aging time of IPv6 neighbor table entry in STALE state is 7200 seconds.

Configure Interval for Retransmission of NS Packets

After the device sends an NS packet, if it does not receive a response within the specified time interval, it will resend the NS packet. The following command allows you to configure the time interval for retransmission of NS packets.

Table 7 Configuring Interval for Retransmission of NS Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-

Configure time interval for NS packets retransmission.	**ipv6 nd ns-interval** *value*	Mandatory By default, the interface sends NS packets at an interval of 1000 milliseconds.

Configure the Attempts to Send an NS Packet during the IPv6 Duplicate Address Detection

After the interface is configured with an IPv6 address, it sends a NS packet to request duplicate address detection. If no response is received within a certain period of time, it will keep sending NS packets. When the number of NS packets sent reaches the set value and no response is received, the address is considered available.

Table 8 Configuring the Attempts to Send an NS Packet during the IPv6 Duplicate Address Detection

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the Attempts to Send an NS Packet during the IPv6 Duplicate Address Detection	**ipv6 nd dad attempts** *value*	Mandatory Dy default, the number of attempts to send an NS packet during the IPv6 duplicate address detection is 1.

Configure Relevant Parameters of RA Packets

Users can configure whether the interface sends RA packets and the time interval for sending RA packets according to the actual situation, and can also configure the relevant parameters in RA packets to notify the host. When the host receives the RA packet, it can use these parameters to operate accordingly.

Table 9 Parameters and Descriptions in RA Packets

Parameter	Description
Hop Limit	The host will use the value of this parameter to fill the Hop Limit field in the IPv6 packet header when sending an IPv6 packet. The value of this parameter is also used as the value of the Hop Limit field in the response packet.

Parameter	Description
MTU	Distributing the link MTU can be used to ensure that all nodes on the same link share the same MTU value.
Router Lifetime	It is used to set the time duration during which the router sending RA packets acts as the default router for the host. Based on the value of the router lifetime parameter in the received RA packet, the host can determine whether to use the router that sent the RA packet as the default router.
Neighbor Reachable Time	When the neighbor reachability is confirmed by neighbor un-reachability detection, the device considers the neighbor reachable within the set reachability time. If the device needs to send packets to the neighbor after the set time, it will reconfirm whether the neighbor is reachable.

Table 10 Relevant Parameters of RA Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure prefix option information in RA packets.	**ipv6 nd prefix** { *ipv6-prefix* | **default** } [*valid-lifetime* | **infinite** | **no-advertise** | **no-autoconfig** | **off-link**] [*prefered-lifetime* | **infinite**]	Mandatory By default, no prefix option information is configured.
Configure the value of the Hop Limit field in the RA packets sent by the interface to be obtained from the global configuration.	**ipv6 nd ra hop-limit**	Optional By default, the value of the Hop Limit field in the RA packets sent by un-configured interfaces is obtained globally, and the value of the Hop Limit field is 0.

Configure the maximum time interval and minimum time interval for sending RA packets.	**ipv6 nd ra interval** *max-value* [*min-value*]	Optional By default, the maximum time interval for sending RA packets is 600 seconds and the minimum time interval is 198 seconds.
Configure to enable RA packets to carry the MTU option.	**ipv6 nd ra mtu**	Optional By default, the RA packets do not carry the MTU option.
Configure router lifetime in the RA packets.	**ipv6 nd ra-lifetime** *value*	Optional By default, router lifetime in the RA packets is 1800 seconds.
Forbid the interface from sending RA packets periodically.	**ipv6 nd suppress-ra period**	Optional By default, RA packets are not sent periodically on the interface.
Forbid the interface from responding to RS packets.	**ipv6 nd suppress-ra response**	Optional By default, the interface receives RS packets and does not respond to RA packets.

Enable the Interface to Send Redirected Packets

After receiving an IPv6 packet that needs forwarding, the device discovers through routing that the receiving interface of the packet is the same as the sending interface, then the device forwards the packet and sends a redirect packet back to the source, notifying the source to re-select the correct next-hop for subsequent packet delivery. By default, the device is able to send redirect packets, but in some specific cases, users can disable the device from sending redirect packets.

Table 11 Enabling the Interface to Send Redirect Packet

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Enter the interface configuration mode	**interface** *interface-name*	-
Enables the interface to send redirected packets.	**ipv6 redirects**	Optional By default, the interface is enabled to send redirected packets.

41.2.4 Configure to Enable the ND Fast Response Function

Configuration Condition

None

Configure to Enable the ND Fast Response Function

Table 12 Configuring to Enable the ND Fast Response Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to enable the ND fast response function.	**nd fast-response**	Mandatory By default, the global ND fast response function is enabled.

41.2.5 Configure L3 Interface ND Proxy

Configuration Condition

None

Configure L3 Interface ND Proxy.

Table 13 Configuring the L3 ND Proxy Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter L3 interface configuration mode.	**interface** *interface-name*	Mandatory After entering the L3 interface configuration mode, subsequent configurations only take effect on the current interface.
Configure L3 interface ND proxy function.	**nd proxy enable**	Mandatory By default, the proxy function is not enabled on the interface.

41.2.6 Configure ICMPv6 Functions

In the IPv6 protocol stack, Internet Control Message Protocol (ICMP) is mainly used to provide network detection services. It also provides an error report if the network layer or transmission layer protocol becomes abnormal, and it informs the related device of the abnormality to facilitate network control management.

Configuration Condition

None

Configure ICMPv6 Error Packets Transmitting Rate

If an excessive number of ICMPv6 error packets are sent in a short period of time in the network, it may lead to network congestion. To avoid this, users can configure the maximum number of ICMPv6 error packets to be sent within a specified time.

Table 14 ICMPv6 Error Packets Transmitting Rate

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure ICMPv6 packets transmitting rate.	**ipv6 icmp error-interval** *interval* [*buckets*]	Optional By default, the period for calculating the transmitting

		rate of ICMPv6 error packets is 100 milliseconds, and the maximum number of ICMPv6 error packets sent in the period is 10.

Enable Transmission of ICMPv6 Destination Unreachable Packets

The ICMPv6 destination unreachable packet sending function allows to discard the IPv6 data packet and send an ICMPv6 destination unreachable error packet to the source if the destination is unreachable after the device receives the IPv6 data packet.

A device sends an ICMPv6 destination unreachable error packet when the following conditions are met:

- When forwarding a packet, the device sends a "no route to destination" ICMPv6 error packet to the source if it fails to find a route.
- When the device forwards a packet, if the packet cannot be sent because of an administrative policy (e.g., firewall, ACL, etc.), it sends an ICMPv6 error packet that says "Communication with the destination address is prohibited by the administrative policy" to the source.
- When the device forwards a packet, if the destination IPv6 address of the packet is out of the range of the source IPv6 address (for example, the source IPv6 address of the packet is a link-local address and the destination IPv6 address of the packet is a global unicast address), the packet will not reach the destination, and an "out of range" ICMPv6 error packet will be sent to the source.
- If the device cannot resolve the link layer address corresponding to the destination IPv6 address when forwarding the packet, it sends an "address unreachable" ICMPv6 error packet to the source.
- When the device receives an IPv6 packet with a local destination address and UDP transport layer protocol, if the destination port number of the packet does not match the process in use, it sends a "port unreachable" ICMPv6 error packet to the source.

Since the information delivered to the user process by the ICMPv6 destination unreachable error packet is unreachable, it may affect the normal use of the end user if there is a malicious attack. To avoid the above situation, users can disable the ICMPv6 destination unreachable error packet sending function of the device.

Table 15 Enabling Transmission of ICMPv6 Destination Unreachable Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Enable transmission of ICMPv6 destination unreachable packets.	**ipv6 unreachables**	Optional By default, the function of sending ICMPv6 destination unreachable packet is enabled.

41.2.7 Configure TCP Anti-attack Function for IPv6

The IPv6 TCP server receives a large number of SYN packets but the peer end does not respond to the SYN-ACK response from the server. This can cause the server's memory to be consumed heavily, taking up the server's syn queue and causing the IPv6 TCP server unable to service normal requests. Such attacks can be avoided by configuring IPv6 TCP anti-attack function.

Configuration Condition

None

Enable the IPv6 TCP Syncache Function

This function does not rush to allocate the TCB when a SYN data packet is received, but first responds with a SYN+ACK packet and stores this half-open connection information in a dedicated cache until a correct response ACK packet is received before allocating the TCB.

Table 16 Enabling the IPv6 TCP Syncache Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the IPv6 TCP Syncache Function	**ipv6 tcp syncache**	Mandatory By default, the IPv6 TCP syncache function is disabled.

Enable the IPv6 TCP Syncookies Function

This function does not use any storage resources at all, it uses a special algorithm to generate Sequence Number. The algorithm takes into account fixed information including the other party's IPv6, port, its own IPv6 and port, and other fixed information of its own, such as MSS, time, etc. After receiving the other party's ACK packet, the algorithm will recalculate it to see if it is the same as the other party's response packet (Sequence Number-1), so as to decide whether to allocate TCB resources.

Table 17 Enabling the IPv6 TCP Syncookies Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the IPv6 TCP Syncookies Function	**ipv6 tcp syncookies**	Mandatory By default, the IPv6 TCP syncookies function is disabled.

41.2.8 IPv6 Basic Monitoring and Maintaining

Table 18 IPv6 Basic Monitoring and Maintaining

Command	Description
clear nd fast-response statistics	The command is used to clear the ND fast response statistics.
clear ipv6 icmp6stat	Clears the ICMPv6 statistics.
clear ipv6 interface statistics	Clears the interface IPv6 packet statistics.
clear ipv6 mtu	Clears the IPv6 path MTU information.
clear ipv6 neighbors	Clears the IPv6 dynamic neighbor table entries.
clear ipv6 statistics	Clears the IPv6 basic statistics.
clear ipv6 tcp syncache statistics	Clears the IPv6 TCP protocol syncache statistics.
clear ipv6 tcp6stat	Clears the IPv6 TCP statistics.
clear ipv6 udp6stat	Clears the IPv6 UDP statistics.
show nd fast-response statistics	The command is used to display the ND fast response statistics.
show ipv6 hop-limit	Displaying the IPv6 global Hop Limit values.

Command	Description
show ipv6 frag-queue	Displaying the cached IPv6 fragment packets.
show ipv6 icmp6state	Displaying the ICMPv6 statistics.
show ipv6 interface	Displaying the interface IPv6 information.
show ipv6 interface statistics	Displaying the interface IPv6 statistics.
show ipv6 max-mtu	Displaying the maximum value of IPv6 MTU currently supported by the system.
show ipv6 mtu	Displaying the IPv6 path MTU information.
show ipv6 neighbors	Displaying the IPv6 neighbor information.
show ipv6 prefix	Displaying the IPv6 address prefix information.
show ipv6 sockets	Displaying the IPv6 socket information.
show ipv6 statistics	Displaying the basic IPv6 statistics.
show ipv6 tcp syncache detail	Displaying the IPv6 TCP protocol syncache table entry information.
show ipv6 tcp syncache statistics	Displaying the IPv6 TCP protocol syncache statistics.
show ipv6 tcp6state	Displaying the IPv6 TCP statistics.
show ipv6 udp6state	Displaying the IPv6 UDP statistics.

41.3 Basic Configuration Example of IPv6

41.3.1 Configure the IPv6 Address of an Interface

Network Requirements

- The two devices are connected via Ethernet interfaces, and the interfaces are configured with IPv6 global unicast addresses to verify Interoperability between them.

Network Topology

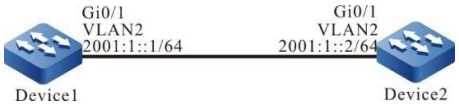


Figure 41 Network Topology for Configuring the IPv6 Address of an Interface

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Enable the IPv6 forwarding function of the device.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 unicast-routing
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 unicast-routing
```

Step 3: Configure the global unicast address of the interface.

#Configure the global unicast address of Device1 interface vlan 2 as 2001:1::1/64.

```
Device1(config)#interface vlan 2
Device1(config-if-vlan2)#ipv6 address 2001:1::1/64
Device1(config-if-vlan2)#exit
```

#Configure the global unicast address of Device2 interface vlan 2 as 2001:1::2/64.

```
Device2(config)#interface vlan 2
Device2(config-if-vlan2)#ipv6 address 2001:1::2/64
Device2(config-if-vlan2)#exit
```

Step 4: Check the result.

#Check the interface details of Device1.

```
Device1#show ipv6 interface vlan 2
vlan2 is up
 VRF: global
 IPv6 is enable, link-local address is
fe80::0201:7aff:fe46:a64d
 Global unicast address(es):
  2001:0001::0001, subnet is 2001:0001::/64
 Joined group address(es):
  ff02::0001:ff00:0001
 ff02::0001:ff00:0
```

```
    ff02::0002
    ff02::0001
    ff02::0001:ff46:a64d
  ND control flags: 0x1
  MTU is 1500 bytes
  ICMP redirects are enabled
  ICMP unreachables are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
```

After the IPv6 address is configured, the IPv6 protocol function is automatically enabled on the interface, and the link-local address is automatically generated and added to the corresponding multicast group.

#Check the interface details of Device2.

```
Device2#show ipv6 interface vlan 2
vlan2 is up
  VRF: global
  IPv6 is enable, link-local address is
fe80::0201:7aff:fe22:e222
  Global unicast address(es):
    2001:0001::0002, subnet is 2001:0001::/64
  Joined group address(es):
    ff02::0001:ff00:0002
    ff02::0001:ff00:0
    ff02::0002
    ff02::0001
    ff02::0001:ff22:e222
  ND control flags: 0x1
  MTU is 1500 bytes
  ICMP redirects are enabled
  ICMP unreachables are enabled
  ND DAD is enabled, number of DAD attempts: 1
  ND reachable time is 30000 milliseconds
  ND advertised reachable time is 0 (unspecified)
  ND advertised retransmit interval is 0 (unspecified)
```

#On Device1, Ping the link-local address fe80::0201:7aff:fe22:e222 of Device2.

```
Device1#ping  fe80::0201:7aff:fe22:e222

Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to
```

```
fe80::201:7aff:fe22:e222 , timeout is 2 seconds:

                    Output Interface: vlan 2
                    !!!!!
                    Success rate is 100% (5/5). Round-trip min/avg/max =
0/96/483 ms.
```

Note

- When pinging the link-local address, you need to specify the output interface, which is an interface on the same link as the pinged link-local address.

#On Device1, Ping the global unicast address 2001:1::2 of Device2.

```
                    Device1#ping 2001:1::2

                    Press key (ctrl + shift + 6) interrupt it.
                    Sending 5, 76-byte ICMP Echos to 2001:1::2 , timeout is
2 seconds:
                    !!!!!
                    Success rate is 100% (5/5). Round-trip min/avg/max =
0/36/183 ms.
```

Device1 and Device2 can communicate with each other.

41.3.2 Configuring IPv6 Neighbor Discovery

Network Requirements

- Device and the PC belong to the same LAN.
- Interface VLAN2 of Device is configured with EUI-64 address.
- The PC obtains an IPv6 address prefix through the IPv6 neighbor discovery protocol and automatically configures an IPv6 address based on the obtained address prefix. Implement IPv6 protocol communication between the PC and Device.

Network Topology

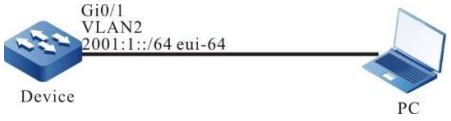


Figure 1 Network Topology for Configuring IPv6 Neighbor Discovery

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Enable the IPv6 forwarding function of the device.

```
Device#configure terminal
Device(config)#ipv6 unicast-routing
```

Step 3: Configure EUI-64 unicast address and enable RA advertisement function.

#Device's vlan2 is configured with EUI-64 address to enable the RA advertisement function of vlan2.

```
Device(config)#interface vlan 2
Device(config-if-vlan 2)#ipv6 address 2001:1::/64 eui-64
Device(config-if-vlan 2)#no ipv6 nd suppress-ra period
Device(config-if-vlan 2)#no ipv6 nd suppress-ra response
Device(config-if-vlan 2)#exit
```

Note

- By default, the RA advertisement function is disabled.

#Check the interface details of Device.

```
Device#show ipv6 interface vlan 2
vlan2 is up
 VRF: global
 IPv6 is enable, link-local address is
fe80::0201:7aff:fe5d:e7d3
 Global unicast address(es):
  2001:0001::0201:7aff:fe5d:e7d3, subnet is
2001:0001::/64 [EUI]
 Joined group address(es):
  ff02::0001:ff00:0
  ff02::0002
  ff02::0001
  ff02::0001:ff5d:e7d3
 ND control flags: 0x85
 MTU is 1500 bytes
 ICMP redirects are enabled
 ICMP unreachables are enabled
```

```
ND DAD is enabled, number of DAD attempts: 1
ND reachable time is 30000 milliseconds
ND advertised reachable time is 0 (unspecified)
ND advertised retransmit interval is 0 (unspecified)
```

Step 4: Configure the PC.

#IPv6 protocol is installed on the PC. The configuration of IPv6 varies by operating system, and the Windows XP is used here as an example.

```
C:\>ipv6 install
Installing...
Succeeded.
```

Step 5: Check the result.

#Check the interface details of PC.

```
C:\>ipconfig
..... (omitted)
Ethernet adapter 130:

        Connection-specific DNS Suffix  . :
        IP Address. . . . . . . . . . . . : 130.255.128.100
        Subnet Mask . . . . . . . . . . . : 255.255.0.0
        IP Address. . . . . . . . . . . . :
2001:1::15b3:d4:f13d:c3da
        IP Address. . . . . . . . . . . . :
2001:1::3a83:45ff:feef:c724
        IP Address. . . . . . . . . . . . :
fe80::3a83:45ff:feef:c724%6
        Default Gateway . . . . . . . . . :
fe80::201:7aff:fe5e:cfc1%6
```

It can be seen that after the PC obtains the IPv6 address prefix 2001:1::/64, and the global unicast address is automatically generated according to this prefix.

Note

- The Windows XP host obtains the address prefix and generates two global unicast addresses, one of which has an interface ID generated based on the MAC address of the interface, and the other has a randomly generated interface ID.

#On Device, ping the link-local address fe80::3a83:45ff:feef:c724 of the PC.

```
Device#ping fe80::3a83:45ff:feef:c724

Press key (ctrl + shift + 6) interrupt it.

Sending 5, 76-byte ICMP Echos to
fe80::3a83:45ff:feef:c724 , timeout is 2 seconds:

Output Interface: vlan2

!!!!!

Success rate is 100% (5/5). Round-trip min/avg/max =
0/29/149 ms.
```

#On Device, ping the global unicast address 2001:1::15b3:d4:f13d:c3da and 2001:1::3a83:45ff:feef:c724 automatically generated on the PC.

```
Device#ping 2001:1::15b3:d4:f13d:c3da

Press key (ctrl + shift + 6) interrupt it.

Sending 5, 76-byte ICMP Echos to
2001:1::15b3:d4:f13d:c3da , timeout is 2 seconds:

!!!!!

Success rate is 100% (5/5). Round-trip min/avg/max =
0/36/183 ms.

Device#ping 2001:1::3a83:45ff:feef:c724

Press key (ctrl + shift + 6) interrupt it.

Sending 5, 76-byte ICMP Echos to
2001:1::3a83:45ff:feef:c724 , timeout is 2 seconds:

!!!!!

Success rate is 100% (5/5). Round-trip min/avg/max =
0/26/133 ms.
```

The PC and Device can communicate with each other.

Note

- When pinging the link-local address, you need to specify the output interface, which is an interface on the same link as the pinged link-local address.

41.3.3 Configure L3 ND Proxy

Network Requirements

- Device is directly connected to PC1 and PC2 respectively. The network prefixes where

PC1 and PC2 are located are the same, both are 2001:1:1::/48.

- The interface VLAN2 of Device has a MAC address of 0001.7a6a.01f0.
- Through the L3 ND proxy of Device, PC1 is able to ping through to PC2, and PC1 can learn PC2's MAC address.

Network Topology

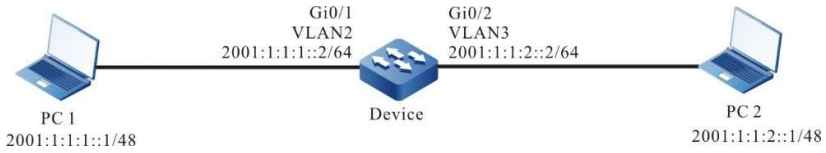


Figure 41 Network Topology for Configuring L3 ND Proxy

Configuration Steps

Step 1: Configure Virtual Local Area Networks (VLANs), and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure L3 ND Proxy.

#Enable L3 ND proxy under the L3 interface VLAN2 of Device.

```
Device(config)#interface vlan 2
Device(config-if-vlan2)#nd proxy enable
Device(config-if-vlan2)#exit
```

#Enable L3 ND proxy under the L3 interface VLAN3 of Device.

```
Device(config)#interface vlan 3
Device(config-if-vlan3)#nd proxy enable
Device(config-if-vlan3)#exit
```

Step 4: Check the results.

#PC1 ping PC2 with the address 2001:1:1:2::1.

```
C:\Documents and Settings>ping 2001:1:1:2::1

Pinging 2001:1:1:2::1 with 32 bytes of data:
Reply from 2001:1:1:2::1: bytes=32 time=9971ms TTL=255
Reply from 2001:1:1:2::1: bytes=32 time<1ms TTL=255
Reply from 2001:1:1:2::1: bytes=32 time<1ms TTL=255
Reply from 2001:1:1:2::1: bytes=32 time<1ms TTL=255
Ping statistics for 2001:1:1:2::1
   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
   Minimum = 0ms, Maximum = 997ms, Average = 249ms
```

#Check the neighbor table entries of Device.

```
Device#sh ipv6 neighbors
IPv6 Address                Age  Link-layer Addr   flags    State   Interface
2001:1:1:1::1               0    00e0.4c6b.f753    405      STALE   vlan2
```

```
2001:1:1:2::1                 1   0857.00da.4715   405     STALE   vlan3
```

#Check the neighbor table entries of PC1.

```
C:\Documents and Settings>netsh interface ipv6 show neighbors
Internet Address                          Physical Address   Type
----------------------------------------- -----------------  -----------
2001:1:1:1::2                             00-01-7a-6a-01-f0  Stale (Router)
2001:1:1:2::1                             00-01-7a-6a-01-f0  Stale (Router)
```

#PC1 is able to ping through to PC2, and PC1 learns the neighbor table entry of PC2. The MAC address in the neighbor table entry is the MAC address of VLAN2 0001.7a6a.01f0.

Note

The device does not have L3 ND proxy enabled by default.

42 DHCPv6

42.1 Overview

It is hard to manage a large network. For example, in a network in which IPv6 addresses are manually allocated, IPv6 address conflicts are common. The only way of solving the problem is to dynamically allocate IPv6 addresses to the hosts. The Dynamic Host Configuration Protocol version 6 (DHCPv6) allocates the IPv6 address to requesting hosts from an address pool. DHCPv6 also provides other information, such as DNS server address. DHCPv6 reduces the workload of the administrator in recording and tracking manually allocated IPv6 addresses.

DHCPv6 is a protocol that is based on UDP broadcast. The process for a DHCPv6 client to obtain an IPv6 address and other configuration information from the DHCPv6 server contains four phases.

SOLICT phase. When the DHCPv6 client accesses the network for the first time, it sends a DHCP SOLICT packet with the source address as the client's linklocal address and the destination address as ff02::1:2.

ADVERTISE phase. When the DHCPv6 server receives the DHCP SOLICT broadcast packet from the client, it will select an IPv6 address from the corresponding address pool according to the policy and send it to the client together with other parameters via the DHCP ADVERTISE packet.

REQUEST phase. If the DHCPv6 client receives responses from multiple DHCPv6 servers on the network, it will pick only one of them, i.e. DHCP ADVERTISE, (usually the first one to arrive), and will send a DHCP REQUEST packet to the network, telling all DHCPv6 servers which server it will accept the IPv6 address from.

In the REPLY phase, when the DHCPv6 server receives a DHCP REQUEST packet from a DHCPv6 client, it sends a DHCP REPLY acknowledgment packet to the DHCPv6 client containing its provided IPv6 address and other configurations, telling the DHCPv6 client that it can use the IPv6 address it provided.

The IPv6 addresses allocated by DHCPv6 server to DHCPv6 clients have a lease, and the DHCPv6 server will take back the allocated IPv6 addresses after it expires. When the IPv6 address lease of a DHCPv6 client is half remaining, the DHCPv6 client sends a DHCP ENEW packet to the DHCPv6 server to renew its IPv6 lease. If the DHCPv6 client can continue to use the IPv6 address, the DHCPv6 server responds to the DHCP REPLY packet to notify the DHCPv6 client to renew the lease; if the DHCPv6 client cannot continue to use the IPv6 address, the DHCPv6 server does not respond.

Since the request packet is sent in multicast mode during the dynamic acquisition of IPv6 address, DHCPv6 is only applicable when the DHCPv6 client and DHCPv6 server are in the same subnet. If there are multiple subnets in a network and the hosts of multiple subnets need to provide IPv6 addresses and other configuration information through DHCPv6 servers, the hosts of these subnets can communicate with DHCPv6 servers through DHCPv6 relay devices to obtain IPv6 addresses and other configuration information.

42.2 DHCPv6 Function Configuration

Table 42 DHCPv6 Function Configuration List

Configuration Task	
Configure a DHCPv6 address pool	Create a DHCPv6 address pool that allows you to specify VRF attributes.
	Configure the IPv6 address range
	Configure a DNS server address.
	Configure the IPv6 address lease
	Configure to bind IPv6 with DUID and IAID.
Configure other parameters of the DHCPv6 server.	Configure the DHCPv6 Server.
	Configure the ranges of the reserved IPv6 address.

	Configure the DHCPv6 ping probe parameters.
	Configure the data logging function of the DHCPv6 server.
Configure the function of DHCPv6 client	Configure DHCPv6 client
	Configure the function of DHCPv6 Option 16
Configure the function of DHCPv6 relay	Configure DHCPv6 relay.
	Configure the source address of DHCPv6 relay packet.
	Configure DHCPv6 server address
	Configure DHCPv6 interface-id option

42.2.1 Configure a DHCPv6 Address Pool

Configuration Condition

None

Create a DHCPv6 Address Pool

The DHCPv6 server selects and allocates IPv6 addresses and other related parameters for clients from the DHCPv6 address pool, therefore, the DHCPv6 server must first create a DHCPv6 address pool.

Table 1 Creating a DHCPv6 Address Pool

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create a DHCPv6 address pool and enter the DHCPv6 configuration mode.	**ipv6 dhcp pool** *pool-name*[**vrf** *vrf-name*]	Mandatory By default, the DHCPv6 address pool is not created by the system.

Note

- Address pools fall into two types: Network and Range. The two types of address pools can be configured respectively through the network and range commands.

Configure IPv6 Address Range

On the DHCPv6 server, each DHCPv6 address pool should be configured with the corresponding IPv6 address range to allocate IPv6 addresses to DHCPv6 clients.

Table 2 Configuring IPv6 Address Range

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCPv6 configuration mode.	**ipv6 dhcp pool** *pool-name*[**vrf** *vrf-name*]	-
Configure the ranges of Network-type IPv6 addresses.	**network** *ipv6-address/prefix-length*	Optional By default, the address pool is not configured with an IPv6 address range.
Configure the ranges of Range-type IPv6 addresses.	**range** *low-ipv6-address high-ipv6-address prefix-length*	Optional By default, the address pool is not configured with an IPv6 address range.

Note

- Change the type of the address pool from network to range (or vice versa). If the address range of the new configuration and the address range of the old configuration intersect, the command line will prompt the user whether to perform this operation, if yes, any relevant address configurations (static binding) and dynamic leases under the address pool will be deleted; if the actual effective address range of the new configuration covers the actual effective address range of the old configuration, the address pool will keep all relevant address configurations under the address pool (static binding). However, it will delete the dynamic lease.

Configure a DNS Server Address

On a DHCPv6 server, you can configure the DNS server address respectively for each DHCPv6 address pool. When a DHCPv6 server allocates an IPv6 address for a DHCPv6 client, it also sends the DNS server address to the client.

When the DHCPv6 client starts dynamic domain name resolution, it queries the DNS server.

Table 3 Configuring a DNS Server Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCPv6 configuration mode.	**ipv6 dhcp pool** *pool-name***[vrf** *vrf-name* **]**	-
Configure a DNS server address.	**dns-server** { *ipv6-address*&<1-8> | **autoconfig** }	Mandatory By default, the DNS server address is not configured.

Configure IPv6 Address Lease

The IPv6 address that the DHCPv6 server allocates to the DHCPv6 client has a lease. After the lease expires, the server will take back the allocated IPv6 address. If the DHCPv6 client wants to continue to use the address, it must have the IPve address lease updated.

On the DHCPv6 server, you can configure the IPv6 address lease time for each DHCPv6 address pool separately.

Table 42 Configuring Ipv6 Address Lease Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCPv6 configuration mode.	**ipv6 dhcp pool** *pool-name***[vrf** *vrf-name* **]**	-
Configure the IPv6 address lease	**lease preferred-lifetime** *preferred-lifetime* **valid-lifetime** *valid-lifetime*	Mandatory By default, the **preferred-lifetime** is 604800 seconds (7 days) and the **valid-lifetime** is 2592000 seconds (30 days).

Configure to Bind IPv6 with DUID and IAID

Configure to bind IPv6 with the client's DUID and IAID. When the client with specified DUID and IAID requests the DHCPv6 server to allocate IPv6 address, the DHCPv6 server will assign its bound IPv6 address. As long as the DUID and IAID of this client remain unchanged, the IPv6 address the client obtains from the server will remain the same every time.

Table 4 Configuring to Bind IPv6 with DUID and IAID

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the DHCPv6 configuration mode.	**ipv6 dhcp pool** *pool-name*[**vrf** *vrf-name*]	-
Configure to bind IPv6 with DUID and IAID.	**bind** *ipv6-address* **duid** *duid* [**iaid** { *iaid* | **decimal** *iaid*}]	Mandatory By default, IPv6 is not configured to bind with DUID and IAID.

Note

- This command is valid only for Range-type and Network-type address pools.
- When configuring static binding for the same DUID and IAID, the address pool allows binding of five IPv6 addresses.
- The configured static binding specifies only the DUID, and when the IAID is not specified, the address pool allows only one IPv6 address to be bound.

42.2.2 Configure Other Parameters of the DHCPv6 Server

Configuration Condition

None

Configure the DHCPv6 Server

After configuring the interface to work in DHCPv6 server mode, when the interface receives DHCPv6 request packets from DHCPv6 clients, the DHCPv6 server allocates IPv6 addresses and other network parameters for the clients.

Table 42 Configuring DHCPv6 Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure DHCPv6 server function.	**ipv6 dhcp server**	Mandatory By default, the DHCPv6 server function is not configured.

Configure the Ranges of the Reserved IPv6 Addresses

In the DHCPv6 address pool, some IPv6 addresses are reserved for specific devices, and some are in conflict with other host IPv6 addresses on the network. Therefore, these IPv6 addresses cannot be used for dynamic allocation.

Table 5 Configuring the Ranges of Reserved IPv6 Addresses

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the ranges of the reserved IPv6 address.	**ipv6 dhcp excluded-address** *low-ipv6-address* [*high-ipv6-address*] [**vrf** *vrf-name*]	Mandatory By default, the range of the reserved IPv6 address is not configured. The IPv6 addresses within the reserved IPv6 address ranges do not participate in address allocation.

Configure DHCPv6 Ping Probe Parameters

To prevent IPv6 address conflict, the DHCPv6 server needs to detect the IPv6 address before dynamically allocating it to the DHCPv6 client. The detection is performed by a ping operation, which determines whether there is an IPv6 address conflict based on the detection of whether an ICMPv6 echo response packet can be received within a specified time.

Table 6 Configuring DHCPv6 Ping Probe Parameters

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the DHCPv6 ping probe parameters.	**ipv6 dhcp ping** { **packets** *packet-num* | **timeout** *milliseconds* }	Mandatory By default, the number of ping packets is 1, and the timeout time is 500 ms.

Configure the Data Logging Function of the DHCPv6 Server

When the data log function of a DHCPv6 server is enabled, the address pool allocation on the DHCPv6 server will be recorded to the data log.

Table 7 Configuring Data Logging Function of DHCPv6 Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the data logging function switch of DHCPv6 server.	**ipv6 dhcp logging security-data**	Mandatory By default, the data logging function is not enabled.

42.2.3 Configure the Function of DHCPv6 Client

Configuration Condition

None

Configure DHCPv6 Client

The interface of DHCPv6 client can obtain IPv6 address and other parameters through DHCPv6.

Table 8 Configuring DHCPv6 Client

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Enter the interface configuration mode	**interface** *interface-name*	-
Configure DHCPv6 Client to Obtain IPv6 Addresses.	**ipv6 dhcp client address [rapid-commit]**	Mandatory By default, the DHCPv6 client request for IPv6 address is not configured.
Configure DHCPv6 client to obtain IPv6 prefixes.	**ipv6 dhcp client pd** *pool-name* **[rapid-commit]**	Mandatory By default, the DHCPv6 client request for IPv6 prefix is not configured.

42.2.4 Configure the Function of DHCPv6 Relay

Configuration Condition

None

Configure DHCPv6 Relay

If there are multiple subnets in a network and the hosts of multiple subnets need to provide IPv6 addresses and other configuration information through DHCPv6 servers, the hosts of these subnets can communicate with DHCPv6 servers through DHCPv6 relay devices to obtain IPv6 addresses and other configuration information. If an interface is configured to work in DHCPv6 relay mode, after the interface receives DHCPv6 packets from a DHCPv6 client, it relays the packet to the specified DHCPv6 server. The DHCPv6 server then allocates an IPv6 address.

Table 9 Configuring DHCPv6 Relay

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the function of DHCPv6 relay	**ipv6 dhcp relay**	Mandatory By default, the DHCPv6 relay function is not configured.

Configure the Source Address of DHCPv6 Relay Packet

The source address used by DHPCv6 relay when forwarding DHCPv6 client-originated packets to a DHCPv6 server is, by default, the output interface address of the route to the DHCPv6 server. In some environments, the DHCPv6 server cannot communicate with this address, therefore users are allowed to configure the source address of the packets forwarded by the DHCPv6 relay to the DHCPv6 server and the LinkAddr field in the packets via the **ipv6 dhcp relay source-address** command.

Table 10 Configuring DHCPv6 Relay Packets Source Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the source address of DHCPv6 relay packet.	**ipv6 dhcp relay source-address** *ipv6-address*	Mandatory By default, the DHCPv6 relay packet source address is not configured.

Configure DHCPv6 Server Address

After the interface receives DHCPv6 packets from a DHCPv6 client, it relays the packet to the specified DHCPv6 server. The DHCPv6 server then allocates an IPv6 address.

Table 11 Configuring DHCPv6 Server Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure DHCPv6 server address	**ipv6 dhcp relay server-address** *ipv6-address*	Mandatory By default, the DHCPv6 server address is not configured.

Configure DHCPv6 Interface-id Option

This command is used to configure the interface-id option fill mode supported by DHCPv6 relay.

Table 12 Configuring DHCPv6 Server Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure DHCPv6 interface-id option	**ipv6 dhcp relay interface –id [interface]**	Mandatory By default, the interface-id option fill mode is not configured.

42.2.5 DHCPv6 Monitoring and Maintaining

Table 13 DHCPv6 Monitoring and Maintaining

Command	Description
clear ipv6 dhcp pool *pool-name* { **lease** | **conflict [***ipv6-address***]** }	Clears dynamic lease information from the address pool or address information with conflicting addresses.
clear ipv6 dhcp server interface [*interface-name* **] statistics**	Clears the key statistics when the DHCPv6 server interacts with clients or relays for packets.
clear ipv6 dhcp relay statistics	Clear the statistics on the DHCPv6 relay device.
show ipv6 dhcp server interface *interface-name* **[statistics]**	Displaying the address pool information associated with the specified interface or display the key statistics when the DHCPv6 server engages in packet interactions with clients or relays under the specified interface.
show ipv6 dhcp pool *pool-name* **{ summary | ping_list | offer_list | excluded_list | conflict_list | lease | binding }**	Displaying the summary information of the specified address pool or the information of the address that is doing ping check or the address that has sent the OFFER packet and is waiting for the DHCPv6 client to respond to the

	REQUEST packet or the information of the excluded address in the address pool or the information of the address that has address conflict in the address pool or the information of dynamic lease in the address pool or the information of static binding in the address pool.
show ipv6 dhcp pool *pool-name* **specific { ipv6-address** *ipv6-address* **| duid** *duid* **}**	Displaying information about the specified ip address or client DUID in the address pool.
show ipv6 dhcp relay [interface *interface-name* **]**	Displaying the packet statistics on the DHCPv6 relay device.

42.3 Typical Configuration Example of DHCPv6

42.3.1 Configure DHCPv6 Server to Statically Allocate IPv6 Addresses

Network Requirements

- Device2 acts as the DHCPv6 server and statically allocates the IPv6 address and DNS server IPv6 address to the client.
- The DHCPv6 server allocates IPv6 address to PC1 with DUID binding and PC2 with DUID+IAID binding.

Network Topology

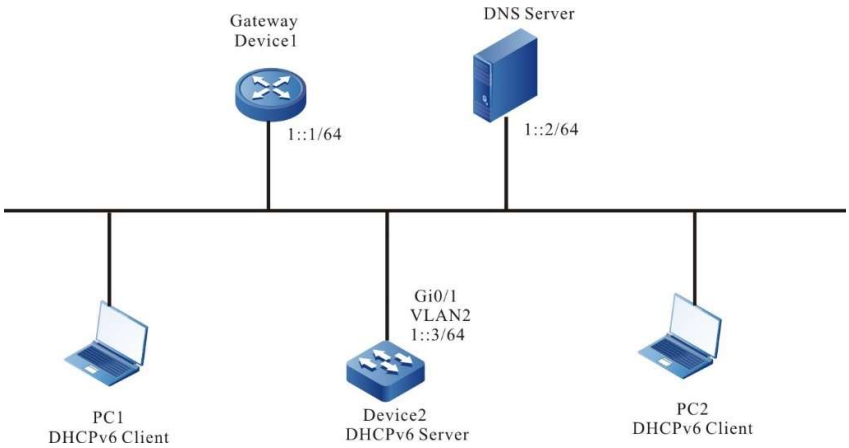


Figure 42 Network Topology for Configuring DHCPv6 Server to Statically Allocate IPv6 Addresses

Configuration Steps

Step 1: Configure the IPv6 address for the Device2 interface and the DHCPv6 server.

```
Device2#configure terminal
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ipv6 address 1::3/64
Device2(config-if-vlan2)#ipv6 dhcp server
Device2(config-if-vlan2)#exit
```

Step 2: Configure statically bound address pools and parameters.

#Configure address pool binding and uses static DUID binding to allocate IPv6 address to PC1. Use static DUID+IAID binding to allocate IPv6 address to PC2.

```
Device2(config)#ipv6 dhcp pool binding
Device2(dhcp6-config)#bind 1::11 duid
00020000161330303031376163663564634
Device2(dhcp6-config)#bind 1::12 duid
000200001613636364383166313037616239 iaid
00010071
Device2(dhcp6-config)#dns-server 1::2
Device2(dhcp6-config)#exit
```

Step 3: Check the result.

#Check the association of the server interfaces and the addresses.

```
Device2#show ipv6 dhcp server interface vlan2
DHCPv6 server status information:
DHCP server is enabled on interface: vlan2
Vrf : global

DHCPv6 server pool information:
Available directly-connected pool:
        Interface IP: 1::1/64
          Pool name: binding
          Range:
              min: 101::
              max: 101::ffff:ffff:ffff:ffff
          utilization: 0.00%
```

#Check the static binding of the server.

```
Device2#show ipv6 dhcp pool binding binding
IPv6 Address            Duid                        Iaid
Type    Time Left(s)
------------  ------------------------------------        --------  -
------  ------------
```

```
      1::11
000200001613303030313761636635646634
00000000   Binding     NA

      1::12
000200001613636364383166313037616239
00010071   Binding     NA
```

#Check the IPv6 addresses allocated to PC1 and PC2 on Device2 with the show ipv6 dhcp pool binding lease command.

```
Device2#show ipv6 dhcp pool mac-binding lease

IPv6 Address            Duid                          Iaid
Type     Time Left(s) ------------ ----------------------------
---------       --------  -------  ------------

1::11       000200001613303030313761636635646634
00000000    Lease      2591974

1::12       000200001613636364383166313037616239
00010071    Lease      2591974
```

Check on PC1 and PC2 that the obtained IPv6 address, and the DNS server IPv6 address is correct.

42.3.2 Configure DHCPv6 Server to Dynamically Allocate IPv6 Addresses

Network Requirements

- The two interfaces vlan2 and vlan3 of Device are configured with IPv6 addresses 1::3/64 and 2::3/64 respectively.
- The DHCPv6 server Device dynamically allocates IPv6 addresses to the 1::/64 and 2::/64 network segments for clients within each of the two directly connected physical networks.
- Addresses within network segment 1::/64 are leased for 1 day with a DNS server address of 2::4; addresses within network segment 2::/64 are leased for 3 days with a gateway address of 2::3 and a DNS server address of 2::4.
- The first 10 IPv6 addresses in network segment 1::/64 and network segment 2::/64 are reserved and cannot be allocated.

Network Topology

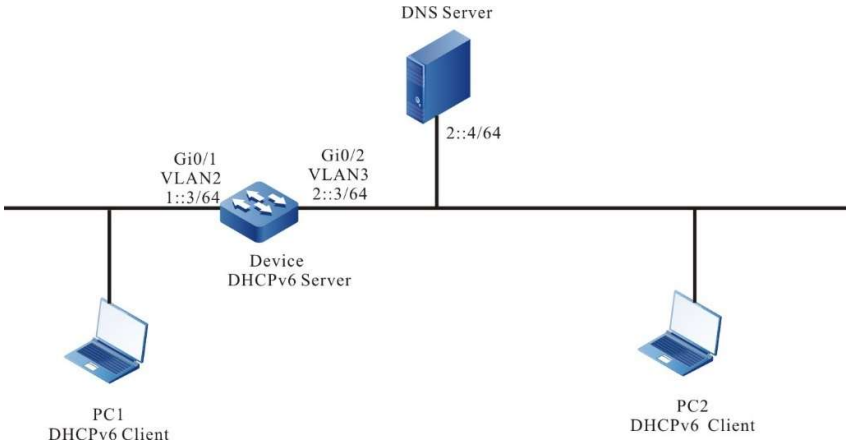


Figure 1 Network Topology for Configuring DHCPv6 to Dynamically Allocate IPv6 Addresses

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. Configure IPv6 addresses for the ports. (Omitted)

Step 2: On the DHCPv6 server Device1, configure two dynamic address pools and their parameters.

#Configure the DHCPv6 server.

```
Device(config)#interface vlan2
Device(config-if-vlan2)#ipv6 dhcp server
Device(config-if-vlan2)#exit
Device(config)#interface vlan3
Device(config-if-vlan3)#ipv6 dhcp server
Device(config-if-vlan3)#exit
```

#Configure the first 10 IPv6 addresses in the two address pools to be reserved.

```
Device(config)#ipv6 dhcp excluded-address 1::0
1::9
Device(config)#ipv6 dhcp excluded-address 2::0
2::9
```

#Configure address pool dynamic-pool1 and its parameters (including address range, DNS, address lease, and local domain name).

```
Device(config)#ipv6 dhcp pool dynamic-pool1
Device(dhcp6-config)#network 1::/64
Device(dhcp6-config)#dns-server 2::4
Device(dhcp6-config)#lease preferred-lifetime
86300 valid-lifetime 86400
Device(dhcp6-config)#exit
```

#Configure address pool dynamic-pool2 and its parameters (including address range, DNS address, address lease, Wins server address, and local domain name).

```
Device(config)#ip DHCPv6 pool dynamic-pool2

Device(dhcp6-config)#network 2::/64

Device(dhcp6-config)#dns-server 2::4

Device(dhcp6-config)#lease preferred-lifetime
259100 valid-lifetime 259200

Device(dhcp6-config)#exit
```

Step 3: Check the result.

#Check the IPv6 address information allocated to the client on the Device.

```
Device#show ipv6 dhcp pool dynamic-pool1
lease

IPv6 Address              Duid                    Iaid
Type      Time Left(s)

------------      ----------------------------      --------  -
------    ------------

1::a
000200001613303030313761636635646634
00000000   Lease        86390

Device2#show ipv6 dhcp pool dynamic-pool2
lease

IPv6 Address          Duid                    Iaid
Type       Time Left(s)

------------    ----------------------------      --------     -
------     ------------

2::a
000200001613303030313761636635646634
00000000    Lease        2591974
```

Check if the IPv6 address is obtained correctly on the DHCPv6 client.

注意:

- The IPv6 addresses in the address pool must be within the network segment range of the interface that provides the service.

42.3.3 Configure DHCPv6 Relay

Network Requirements

- Device1 is the DHCPv6 server and Device2 interface is enabled for DHCPv6 relay function.
- The DHCPv6 server serves clients in the 1::/64 network segment, and the first 10 IPv6 addresses are reserved.
- The DHCPv6 client obtains IPv6 addresses through the DHCPv6 relay.

Network Topology

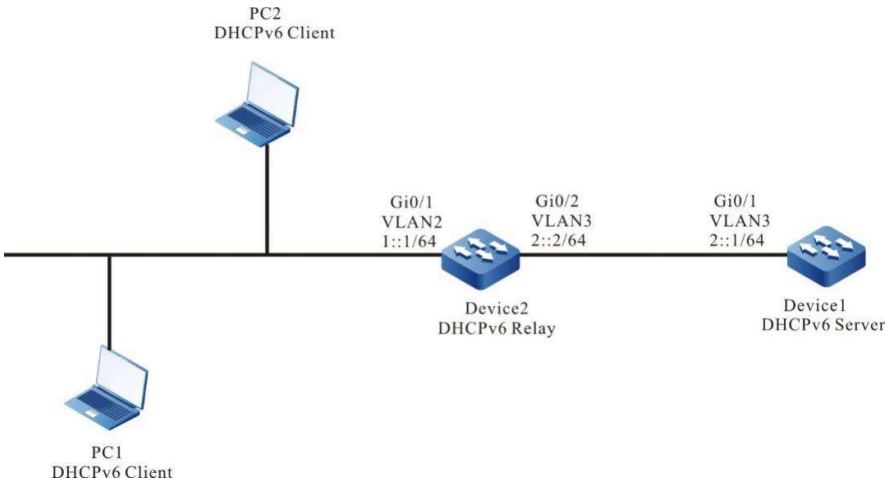


Figure 2 Network Topology for Configuring DHCPv6 Relay

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. Configure the IPv6 address of each interface (omitted).

Step 2: Configure Device1's IPv6 address pool and reserved IPv6 addresses.

#Configure Device1 as the DHCPv6 server.

```
Device1#configure terminal
Device1(config)#interface vlan3
Device2(config-if-vlan3)#ipv6 dhcp server
Device2(config-if-vlan3)#exit
```

#Configure to ensure the IPv6 addresses from 1::0 to 1::9 cannot be allocated.

```
Device1(config)#ipv6 dhcp excluded-address 1::0 1::9
```

Configure the IPv6 address pool dynamic-pool of Device1.

```
Device1(config)#ipv6 dhcp pool dynamic-pool
Device1(dhcp6-config)#network 1::/64
Device1(dhcp6-config)#lease preferred-lifetime 300
valid-lifetime 600
Device1(dhcp6-config)#exit
```

#Configure a static route to network segment 1::/64.

```
Device1(config)#ipv6 route 1::0/64 2::2
```

Step 3: Enable the DHCPv6 relay and configure DHCPv6 server address 2::1 on the vlan2 interface of Device2.

```
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ipv6 dhcp relay
Device2(config-if-vlan2)#ipv6 dhcp relay server-
```

```
address 2::1

Device2(config-if-vlan2)#exit
```

Step 4: Check the result.

#Check the IPv6 address information allocated on Device1.

```
Device1#show ipv6 dhcp pool dynamic-pool lease

IPv6 Address              Duid                    Iaid
Type     Time Left(s)

------------  ----------------------------------  --------  --
-----  ------------

1::0
00020000161330303031376163663564663 4
00000000  Lease      574
```

Using the show ipv6 dhcp pool dynamic-pool lease command to view information about the IPv6 address allocated to the client, indicating that the client has acquired IPv6 address 1::0.

43 Routing Basics

43.1 Overview

After a device receives a packet through an interface, the device selects a route according to the destination of the route and then forwards the packet to another interface. This process is called routing. In network devices, routes are stored in a routing table database. The packets search the routing table to determine the next hop and output interface according to the destination of the packets. Routes are categorized into three types according to their sources.

- Direct route: The route is generated based on the interface address. After a user configures the IP address of an interface, the device generates a direct route of the network segment according to the IP address and mask.
- Static route: The route is manually configured by the user.
- Dynamic route: The route is discovered through the dynamic route discovery protocol.

Based on whether the dynamic routing protocol is used within an autonomous domain, two types of dynamic routing protocols are available: Interior Gateway Protocol (IGP) and Exterior Gateway Protocol (EGP). Here an autonomous domain refers to a network which has a unified management organization and unified routing policy. A routing protocol that is used within an autonomous domain is an IGP. Common IGPs include Routing Information Protocol (RIP) and Open Shortest Path First (OSPF). EGPs are usually used for routing among multiple autonomous domains. A common EGP is BGP.

Routing supports load balancing, that is, multiple routes to the same destination. In forwarding packets, a device transmits packets in load balancing mode according to the routing table search result.

43.2 Routing Basic Function Configuration

Table 43 Routing Basic Function Configuration List

Configuration Task	
Configure load balancing for routing.	Configure the maximum number of load balancing entries.
	Configure the load balancing calculation method
Configure the capacity of routes for Virtual Route Forwarding (VRF) routes.	Configure the capacity of routes for Virtual Route Forwarding (VRF) routes.

43.2.1 Configure Load Balancing for Routing

Configuration Condition

None

Configure Maximum Number of Load Balancing Entries

If the costs of several paths to one destination are the same, the paths form load balancing. Configuring the maximum number of load balancing entries helps to improve the link utility rate and reduce the load of links.

Table 1 Configuring Maximum Number of Load Balancing Entries

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the maximum number of load balancing entries.	**route path-limit** *max-number*	Optional By default, the maximum number of load balancing entries for routing is 4.

Configure Load Balancing Calculation Method

There are three load balancing calculation methods:

- Based on source and destination address: Identify a flow with source address and a destination address. The packets of the same flow follow the same path to keep in order. When the loads of each flow are not balanced, the unbalancing of line loads may be caused.
- Based on source address: Identify a flow with source address only. The packets of the same flow use the same path so that the same flow follows the same path to keep in order. When the loads of each flow are not balanced, the unbalancing of line loads may be caused.
- Based on packets: The packets going to the same destination follow different paths to achieve load balancing on each path as much as possible. But they may be out of order.

Table 2 Configuring Load Balancing Calculation Method

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IPv4 packet load balancing method	**ip load-sharing** { **per-destination** | **per-packet** | **per-source** }	Optional By default, the calculation method based on source and address address is used.

43.2.2 Routing Basic Monitoring and Maintaining

Table 3 Routing Basic Monitoring and Maintaining

Command	Description
clear ip route [**vrf** *vrf-name*] { *ip-address mask* **| all** }	Clear the specified IP routes in the routing table
show ip route [**vrf** *vrf-name*] [**bgp** | **connected** | **irmp** | isis | **ospf** | **rip** | **static | statistic** [**all**] | *ip-address* { *mask* | *mask-len* }]	Show the information of IP routes

44 IPv6 Routing Basics

44.1 Overview

After a device receives an IPv6 packet through an interface, the device selects a route according to the destination of the IPv6 packet and then forwards it to another interface. This process is called routing. In network devices, routes are stored in a routing table database. The packets search the routing table to determine the next hop and output interface according to the destination of the packets. Routes are categorized into three types according to their sources.

- Direct route: The route is generated based on the interface address. After a user configures the IPv6 address of an interface, the device generates a direct route of the network segment according to the this address and mask.
- Static route: The route is manually configured by the user.
- Dynamic route: The route is discovered through the dynamic route discovery protocol. Based on whether the dynamic routing protocol is used within an autonomous domain, two types of dynamic routing protocols are available: Interior Gateway Protocol (IGP) and Exterior Gateway Protocol (EGP). Here an autonomous domain refers to a network which has a unified management organization and unified routing policy. A routing protocol that is used within an autonomous domain is an IGP. Common IGPs include RIPng and OSPFv6. Exterior Gateway Protocols (EGPs) are usually used for routing among multiple autonomous domains. A common EGP is IPv6 BGP.

Routing supports load balancing, that is, multiple routes to the same destination. In forwarding packets, a device transmits packets in load balancing mode according to the routing table search result.

44.2 IPv6 Routing Basic Function Configuration

Table 44 IPv6 Routing Basic Function Configuration List

Configuration Task	
Configure IPv6 routing load balancing	Configure IPv6 load balancing calculation method

44.2.1 Configure IPv6 routing Load Balancing

Configuration Condition

None

Configure IPv6 Load Balancing Calculation Method

There are three load balancing calculation methods:

- Based on source and destination address: Identify a flow with source address and a destination address. The packets of the same flow follow the same path to keep in order. When the loads of each flow are not balanced, the unbalancing of line loads may be caused.
- Based on source address: Identify a flow with source address only. The packets of the same flow use the same path so that the same flow follows the same path to keep in order. When the loads of each flow are not balanced, the unbalancing of line loads may be caused.
- Based on packets: The packets going to the same destination follow different paths to achieve load balancing on each path as much as possible. But they may be out of order.

Table 44 Configuring IPv6 Load Balancing Calculation Method

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IPv6 packet load balancing method	**ipv6 load-sharing** { **per-destination** | **per-packet** | **per-source** }	Optional By default, the calculation method based on source and address address is used.

44.2.2 IPv6 routing Basic Monitoring and Maintaining

Table 1 IPv6 Routing Basic Monitoring and Maintaining

Command	Description
clear ipv6 route { *ipv6-address* **|** *ipv6-prefix* **| all** }	Clear the specified IPv6 routes in the routing table
show ipv6 route [**vrf** *vrf-name*] [*ipv6-address* | *ipv6-prefix* | **bgp** | **brief** |	Show the information of IPv6 routes

Command	Description
connected | **isis** | **linklocal** | **local** | **ospf** | **rip** | **static | statistic** | **all**]	

45 Static Routes

45.1 Overview

A static route is a self-defined route which is manually configured by a user. It specifies a path for transmitting IP packets which are targeted at a specified destination.

Compared with dynamic routing, static routing has higher security and lower device resource occupancy. The disadvantage is that when the network topology changes, manual configuration is required, and there is no automatic re-configuration mechanism.

Static routes do not occupy line bandwidth or occupy CPU to calculate and advertise routes periodically, improving the device and network performance.

Static routes can be used to ensure the security of a small-scale network, for example, in a network where there is only one path connecting to an external network. In a large-scale network, static routes can implement security control on services or links of certain types. A majority of networks adopt dynamic routing protocols but you can still configure some static routes for special purposes.

Static routes can be re-distributed to a dynamic routing protocol, but dynamic routes cannot be re-distributed to static routes. Note that improper static route configuration may cause routing loops.

The default route is a special route which can be a static route. In a routing table, the default route is a route to network 0.0.0.0 with the mask 0.0.0.0. You can use the show ip route command to check whether the route is valid. When the destination address of a received packet does not match any entry in the routing table, the packet takes the default route. If no default route is available and the destination is not in the routing table, the packet is discarded, and an ICMP packet is returned to the source end reporting that the destination address or network is not reachable. To prevent the routing table from becoming too large, you can set a default route. The packet that fails to find a matching routing table entry takes the default route for forwarding.

Null0 route is a special route with an Null0 interface. Null0 interface is always UP, though it cannot forward data packets. The data packets sent to this interface are all discarded. When a static route is configured to reach the output interface Null0 of a certain network segment, any packet sent to that network segment will be discarded. Therefore, the packet filtering function can be implemented by configuring a Null0 static route.

45.2 Static Routing Function Configuration

Table 45 Static Routing Function Configuration List

Configuration Task	
Configure a Static Route	Configure a Static Route
Configure the Default Administrative Distance	Configure the Default Administrative Distance
Configure the Recursive Function	Configure the Recursive Function
Configure Load Balancing Routes	Configure Load Balancing Routes
Configure a Floating Route	Configure a Floating Route
Configure a Static Route to Coordinate with BFD	Configure a Static Route to Coordinate with BFD
Configure a Static Route to Coordinate with Track	Configure a Static Route to Coordinate with Track

45.2.1 Configure a Static Route

Configuration Condition

Before configuring a static route, ensure that:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer.

Configure a Static Route

According to the parameters that have been specified, static routes are categorized into the following three types:

- Interface route: For an interface route, only the output interface is specified.
- Gateway route: For a gateway route, only the gateway address is specified.
- Interface gateway route: For an interface gateway route, both the output interface and

the gateway address are specified.

Configured static routes become invalid if some of the following conditions are met:

1) The destination address is the local interface address.

2) The destination address is the network of the local direct interface.

3) The administrative distance of the route is 255.

4) The output interface of the route is DOWN.

5) No IP address has been configured for the output interface of the route.

6) The gateway address is not reachable.

7) The output interface and the gateway of the route conflict.

8) The output interface of the route does not exist.

9) The TRACK object that is associated with the route is "fake".

10) The status of the Bidirectional Forwarding Detection (BFD) session that is associated with the route is DOWN.

If an interface route meets any one condition among 1), 2), 3), 4), 5), 8), and 10), the route is invalid. If a gateway route meets any one condition among 1), 2), 3), 4), 6), 8), 9), and 10), the route is invalid. If an interface gateway route meets any of the above conditions, the route is invalid.

Table 45 Configuring Static Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure a Static Route	**ip route** [**vrf** *vrf-name1*] *destination-ip-address destination-mask* { *interface-name* / [*nexthop-ip-address* [**vrf** *vrf-name2*]] } [**name** *nexthop-name*] [**tag** *tag-value*] [**track** *track-id*] [*administrative-distance*]	Mandatory *Administrative-distance* is the administrative distance of the static route. When it is not specified, the default value is used.

Note

- When configuring the default route, both destination network and mask should be

0.0.0.0.

- The output interface of Null0 route should be configured as Null0.
- No IP address is required for the output interface of Null0 route.

45.2.2 Configure the Default Administrative Distance

Configuration Condition

None

Configure the Default Administrative Distance

The smaller the administrative distance that is specified for a static route in configuring the static route is, the higher the priority of the route is. If the administrative distance is not specified, the default administrative distance is used. You can modify the default administrative distance dynamically. After the default administrative distance is re-configured, the new default administrative distance is valid only for new static routes.

Table 1 Configuring Default Administrative Distance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enters the static route configuration mode.	**router static**	-
Configure the Default Administrative Distance	**distance** *administration-distance*	Optional The value of default administrative distance is 1.

Note

- When using the **ip route** command to configure a static route, you can specify the administrative distance separately (*administrative-distance* parameter). If the administrative distance is not specified, use the default administrative distance.

45.2.3 Configure the Recursive Function

Configuration Condition

None

Configure the Recursive Function

If the gateway address that is configured for a route is valid only when a route to the gateway is reachable, you must enable the recursive function of the static route to validate the route. By default, the recursive function is enabled for a static route.

Table 2 Configuring Recursive Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enters the static route configuration mode.	**router static**	-
Configure a static route to support the recursive function.	**recursion**	Optional By default, a static route supports the recursive function for routing.

45.2.4 Configure Load Balancing Routes

Configuration Condition

None

Configure Load Balancing Routes

Load balancing routes means that multiple routes are configured to the same destination network. The output interfaces and the gateway addresses of the routes are different, but the administrative distances (priorities) of the routes are the same. Load balancing routes help to improve the link utility rate.

Table 3 Configuring Load Balancing Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure the first load balancing route	**ip route** *destination-ip-address destination-mask interface-name1 distance*	Mandatory The output interface is interface-name1.
Configure the second load balancing route	**ip route** *destination-ip-address destination-mask interface-name2 distance*	Mandatory The output interface is *interface-name2*.

Note

- When configuring the load balancing route, the *distance* values should be equal.

45.2.5 Configure a Floating Route

Configuration Condition

None

Configure a Floating Route

Multiple routes are available to the same destination network. The output interfaces or gateway addresses of the routes are different, and the priorities of the routes are also different. The route with the higher priority becomes the primary route while the route with the lower priority becomes the floating route. In the routing table, only the primary route is visible. The floating table appears in the routing table only when the primary route becomes invalid. Therefore, the floating route is usually used as a backup route.

Table 4 Configuring Floating Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the preferred route	**ip route** *destination-ip-address destination-mask interface-name1 distance1*	Mandatory The output interface of preferred route is *interface-name1*, and the priority is *distance1*.

Step	Command	Description
Configure a Floating Route	**ip route** *destination-ip-address destination-mask interface-name2 distance2*	Mandatory The output interface of the floating route is *interface-name2*, and the priority is *distance2*. The value of *distance2* should be greater than *distance1*.

Note

- For the priority of the specified route, the smaller the *distance* value, the higher the priority.

45.2.6 Configure a Static Route to Coordinate with Track

Configuration Condition

None

Configure a Static Route to Coordinate with Track

Some modules in the system need to monitor some system information and then determine their working modes based on the information. The objects that are monitored by the other modules are called monitoring objects. To simplify the relations between the modules and monitoring objects, Track objects are used. A Track object can contain multiple monitoring objects, and it displays the comprehensive status of the monitoring object to external modules. The external modules are associated only with Track objects and they do not care about monitoring objects contained in the Track objects any more. A Track object has two statuses, "true" and "false". The external modules that are associated with the Track object determine its working modes according to the Track object status.

A static route can associate with a Track object to monitor system information and determine whether the route is valid according to the status reported by the Track object. If the Track object reports "true", the conditions required by the static route are satisfied, and the route is added to the routing table. If the Track object reports "false", the route is deleted from the routing table.

Table 5 Configuring a Static Route to Coordinate with TRACK

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create Track object and enter its configuration mode	**track** *track-id*	Mandatory
Configure the link status of the specified interface for Track object monitoring	**interface** *interface-name* **line-protocol**	Optional
Return to the global configuration mode	**exit**	-
Configure a static route and associate with Track	**ip route** *destination-ip-address destination-mask interface-name* **track** *track-id*	Mandatory When the link layer of the monitoring interface is UP, the route takes effect; otherwise, it becomes invalid.

45.2.7 Static Route Monitoring and Maintaining

Table 6 Static Route Monitoring and Maintaining

Command	Description
show ip route [**vrf** *vrf-name*] **static**	Show the static route in the routing table
show running-config ip route	Show the configuration information of static route

45.3 Typical Example of Configuration of Static Route

45.3.1 Configure Basic Functions of Static Route

Network Requirements

- Configure static routes for Device1, Device2 and Device3 to achieve intercommunication between PC1 and PC2.

Network Topology

Figure 45 Network Topology for Configuring Basic Functions of Static Route

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure static routes.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ip route 20.1.1.0 255.255.255.0 10.1.1.2
Device1(config)#ip route 100.1.1.0 255.255.255.0 10.1.1.2
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ip route 110.1.1.0 255.255.255.0 10.1.1.1
Device2(config)#ip route 100.1.1.0 255.255.255.0 20.1.1.2
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#ip route 0.0.0.0 0.0.0.0 20.1.1.1
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.1.1.0/24 is directly connected, 00:06:47, vlan3
S   20.1.1.0/24 [1/100] via 10.1.1.2, 00:00:13, vlan3
S   100.1.1.0/24 [1/100] via 10.1.1.2, 00:00:05, vlan3
C   110.1.1.0/24 is directly connected, 00:08:21, vlan2
C   127.0.0.0/8 is directly connected, 28:48:33, lo0
```

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.1.1.0/24 is directly connected, 00:00:37, vlan2
C   20.1.1.0/24 is directly connected, 00:00:27, vlan3
S   100.1.1.0/24 [1/100] via 20.1.1.2, 00:00:05, vlan3
S   110.1.1.0/24 [1/100] via 10.1.1.1, 00:00:13, vlan2
C   127.0.0.0/8 is directly connected, 30:13:18, lo0
```

#Check the routing table of Device3.

```
Device3#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is 20.1.1.2 to network 0.0.0.0

S   0.0.0.0/0 [1/100] via 20.1.1.1, 00:00:07, vlan2
C   20.1.1.0/24 is directly connected, 00:00:08, vlan2
C   100.1.1.0/24 is directly connected, 00:00:13, vlan3
C   127.0.0.0/8 is directly connected, 29:17:19, lo0
```

Step 4: Check the result. Use the **ping** command to check the connectivity between PC1 and PC2.

#Use the **ping** command to check connectivity on PC1.

```
C:\Documents and Settings\Administrator>ping 100.1.1.2

Pinging 100.1.1.2 with 32 bytes of data:

Reply from 100.1.1.2: bytes=32 time<1ms TTL=125
Reply from 100.1.1.2: bytes=32 time<1ms TTL=125
Reply from 100.1.1.2: bytes=32 time<1ms TTL=125
Reply from 100.1.1.2: bytes=32 time<1ms TTL=125

Ping statistics for 100.1.1.2:
   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
   Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

PC1 and PC2 can communicate with each other.

45.3.2 Configure Static Floating Route

Network Requirements

- On Device1, configure two static routes leading to the network segment 192.168.1.0/24, one through Device2 and the other through Device3.
- Device1 prefers to use the line between it and Device2 to forward packets; when this line fails, it will switch to Device3 for communication.

Network Topology

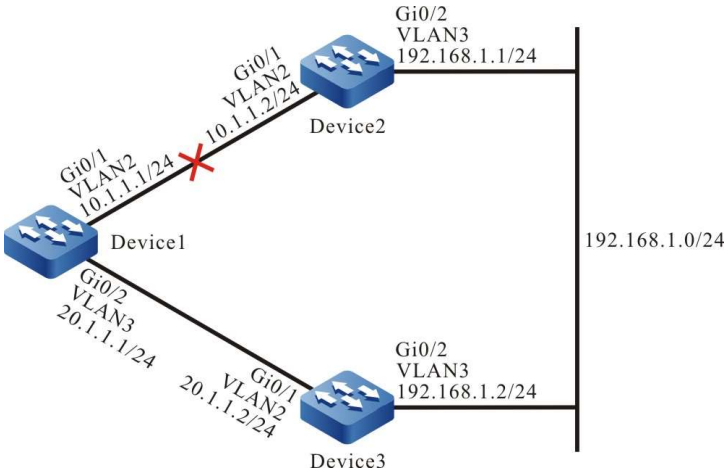


Figure 45 Network Topology for Configuring Static Floating Route

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure static routes.

#Enable Device1 to pass through Device2 and Device3 towards the network segment 192.168.1.0/24.

```
Device1#configure terminal
Device1(config)#ip route 192.168.1.0 255.255.255.0 10.1.1.2
Device1(config)#ip route 192.168.1.0 255.255.255.0 20.1.1.2
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
     D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.1.1.0/24 is directly connected, 02:16:43, vlan2
C   20.1.1.0/24 is directly connected, 03:04:15, vlan3
C   127.0.0.0/8 is directly connected, 14:53:00, lo0
S   192.168.1.0/24 [1/100] via 10.1.1.2, 00:00:05, vlan2
              [1/100] via 20.1.1.2, 00:00:02, vlan3
```

It can be seen that there are two routes that can get to the network segment 192.168.1.0/24 on Device1, reaching load balancing.

Step 4: Configure floating route.

#Configure Device1. Modify the gateway as 20.1.1.2 and make the administrative distance of the route 15 so that it can become a floating route.

```
Device1(config)#ip route 192.168.1.0 255.255.255.0 20.1.1.2 15
```

Step 5: Check the result.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.1.1.0/24 is directly connected, 02:28:25, vlan2
C   20.1.1.0/24 is directly connected, 03:15:58, vlan3
C   127.0.0.0/8 is directly connected, 15:04:42, lo0
S   192.168.1.0/24 [1/100] via 10.1.1.2, 00:11:47, vlan2
```

According to the routing table, since the route with an administrative distance of 1 comes before the route with an administrative distance of 15, the route with a gateway of 20.1.1.2 is deleted.

#When the lines between Device1 and Device2 fail, view the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   20.1.1.0/24 is directly connected, 03:23:44, vlan3
C   127.0.0.0/8 is directly connected, 15:12:28, lo0
S   192.168.1.0/24 [15/100] via 20.1.1.2, 00:00:02, vlan3
```

The routing table indicates that the route with a larger administrative distance will be added into the routing table to be forwarded by Device3.

Note

- Route backup is the most important feature of static floating route.

45.3.3 Configure Static Null0 Interface Route

Network Requirements

- Configure a static default route on Device1 and Device2 respectively. The gateway address is the address of the interface address of the peer ports of the 2 devices. Configure a static Null0 interface route for Device1 to filter the data leading to PC2 only.

Network Topology

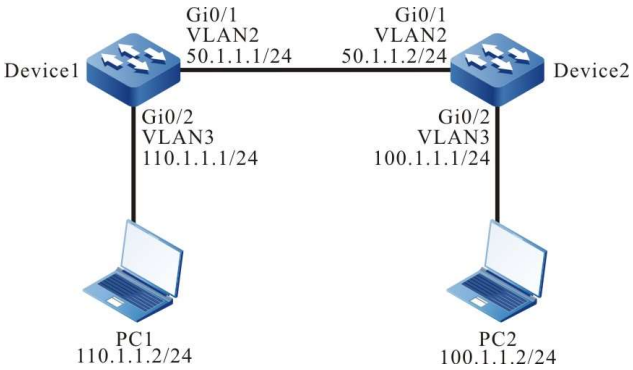


Figure 45 Network Topology for Configuring Static Null0 Interface Route

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure static routes.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ip route 0.0.0.0 0.0.0.0 50.1.1.2
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ip route 0.0.0.0 0.0.0.0 50.1.1.1
```

#On PC1, use the **ping** command to verify the connectivity with PC2.

```
C:\Documents and Settings\Administrator>ping 100.1.1.2

Pinging 100.1.1.2 with 32 bytes of data:

Reply from 100.1.1.2: bytes=32 time<1ms TTL=126
Reply from 100.1.1.2: bytes=32 time<1ms TTL=126
Reply from 100.1.1.2: bytes=32 time<1ms TTL=126
Reply from 100.1.1.2: bytes=32 time<1ms TTL=126

Ping statistics for 100.1.1.2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Step 4: Configure static Null0 interface route.

#Configure Device1.

```
Device1(config)#ip route 100.1.1.2 255.255.255.255 null0
```

Step 5: Check the result.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is 50.1.1.2 to network 0.0.0.0

S   0.0.0.0/0 [1/100] via 50.1.1.2, 00:07:28, vlan2
C   50.1.1.0/24 is directly connected, 00:07:34, vlan2
C   110.1.1.0/24 is directly connected, 00:00:08, vlan3
C   127.0.0.0/8 is directly connected, 11:46:35, lo0
S   100.1.1.2/32 [1/1] is directly connected, 00:02:31, null0
```

The static Null0 interface route has been added to the routing table.

#On PC1, use the ping command to verify the connectivity with PC2.

```
C:\Documents and Settings\Administrator>ping 100.1.1.2

Pinging 100.1.1.2 with 32 bytes of data:

Request timed out.
Request timed out.
Request timed out.
Request timed out.

Ping statistics for 100.1.1.2:
    Packets: Sent = 4, Received = 0, Lost = 4 (100% loss)
```

After looking up in the routing table on Device1, the ICMP packet sent by PC1 which finds that the output interface is Null0 will be directly discarded. Therefore, PC1 cannot communicate with PC2.

Note

- Static Null0 interface route is a special route. The data packets sent to this Null0 interface are all discarded. Therefore, configuring static Null0 interface route can realize packet filtering.

45.3.4 Configure Static Recursive Route

Network Requirements

- On Device1, configure two static routes leading to the network segment 192.168.1.1/32, one through Device2 and the other through Device3. Device1 prefers to use the lines between it and Device3 to forward packets.
- On Device1, configure a static recursive route leading to the network segment 200.0.0.0/24. The gateway address is the loopback interface address 192.168.1.1 of Device3. After the lines between Device1 and Device3 fail, this route will switch to

Device2 for communication.

Network Topology

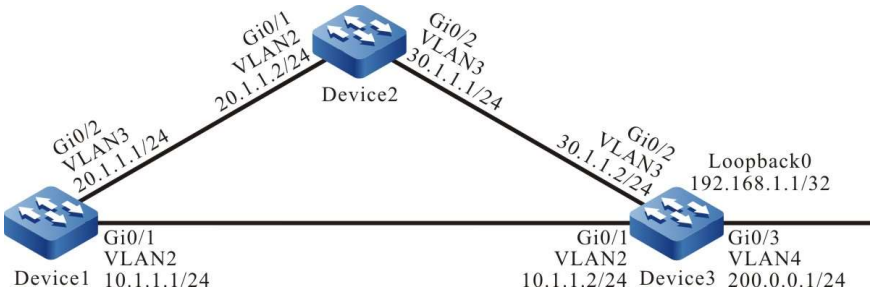


Figure 1 Network Topology for Configuring Static Recursive Route

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure static routes.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ip route 192.168.1.1 255.255.255.255 10.1.1.2
Device1(config)#ip route 192.168.1.1 255.255.255.255 20.1.1.2 10
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ip route 192.168.1.1 255.255.255.255 30.1.1.2
```

Step 4: Configure static recursive route.

#Configure Device1.

```
Device1(config)#ip route 200.0.0.0 255.255.255.0 192.168.1.1
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.1.1.0/24 is directly connected, 00:04:07, vlan2
C   20.1.1.0/24 is directly connected, 00:03:58, vlan3
C   127.0.0.0/8 is directly connected, 73:10:12, lo0
S   200.0.0.0/24 [1/100] via 192.168.1.1, 00:00:08, vlan2
S   192.168.1.1/32 [1/100] via 10.1.1.2, 00:01:46, vlan2
```

The routing table indicates that the gateway address of the route 200.0.0.0/24 is 192.168.1.1, and the output interface is VLAN2. This route depends on the route 192.168.1.1/32.

Step 5: Check the result.

#When the lines between Device1 and Device3 fail, view the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   20.1.1.0/24 is directly connected, 00:09:04, vlan3
C   127.0.0.0/8 is directly connected, 73:15:18, lo0
S   200.0.0.0/24 [1/100] via 192.168.1.1, 00:00:02, vlan3
S   192.168.1.1/32 [10/100] via 20.1.1.2, 00:00:02, vlan3
```

By comparing with the routing table mentioned in step 3, you will find that the output interface of the route 200.0.0.0/24 is VLAN3, which means it has switched to Device2 for communication.

46 IPv6 Static Route

46.1 Overview

The IPv6 static routing protocol has the same protocol behaviors as the static routing protocol except for the IP address structure in the packet. For details, see the overview of static route.

46.2 IPv6 Static Routing Function Configuration

Table 46 IPv6 Static Routing Function Configuration List

Configuration Task	
Configure IPv6 static route	Configure IPv6 static route
Configure IPv6 load balancing route	Configure IPv6 load balancing route
Configure IPv6 floating route	Configure IPv6 floating route

Configuration Task	
Configure IPv6 static route to coordinate with Track	Configure IPv6 static route to coordinate with Track
Configure IPv6 static route FRR	Configure IPv6 static route FRR

46.2.1 Configure IPv6 Static Route

Configuration Condition

Before configuring IPv6 static route, ensure that:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Configure the IPv6 address of interface so that neighbor nodes are reachable at the network layer.

Configure IPv6 static route

According to the parameters that have been specified, IPv6 static routes are categorized into the following three types:

- Interface route: For an interface route, only the output interface is specified.
- Gateway route: For a gateway route, only the gateway address is specified.
- Interface gateway route: For an interface gateway route, both the output interface and the gateway address are specified.

Configured IPv6 static routes become invalid if some of the following conditions are met:

1) The destination address is the local interface address.

2) The administrative distance of the route is 255;

3) The output interface of the route is DOWN;

4) The output interface of the route doesn't enable IPv6;

5) The gateway address is not reachable;

6) The gateway address conflicts with local address;

7) The output interface and the gateway of the route conflict.

8) The output interface of the route does not exist.

9) The TRACK object that is associated with the route is "fake".

10) The status of the BFDv6 session that is associated with the route is DOWN.

If an interface route meets any one condition among 1), 2), 3), 4), 8), 9), and 10), the route is invalid. If a gateway route meets any one condition among 1), 2), 5), 6), 9), and 10), the route is invalid. If an interface gateway route meets any of the above conditions, the route is invalid.

Table 46 Configuring IPv6 Static Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IPv6 static route	**ipv6 route** *destination-ipv6-address/destination-mask* { *interface-name* / [*nexthop-ipv6-address*] } [**name** *nexthop-name*] [**tag** *tag-value*] [**track** *track-id*] [*administrative-distance*]	Mandatory *Administrative-distance* is the administrative distance of the static route. When it is not specified, the default value is used.

Note

- When configuring the default route, both destination network and mask should be 0::/0.
- The output interface of Null0 route should be configured as Null0.
- No IPv6 address is required for the output interface of Null0 route.

46.2.2 Configure IPv6 Load Balancing Route

Configuration Condition

None

Configure IPv6 Load Balancing Route

IPv6 load balancing route means that multiple routes are configured to the same destination network. The output interfaces and the gateway addresses of the routes are different, but the administrative distances (priorities) of the routes are the same. Load balancing routes help to improve the link utility rate.

Table 46 Configuring IPv6 Load Balancing Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure the first IPv6 load balancing route	**ipv6 route** *destination-ipv6-address/destination-mask interface-name1 distance*	Mandatory The output interface is *interface-name1*.
Configure the second IPv6 load balancing route	**ipv6 route** *destination-ipv6-address/destination-mask interface-name2 distance*	Mandatory The output interface is *interface-name2*.

Note

- When configuring the load balancing route, the distance values should be equal.

46.2.3 Configure IPv6 Floating Route

Configuration Condition

None

Configure IPv6 Floating Route

IPv6 floating static route means that multiple routes are available to the same destination network. The output interfaces or gateway addresses of the routes are different, and the priorities of the routes are also different. The route with the higher priority becomes the primary route while the route with the lower priority becomes the floating route. In the routing table, only the primary route is visible. The floating table appears in the routing table only when the primary route becomes invalid. Therefore, the floating route is usually used as a backup route.

Table 46 Configuring Floating Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IPv6 preferred route	**ipv6 route** *destination-ipv6-address/destination-mask interface-name1 distance1*	Mandatory The output interface of preferred route is *interface-name1*, and the priority is *distance1*.

Step	Command	Description
Configure IPv6 floating route	**ipv6 route** *destination-ipv6-address/destination-mask interface-name2 distance2*	Mandatory The output interface of the floating route is *interface-name2*, and the priority is *distance2*. The value of *distance2* should be greater than *distance1*.

Note

- For the priority of the specified route, the smaller the distance value, the higher the priority.

46.2.4 Configure IPv6 Static Route to Coordinate with Track

Configuration Condition

None

Configure IPv6 Static Route to Coordinate with Track

Some modules in the system need to monitor some system information and then determine their working modes based on the information. The objects that are monitored by the other modules are called monitoring objects. To simplify the relations between the modules and monitoring objects, Track objects are used. A Track object can contain multiple monitoring objects, and it displays the comprehensive status of the monitoring object to external modules. The external modules are associated only with Track objects and they do not care about monitoring objects contained in the Track objects any more. A Track object has two statuses, "true" and "false". The external modules that are associated with the Track object determine its working modes according to the Track object status.

A static route can associate with a Track object to monitor system information and determine whether the route is valid according to the status reported by the Track object. If the Track object reports "true", the conditions required by the static route are satisfied, and the route is added to the routing table. If the Track object reports "false", the route is deleted from the routing table.

Table 1 Configuring Coordination of IPv6 Static Route with TRACK

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create Track object and enter its configuration mode	**track** *track-id*	Mandatory
Configure the link status of the specified interface for Track object monitoring	**interface** *interface-name* **line-protocol**	Optional
Return to the global configuration mode	**exit**	-
Configure a IPv6 static route and associate with Track	**ipv6 route** *destination-ipv6-address/destination-mask interface-name* **track** *track-id*	Mandatory When the link layer of the monitoring interface is UP, the route takes effect; otherwise, it becomes invalid.

46.2.5 IPv6 Static Route Monitoring and Maintaining

Table 2 IPv6 Static Routing Monitoring and Maintaining

Command	Description
show ipv6 route [vrf vrf-name] static	Show the static route in the IPv6 routing table
show ipv6 static route [*ipv6-address/mask-length***]**	Show the IPv6 static route
show running-config ipv6 route	Show the configuration information of IPv6 static route

46.3 Typical Example of Configuration of IPv6 Static Route

46.3.1 Configure Basic Functions of IPv6 Static Route

Network Requirements

- Configure IPv6 static routes for Device1, Device2 and Device3 to achieve intercommunication between PC1 and PC2.

Network Topology

Figure 46 Network Topology for Configuring Basic Functions of IPv6 Static Route

Configuration Steps

Step 1: Configure VLAN. And add ports to the required VLAN. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure IPv6 static route.

#Configure IPv6 route on Device1.

```
Device1#configure terminal
Device1(config)#ipv6 route 2001:4::/64 2001:2::2
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 route 2001:1::/64 2001:2::1
Device2(config)#ipv6 route 2001:4::/64 2001:3::2
```

#Configure IPv6 route on Device3.

```
Device3#configure terminal
Device3(config)#ipv6 route 2001:1::/64 2001:3::1
```

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
```

```
      O - OSPF, OE-OSPF External, M - Management

S   2001:4::/64 [1/10]
    via 2001:2::2, 00:03:14, vlan3
L   ::1/128 [0/0]
    via ::, 2w0d:01:09:06, lo0
C   2001:1::/64 [0/0]
    via ::, 00:25:55, vlan2
L   2001:1::1/128 [0/0]
    via ::, 00:25:53, lo0
C   2001:2::/64 [0/0]
    via ::, 04:01:46, vlan3
L   2001:2::1/128 [0/0]
    via ::, 04:01:45, lo0
```

#View the IPv6 routing table of Device 2.

```
Device2#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
    via ::, 5w2d:23:52:04, lo0
S   2001:1::/64 [1/10]
    via 2001:2::1, 00:02:56, vlan2
C   2001:2::/64 [0/0]
    via ::, 04:00:52, vlan2
L   2001:2::2/128 [0/0]
    via ::, 04:00:50, lo0
C   2001:3::/64 [0/0]
    via ::, 04:00:20, vlan3
L   2001:3::1/128 [0/0]
    via ::, 04:00:19, lo0
S   2001:4::/64 [1/10]
    via 2001:3::2, 00:02:36, vlan3
```

Check the IPv6 routing table of Device3.

```
Device3#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

S   2001:1::/64 [1/10]
    via 2001:3::1, 00:00:08, vlan2
L   ::1/128 [0/0]
    via ::, 1w2d:20:54:36, lo0
C   2001:3::/64 [0/0]
    via ::, 03:58:28, vlan2
L   2001:3::2/128 [0/0]
    via ::, 03:58:26, lo0
C   2001:4::/64 [0/0]
    via ::, 00:11:13, vlan3
L   2001:4::1/128 [0/0]
    via ::, 00:11:12, lo0
```

Step 4: Check the result. Use the ping command to check the connectivity between PC1 and PC2.

#Use the ping command to check connectivity on PC1.

```
C:\Documents and Settings\Administrator>ping 2001:4::2

Pinging 2001:4::2 with 32 bytes of data:

Reply from 2001:4::2: bytes=32 time<1ms TTL=128
Reply from 2001:4::2: bytes=32 time<1ms TTL=128
Reply from 2001:4::2: bytes=32 time<1ms TTL=128
Reply from 2001:4::2: bytes=32 time<1ms TTL=128
```

```
Ping statistics for 2001:4::2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

PC1 and PC2 can communicate with each other.

46.3.2 Configure IPv6 Static Floating Route

Network Requirements

- On Device1, configure two static routes leading to the network segment 2001:3::/64, one through Device2 and the other through Device3.
- Device1 prefers to use the line between it and Device2 to forward packets; when this line fails, it will switch to Device3 for communication.

Network Topology

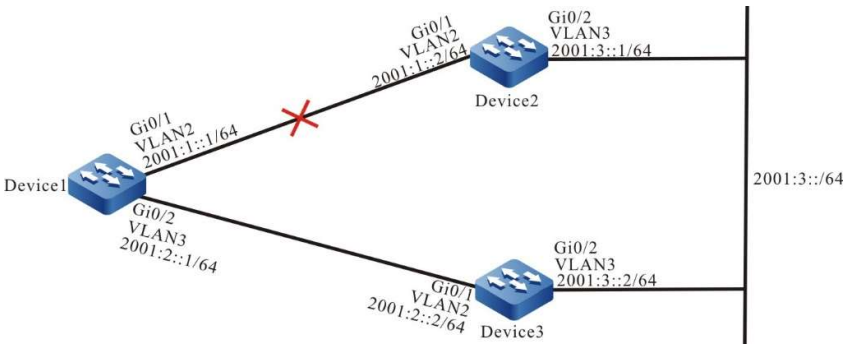


Figure 46 Network Topology for Configuring IPv6 Static Floating Route

Configuration Steps

Step 1: Configure VLAN. And add ports to the required VLAN. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure IPv6 static route.

#Enable Device1 to pass through Device2 and Device3 towards the network segment 2001:3::/64.

```
Device1#configure terminal

Device1(config)#ipv6 route 2001:3::/64 2001:1::2

Device1(config)#ipv6 route 2001:3::/64 2001:2::2
```

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management
```

```
L   ::1/128 [0/0]
    via ::, 2w0d:02:13:16, lo0
C   2001:1::/64 [0/0]
    via ::, 00:22:33, vlan2
L   2001:1::1/128 [0/0]
    via ::, 00:22:32, lo0
C   2001:2::/64 [0/0]
    via ::, 00:17:47, vlan3
L   2001:2::1/128 [0/0]
    via ::, 00:17:46, lo0
S   2001:3::/64 [1/10]
    via 2001:1::2, 00:01:47, vlan2
          [1/10]
    via 2001:2::2, 00:01:36, vlan3
```

According to the result, there are two routes that can get to the network segment 2001:3::/64 on Device1, reaching load balancing.

Step 4: Configure IPv6 floating route.

#Configure Device1. Modify the gateway as 2001:2::2 and make the administrative distance of the route 15 so that it can become a floating route.

```
Device1(config)#ipv6 route 2001:3::/64 2001:2::2 15
```

Step 5: Check the result.

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
    via ::, 2w0d:02:16:38, lo0
C   2001:1::/64 [0/0]
    via ::, 00:25:56, vlan2
L   2001:1::1/128 [0/0]
    via ::, 00:25:55, lo0
C   2001:2::/64 [0/0]
    via ::, 00:21:10, vlan3
L   2001:2::1/128 [0/0]
    via ::, 00:21:09, lo0
S   2001:3::/64 [1/10]
    via 2001:1::2, 00:05:10, vlan2
```

According to the IPv6 routing table, since the route with an administrative distance of 1 comes before the route with an administrative distance of 15, the route with a gateway of 2001:2::2 is deleted.

#When the lines between Device1 and Device2 fail, view the routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
    via ::, 2w0d:02:21:06, lo0
C   2001:2::/64 [0/0]
    via ::, 00:25:38, vlan3
```

```
L   2001:2::1/128 [0/0]
    via ::, 00:25:37, lo0
S   2001:3::/64 [15/10]
    via 2001:2::2, 00:00:05, vlan3
```

According to the IPv6 routing table, the route with a larger administrative distance will be added into the routing table to be forwarded by Device3.

Note

- Route backup is the most important feature of static floating route.

46.3.3 Configure IPv6 Static NULL0 Interface Route

Network Requirements

- Configure a static default route on Device1 and Device2 respectively. The gateway address is the address of the interface address of the peer ports of the 2 devices. Configure a static Null0 interface route for Device1 to filter the data leading to PC2.

Network Topology

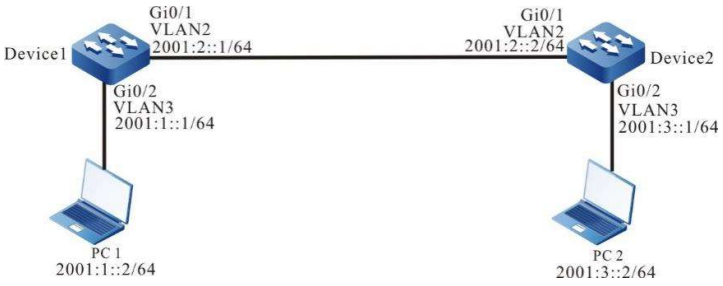


Figure 1 Network Topology for Configuring IPv6 Static NULL0 Interface Route

Configuration Steps

Step 1: Configure VLAN. And add ports to the required VLAN. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure IPv6 static route.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 route ::/0 2001:2::2
```

#Configure Device2.

```
Device2#configure terminal
```

```
Device2(config)#ipv6 route ::/0 2001:2::1
```

#Use the ping command to check connectivity on PC1.

```
C:\Documents and Settings\Administrator>ping 2001:3::2

Pinging 2001:3::2 with 32 bytes of data:

Reply from 2001:3::2: bytes=32 time<1ms TTL=128
Reply from 2001:3::2: bytes=32 time<1ms TTL=128
Reply from 2001:3::2: bytes=32 time<1ms TTL=128
Reply from 2001:3::2: bytes=32 time<1ms TTL=128

Ping statistics for 2001:3::2:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms
```

Step 4: Configure IPv6 static Null0 interface route.

#Configure Device1.

```
Device1(config)#ipv6 route 2001:3::2/128 null0
```

Step 5: Check the result.

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

S   ::/0 [1/10]
     via 2001:1::2, 00:04:55, vlan2
L   ::1/128 [0/0]
     via ::, 2w0d:03:36:10, lo0
C   2001:1::/64 [0/0]
     via ::, 00:08:54, vlan3
L   2001:1::1/128 [0/0]
     via ::, 00:08:53, lo0
C   2001:2::/64 [0/0]
     via ::, 00:08:32, vlan2
L   2001:2::1/128 [0/0]
     via ::, 00:08:30, lo0
S   2001:3::2/128 [1/1]
     via ::, 00:00:34, null0
```

The IPv6 static Null0 interface route has been added to the IPv6 routing table.

#On PC1, use the ping command to verify the connectivity with PC2.

```
C:\Documents and Settings\Administrator>ping 2001:3::2

Pinging 2001:3::2 with 32 bytes of data:

Request timed out.
```

Request timed out.

Request timed out.

Request timed out.

Ping statistics for 2001:3::2:

Packets: Sent = 4, Received = 0, Lost = 4 (100% loss),

After looking up in the routing table on Device1, the ICMP packet sent by PC1 which finds that the output interface is Null0 will be directly discarded. Therefore, PC1 cannot communicate with PC2.

Note

- Static Null0 interface route is a special route. The data packets sent to this Null0 interface are all discarded. Therefore, configuring static Null0 interface route can realize packet filtering.

46.3.4 Configure IPv6 Static Recursive Route

Network Requirements

- On Device1, configure two static routes leading to the network segment 192::3/128, one through Device2 and the other through Device3. Device1 prefers to use the lines between it and Device3 to forward packets.
- On Device1, configure a static recursive route leading to the network segment 2001:4::/64. The gateway address is the loopback interface address 192::3 of Device3. After the lines between Device1 and Device3 fail, this route can switch to Device2 for communication.

Network Topology

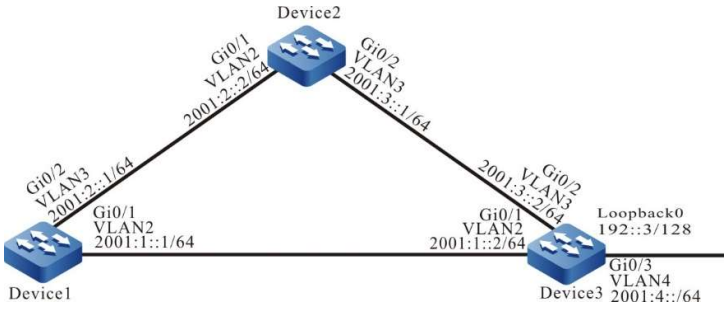


Figure 2 Network Topology for Configuring IPv6 Static Recursive Route

Configuration Steps

Step 1: Configure VLAN. And add ports to the required VLAN. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure IPv6 static route.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 route 192::3/128 2001:1::2
Device1(config)#ipv6 route 192::3/128 2001:2::2 10
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 route 192::3/128 2001:3::2
```

Step 4: Configure IPv6 static recursive route.

#Configure Device1.

```
Device1(config)#ipv6 route 2001:4::/64 192::3
```

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
    via ::, 2w0d:03:12:46, lo0
S   192::3/128 [1/10]
    via 2001:1::2, 00:04:54, vlan2
C   2001:1::/64 [0/0]
    via ::, 00:22:47, vlan2
L   2001:1::1/128 [0/0]
    via ::, 00:22:45, lo0
C   2001:2::/64 [0/0]
    via ::, 00:16:16, vlan3
L   2001:2::1/128 [0/0]
    via ::, 00:16:15, lo0
S   2001:4::/64 [1/10]
    via 192::3, 00:00:43, vlan2
```

According to the IPv6 routing table, the gateway address of the route 2001:4::/64 is 192::3, and the output interface is VLAN2. This route depends on the route 192::3/128.

Step 5: Check the result.

#When the lines between Device1 and Device3 fail, view the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
    via ::, 2w0d:03:17:48, lo0
S   192::3/128 [10/10]
    via 2001:2::2, 00:00:06, vlan3
C   2001:2::/64 [0/0]
    via ::, 00:21:18, vlan3
L   2001:2::1/128 [0/0]
    via ::, 00:21:17, lo0
```

```
S   2001:4::/64 [1/10]
    via 192::3, 00:00:06, vlan3
```

According to the routing table mentioned in step 3, the output interface of the route 2001:4::/64 is VLAN3, which means it has switched to Device2 for communication.

47 RIP

47.1 Overview

On the current Internet, it is impossible to run only one gateway protocol. You can divide it into multiple Autonomous Systems (ASs), each of which has its own routing technology. The internal routing protocols within an AS are Interior Gateway Protocols (IGPs). Routing Information Protocol (RIP) is one type of IGP. RIP adopts the Vector-Distance algorithm. RIP features simple and easy-to-use, so it is widely used in numerous small-sized networks.

RIP has two versions: RIPv1 and RIPv2. RIPv1 does not support classless routing, and RIPv2 supports classless routing. Usually, RIPv2 is used.

RIP is a simple protocol which provides simple configuration. However, the number of routes to be advertised by RIP is directly proportional to the number of routes in the routing table. If the number of routes is large, a lot of device resources and network resources are consumed. In addition, RIP specifies that the maximum number of hops that a routing path that passes routers is 15, so RIP is applicable only to simple smalland medium-sized network. RIP is applicable for most campus networks and LANs with a simple structure and strong continuity. For a more complex environment, RIP is not recommended.

RIPv1 was introduced earlier in RFC1058, but it has many deficiencies. To improve the deficiencies of RIPv1, RFC1388 introduced RIPv2, which was then revised in RFC 1723 and RFC 2453.

47.2 RIP Function Configuration

Table 47 RIP Function Configuration List

Configuration Task	
Configure RIP Basic Functions	Globally Enable RIP
	Enable RIP via VRF
	Configure RIP Version

Configuration Task	
Configure RIP Route Generation	Configure RIP to Distribute Default Route
	Configure RIP Route Redistribution
Configure RIP Route Control	Configure RIP Administrative Distance
	Configure RIP Route Summarization
	Configure the RIP Metric Offset
	Configure RIP Route Filtration
	Configure the Metric of the RIP Interface
	Configure the Routing Flag for an RIP Interface
	Configure the Maximum Load Balancing
Configure RIP Network Authentication	Configure RIP Network Authentication
Configure RIP Network Optimization	Configure RIP Timers
	Configure Split Horizon and Toxicity Reverse of RIP
	Configure Source Address Check
	Configure a Static RIP Neighbor
	Configure a Passive RIP Interface
	Configure RIP to Trigger Updates
	Configure an RIP Standby Interface
Configure RIP to Coordinate with BFD	Configure RIP to Coordinate with BFD

47.2.1 Configure RIP Basic Functions

Configuration Condition

Before configuring the basic functions of RIP, ensure that:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Configure address of interface at network layer so that neighbor network nodes are reachable at the network layer.

Globally Enable RIP

To use RIP, the following configurations are required:

- Create RIP process;
- Configure RIP to cover direct network or an interface.

Table 1 Globally Enabling RIP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create RIP process and enter RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Cover the specified network segment or interface	**network** { *ip-address* | *interface-name* }	Mandatory By default, no direct network or interface is covered.

Note

- The network segment configured to cover will be automatically classified as classful address.
- **network** *ip-address* cannot cover supernet address, but this can be done through **network** *interface-name*.

Enable RIP via VRF

RIP supports VRF function. The following configurations are required:

- Configure a VRF, and specify an interface to add into this VRF;

- Specify to enable RIP function in the address family of this VRF;
- Configure RIP to cover a VRF direct network or the interface where it belongs.

Table 2 Enabling RIP via VRF

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create RIP process and enter RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Enter the RIP VRF address family configuration mode	**address-family** { **ipv4 vrf** *vrf-name* }	Mandatory By default, the VRF address family mode is disabled.
Cover the specified network segment or interface	**network** { *ip-address* | *interface-name* }	Mandatory By default, no direct network or interface is covered.

Note

- To enable RIP in VRF mode, VRF-related configurations must be created first.

Configure RIP Version

RIP supports two versions, i.e. RIPv1 and RIPv2. It can be configured in three modes: global, VRF, and interface:

- By default, the RIPv1 version is enabled in global and VRF mode, and it is not configured in interface mode;
- The priority of the version command configured in interface mode is higher than that in global or VRF mode;
- When the version command is not configured in interface mode, that in VRF or global mode where the interface is located will be used;
- In interface mode, the RIP receiving and sending version can be configured separately;
- After a version is configured, RIP will implement strict packet receiving and sending rules:

When RIPv1 is configured, only RIPv1 broadcast or unicast packets are sent and received; when RIPv2 is configured, RIPv2 unicast, multicast or broadcast packets are sent and received; in RIPv1 compatible mode, RIPv2 unicast and broadcast packets are sent.

Table 47 Configuring RIP Version

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create RIP process and enter RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure global RIP version	**version** { 1 | 2 }	Mandatory By default, RIPv1 is enabled.
Enter the RIP VRF configuration mode	**address-family** { **ipv4 vrf** *vrf-name* }	Mandatory By default, the VRF address family is disabled.
Configure the RIP version in RIP VRF configuration mode	**version** { 1 / 2 }	Mandatory By default, RIPv1 is enabled.
Return to RIP configuration mode	**exit-address-family**	-
Return to global configuration mode	**exit**	-
Enter the interface configuration mode	**interface** *interface_name*	-
Configure the interface to send RIP version	**ip rip send version** {{ 1 / 2 } | 1-compatible }	Optional By default, the packets are sent based on the RIP global version.
Configure the interface to receive RIP Version	**ip rip receive version** { 1 / 2 }	Optional By default, the packets are received based on the RIP global version.

47.2.2 Configure RIP Route Generation

Configuration Condition

Before configuring RIP route generation, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer.
- RIP is enabled.

Configure RIP to Distribute Default Route

Through configuration, the device sends default routes under all RIP interfaces and sets itself as the default gateway of other adjacent devices.

Table 3 Configuring RIP to Distribute Default Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure RIP to Distribute Default Route	**default-information originate {only | originate [metric** *value*] **}**	Mandatory By default, RIP doesn't distribute default route.

Note

- If a default route (0.0.0.0/0) is learned, it will replace the default route (0.0.0.0/0) distributed by the device. When there is loop in the network, route oscillation may be caused. Thus, when using this command, be sure that several other devices in the same routing domain are not enabling it at the same time.

Configure RIP Route Redistribution

The routes generated by other protocols can be imported into RIP by configuring route redistribution.

Table 4 Configuring RIP Route Redistribution

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure the default metric value of importing other routing protocol by RIP	**default-metric** *metric-value*	Optional By default, the default metric value of importing other routing protocol is 1.
Configure RIP Route Redistribution	**redistribute** *protocol* [*protocol-id*] [**metric** *metric-value*] [**route-map** *route-map-name*] [**match** *route-sub-type*]	Mandatory By default, no route redistribution is configured.

Note

- In case of redistribution, after the metric command option is specified, the route redistributed will adopt this metric value.
- For RIP, when configuring route redistribution application routing policies, the match options supported include ip address, route type, and tag, and the set options supported include interface, ip next-hop, route source, and metric.

47.2.3 Configure RIP Route Control

Configuration Condition

Before configuring RIP route control, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer.
- RIP is enabled.

Configure RIP Administrative Distance

Multiple routing protocols can run in the device at the same time. The device selects the routes learned by each protocol through administrative distance. The smaller the administrative distance, the more like the route is selected.

Table 47 Configuring RIP Administrative Distance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	-
Configure RIP Administrative Distance	**distance** *distance-value*	Mandatory By default, RIP administrative distance is 120.

Configure RIP Route Summarization

RIP route summarization means the device summarizes the subnet routes in the same natural network segment into one route. The route generated by summarization and the original subnet routes are listed in the RIP routing table at the same time.

After RIP route summarization is configured, the device only advertises the summarized routes. This can significantly reduce the scale of adjacent RIP routing tables in large and medium-sized networks and the consumption of network bandwidth by routing protocol packets.

The metric of the summarized route will be the minimum metric value among all subnet routes.

RIPv1 supports automatic route summarization, and RIPv2 supports both automatic and manual route summarization.

1. RIP automatic route summarization

Automatic route summarization is different from manual route summarization. It automatically generates a natural mask route according to the subnet routes within the same natural network segment.

Table 5 Configuring Automatic Route Summarization Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure automatic route summarization function	**auto-summary**	Mandatory By default, the automatic route summarization function is disabled.

Note

- RIPv1 does not allow route summarization through commands.
- The tag of the summarized route is 0, and the metric value of the route is the minimum value among the detail routes. When the automatic summarization function is configured, automatic summarization occurs first.
- For RIPv2, be careful to use the automatic route summarization function. Make ensure that automatic route summarization is necessary in the network, otherwise routing loops may be produced.
- If the automatic route summarization is enabled in RIPv2, when the interface advertises the route is in the same natural network segment as the route, the update packet sent from this interface will not summarize all the subnet routes in this natural network segment. Otherwise, the routes will be summarized into natural network segment for advertisement.

2. Manual route summarization

For manual route summarization, a pair of destination address and mask combination need to be configured. They will summarize the routes in the covered network segment.

Table 6 Configuring Manual Route Summarization Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-

Step	Command	Description
Configure the manual route summarization function of RIPv2 on the interface	**ip summary-address rip** *prefix-address*	-

Configure the RIP Metric Offset

By default, RIP applies the route metric advertised by the neighbor device to the received routes. To modify the metric in some special application scenarios, you can configure the RIP metric offset to correct the metric of the specified route.

If the metric in the incoming direction is configured, RIP modifies the metric of the received routes and saves the routes into the routing table. When RIP advertises a metric to the neighbor devices, it advertises the new metric. If the metric in the outgoing direction is configured, the metric is modified only when RIP advertises a metric to the neighbor devices.

Table 7 Configuring RIP Metric Offset

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure RIP to modify the metric of the specified route	**offset-list** *access-list-name* { **in** | **out** } *metric-offset* [*interface-name*]	Mandatory By default, no metric value of interface is configured.

Note

- Route metric offset supports the standard access list only.

Configure RIP Route Filtration

A router can filter the received or advertised routes by configuring an Access Control List (ACL) or prefix list. In receiving RIP routes, you can filter some learnt routes; or in announcing RIP routes, you can filter some routes that are advertised to neighbor devices.

Table 8 Configuring RIP Route Filtration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure RIP route filtration function	**distribute-list** { *access-list-name* | **prefix** *prefix-list-name* } { **in | out** } [*interface-name*]	Mandatory By default, no route filtration function is configured. When the route filtration function is configured, if an interface is not specified, route filtration will be enabled for all RIP covered interfaces during the receiving or sending process.

Note

- When using ACL filtration, only standard ACL is supported.

Configure the Metric of the RIP Interface

If an interface is overwritten by an RIP process, the corresponding direct route is generated in the database, with the default metric 1. When the route is in the RIP database or it is advertised to neighbor devices, if the interface is configured with a metric, the interface metric is used as the metric of the route.

If the interface metric is changed, the RIP database immediately updates the corresponding direct route of RIP and advertises the new metric to the neighbor devices.

Table 9 Configure Metric Value of RIP Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the metric of the RIP interface	**ip rip metric** *metric-value*	Mandatory By default, the matrix value of the RIP interface is 1.

Note

- When the matrix value of the RIP interface is configured, the matrix of the direct subnet on the interface instead of that of route learning will be affected.

Configure the Routing Flag for an RIP Interface

The network administrator can attach tags to some routes. Then, in applying a routing policy, the network administrator can perform route filtration or route property advertisement based on the tags.

Only the routing tags of RIPv2 are supported.

Table 10 Configuring Routing Flag for RIP interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the routing tag on the direct subnet on the interface of RIP	**ip rip tag** *tag-value*	-

Configure the Maximum Number of RIP Load Balancing Entries

This command helps you to control the number of RIP load balancing entries for routing.

Table 11 Configuring Maximum Number of Load Balancing Entries of RIP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure the Maximum Number of RIP Load Balancing Entries	**maximum-paths** *max-number*	Optional By default, the maximum number of load balancing entries of RIP is 4.

47.2.4 Configure RIP Network Authentication

RIPv2 supports protocol packet authentication, therefore, it can satisfy the high security requirement of some networks. Currently, plain text authentication and Message Digest 5 (MD5) authentication are supported. Plain text authentication features low security because it transmits plain text. MD5 converts an authentication code into the MD5 code for transmission, ensuring higher security.

Owing to the limit of RIPv2 packets, a packet that advertises a route contains only 16 bytes. Therefore, the length of a plain text authentication string must not exceed 16 bytes. Meanwhile, the MD5 code that is converted from any character string is a standard 16-byte code, meeting the requirement on the string length.

Table 12 Configuring RIP Network Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure RIPv2 network authentication	**ip rip authentication** { { **key** { 0 | 7 } *key-string* } | { **key-chain** *key-chain-name* } |	Mandatory By default, no RIPv2 authentication function is configured.

Step	Command	Description
	{ **mode** { **text** | **md5** | **sm3** } } }	

Note

- Before implementing MD5 authentication, pay attention to the following points:
- RIPv1 does not support network authentication.
- RIPv2 supports one authentication mode at a time.
- Key ID must be carried in the MD5 authentication information. If you use the ip rip authentication key command to configure a password, the key ID is 1. If you use the ip rip authentication key-chain command to configure a password, the key ID is the key ID in Key-chain.
- In obtaining a packet transmit authentication password from Key-chain, select a Key ID in the sequence of from small to large. Therefore, the Key ID with the smallest valid transmit password will be selected.
- In obtaining a packet receive authentication password from Key-chain, select the first valid receive password whose Key ID is equal to or larger than the packet receive Key ID. Therefore, if Key IDs are different for the two ends of authentication, the end with the larger Key ID can pass the authentication while the end with the smaller Key ID fails in the authentication.

47.2.5 Configure RIP Network Optimization

Configuration Condition

Before configuring RIP network optimization, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer.
- RIP is enabled.

Configure RIP Timers

RIP does not maintain neighbor relations and it does not support route withdrawn; therefore, the protocol provides four configurable timers to control the network convergence speed. The four timers are: route update timer, router timeout timer, route dampening update timer, and route clear timer.

The route timeout time must be at least three times of the route update time. If no route update packet is received within the route timeout time, the route becomes invalid and it enters a dampening cycle. The length of the dampening cycle is determined by the dampening update time. During the cycle, the route

will not be cleared. After the dampening cycle is completed, the route enters the clear cycle. During the cycle, the route can be updated. However, if no route update packet is received during the cycle, the route will be deleted.

Table 13 Configuring RIP Timer

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure the time of RIP timer	**timers basic** *update-interval invalid-interval holddown-interval flush-interval*	Optional By default, the RIP update interval is 30 seconds, the effective time of advertisement 180 seconds, the suppression time 180 seconds, and the clearing time 240 seconds.

Caution

- In the same RIP routing domain, the **timer basic** configurations on all devices must be consistent to avoid network flapping.

Configure RIP Split Horizon and Toxicity Reverse of RIP

Split horizon and toxicity reverse are mechanisms that are used to prevent route loops.

1. Configure split horizon.

RIP does not advertise routes that it has learnt from an interface to the interface, preventing routing loops.

Table 14 Configuring RIP Split Horizon

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the interface configuration mode	**interface** *interface-name*	-
Configure RIP split horizon	**ip split-horizon**	Mandatory By default, the split horizon function is disabled.

2. Configure toxicity reverse.

RIP announces routes that have been learnt from an interface to the interface, but the route metric is the maximum number of hops, 16, preventing routing loops.

Table 15 Configuring RIP Toxicity Reverse

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure RIP toxicity reverse	**ip split-horizon poisoned**	Optional By default, the toxicity reverse function is enabled.

Note

- The split horizon and toxicity reverse functions are valid only for the learnt routes, direct routes in the network covered by RIP, and the redistributed direct and static routes.
- The split horizon function and the toxicity reversion function cannot be used at the same time.

Configure RIP Source Address Check

Through source address check, RIP checks the source addresses of the received packets. RIP processes only the packets whose source addresses meet the requirements. The check items include: the packet source

address is in the same network segment as the input interface address; the packet source address matches the peer end address of the Point-to-Point (P2P) interface.

By default, RIP is enabled to check whether the source addresses received through the Ethernet port are in the same network segment as the address of the interface, and this function cannot be cancelled.

Table 16 Configuring RIP Source Address Check

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure RIP source address check on the interface of P2P	**validate-update-source check-p2p-destination**	Mandatory By default, address of peer port is not checked for P2P interface.

Configure a Static RIP Neighbor

RIP does not maintain neighbor relations, so it does not have the concept of neighbor. Here the neighbor refers to the neighbor RIP routing device. After a static RIP neighbor is specified, RIP sends RIP packets to the neighbor in unicast mode. The configuration is applied to a network that does not support broadcast or multicast, such as point-to-point links. If the configuration is applied to a broadcast or multicast network, it may cause repeated RIP packets in the network.

Table 17 Configuring Static RIP Neighbor

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure the neighbor which advertises routing	**neighbor** *ip-address*	Mandatory

Step	Command	Description
information in the form of unicast		The parameter ip-address is the ip address of the direct interface of the peer port.

Note

- The advertisement of routing information to static neighbors occurs only on the interfaces covered by RIP, and "**passive-interface**" cannot prevent them from sending packets to static neighbors.

Configure a Passive RIP Interface

To decrease the network bandwidth consumed by the routing protocol, the dynamic routing protocol uses the passive interface function. RIP receives only route update packets on a passive interface, and it does not send route update packets on the passive interface. In a low-speed network with small bandwidth, the passive interface function and the neighbor function cooperate to effectively reduce interactions of RIP routes.

Table 18 Configuring Passive RIP Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RIP configuration mode	**router rip**	Mandatory By default, RIP process is disabled.
Configure a Passive RIP Interface	**passive-interface** { **default** | *interface-name* }	Mandatory By default, no passive interface is configured.

Note

- The passive interface function does not restrain an interface from sending unicast route updates to its neighbor devices. When the passive interface function is used

with the neighbor command, the function does not restrain an interface from sending unicast route updates to its neighbor devices. This application mode controls a router so that it sends route updates only to some neighbor devices in unicast mode instead of sending route updates to all neighbor devices in broadcast mode (or multicast mode in the case of RIPv2).

Configure RIP to Trigger Updates

After a device receives an RIP update packet, to reduce the possibility of introducing loops owning to routing table differences, the device advertises the update packet of the route to its neighbor devices immediately instead of waiting for the update timer to time out before an update. The update trigger mechanism speeds up network convergence.

Table 19 Configuring RIP to Trigger Updates

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure RIP to trigger updates on the interface	**ip rip triggered**	Optional By default, the trigger updates function is disabled.

Configure an RIP Standby Interface

To speed up backup route convergence, RIP newly supports a backup interface (standby interface) function. On the main route interface of RIP, specify a backup interface for the main interface. In a specific application environment, RIP learns RIP routes only from one line, and the backup line does not provide routing information interaction. If the main interface gets offline, RIP sends Request packets to the peer end through the backup interface periodically (Default: 1s) to request for all routes. If the backup interface receives a Response packet from the peer route, RIP cancels sending of Request packets. It updates the local routing table, and advertises the local routing table to the backup interface. If the backup interface fails to receive a Response packet from the peer end before timeout, RIP cancels sending of Request packets.

Table 20 Configuring RIP Backup Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure an RIP Standby Interface	**ip rip standby** *interface-name* [**timeout** *timeout-value*]	Optional By default, the backup interface function is disabled, and the default value of *timeout-value* is 300s.

47.2.6 RIP Monitoring and Maintaining

Table 21 Configuring RIP Monitoring and Maintaining

Command	Description
show ip rip [**vrf** *vrf-name*]	Show the basic information of RIP
show ip rip [**vrf** *vrf-name*] **database** [**detail** | *prefix/mask* [[**detail** | **longer-prefixes** [**detail**]]]]	Show the RIP routing database information
show ip rip [**vrf** *vrf-name*] **statistics**	Show the statistical information of RIP
show ip rip interface [*interface-name*]	Show the RIP interface information
clear ip rip [**vrf** *vrf-name*] { **process** | **statistics** }	Clear the RIP process and statistical information

47.3 Typical Example of Configuration of RIP

47.3.1 Configure RIP Version

Network Requirements

- Run RIPv2 between Device1 and Device2 for route interaction.

Network Topology

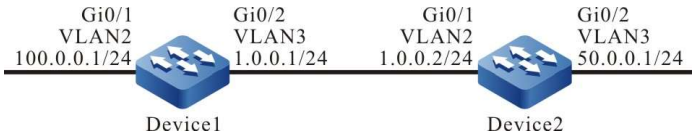


Figure 47 Network Topology for Configuring RIP Version

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure RIP.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router rip
Device1(config-rip)#network 1.0.0.0
Device1(config-rip)#network 100.0.0.0
Device1(config-rip)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router rip
Device2(config-rip)#network 1.0.0.0
Device2(config-rip)#network 50.0.0.0
Device2(config-rip)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan3
R   50.0.0.0/8 [120/1] via 1.0.0.2, 00:13:26, vlan3
C   100.0.0.0/24 is directly connected, 00:23:06, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

#View the routing table of Device 2.

```
Device2#show ip route
```

```
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan2
C   50.0.0.0/24 is directly connected, 00:23:06, vlan3
R   100.0.0.0/8 [120/1] via 1.0.0.1, 00:13:26, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

According to the routing table, the routing information advertised by the device uses 8-bit natural mask.

Step 4: Configure RIP version.

#Configure Device1.

```
Device1(config)#router rip
Device1(config-rip)#version 2
Device1(config-rip)#exit
```

#Configure Device2.

```
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#exit
```

Step 5: Check the result.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan3
R   50.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan3
C   100.0.0.0/24 is directly connected, 00:23:06, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan2
C   50.0.0.0/24 is directly connected, 00:23:06, vlan3
R   100.0.0.0/24 [120/1] via 1.0.0.1, 00:13:26, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

According to the routing table, the routing information advertised by the device uses 24-bit accurate mask.

47.3.2 Configure RIP Route Redistribution

Network Requirements

- Run the OSPF protocol between Device1 and Device2. Device2 learns the OSPF routes 100.0.0.0/24 and 200.0.0.0/24 distributed by Device1.

- Run the RIPv2 protocol between Device2 and Device3. Device2 only redistributes the OSPF route 100.0.0.0/24 into RIP, and advertises such route to Device3.

Network Topology

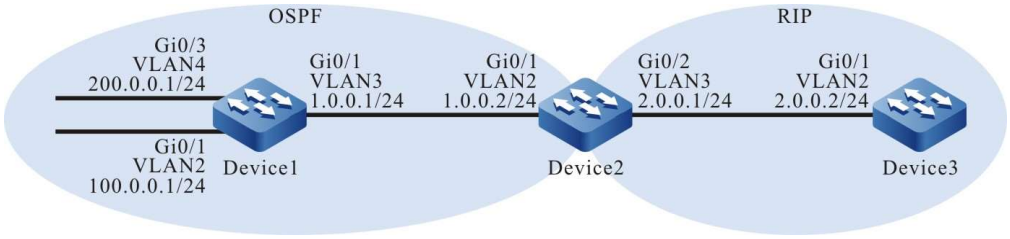


Figure 47 Network Topology for Configuring RIP Route Redistribution

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure OSPF.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#network 1.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#network 100.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#network 200.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#network 1.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#exit
```

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external


C   1.0.0.0/24 is directly connected, 00:23:06, vlan2

C   2.0.0.0/24 is directly connected, 00:13:06, vlan3

O   100.0.0.0/24 [110/2] via 1.0.0.1, 00:04:12, vlan2

C   127.0.0.0/8 is directly connected, 76:51:00, lo0

O   200.0.0.0/24 [110/2] via 1.0.0.1, 00:04:12, vlan2
```

According to the routing table, Device2 learns the OSPF route advertised by Device1.

Step 4: Configure RIP.

#Configure Device2.

```
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 2.0.0.0
Device2(config-rip)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router rip
Device3(config-rip)#version 2
Device3(config-rip)#network 2.0.0.0
Device3(config-rip)#exit
```

Step 5: Configure routing policy.

#On Device2, configure route-map to invoke ACL to match 100.0.0.0/24 and filter 200.0.0.0/24.

```
Device2(config)#ip access-list standard 1
Device2(config-std-nacl)#permit 100.0.0.0 0.0.0.255
Device2(config-std-nacl)#commit
Device2(config-std-nacl)#exit
Device2(config)#route-map OSPFtoRIP
Device2(config-route-map)#match ip address 1
Device2(config-route-map)#exit
```

Note

- When configuring a routing policy, both the prefix list and ACL can create filtering rules. The difference is that the prefix list can exactly match the routing mask.

Step 6: Configure RIP to redistribute OSPF routes.

#Configure Device2.

```
Device2(config)#router rip
Device2(config-rip)#redistribute ospf 100 route-map OSPFtoRIP
Device2(config-rip)#exit
```

Step 7: Check the result.

#View the RIP routing table of Device 2.

```
Device2#show ip rip database
Types: N - Network, L - Learn, R - Redistribute, D - Default config, S - Static config
Proto: C - connected, S - static, R - RIP, O - OSPF, E - IRMP,
     o - SNSP, B - BGP, i-ISIS

RIP routing database in VRF kernel (Counter 3):
```

```
T/P Network        ProID Metric Next-Hop      From          Time  Tag   Interface
N/C 2.0.0.0/24     none  1      --            --            --    0     vlan3
R/O 100.0.0.0/24   1     1      1.0.0.1       --            --    0     vlan2
```

#Check the routing table of Device3.

```
Device3#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   2.0.0.0/24 is directly connected, 00:23:06, vlan2
R   100.0.0.0/24 [120/1] via 2.0.0.1, 00:13:26, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

After checking the RIP routing tables of Device2 and Device3, you will find that the route 100.0.0.0/24 on Device2 has been redistributed to RIP and successfully advertised to Device3, while the route 200.0.0.0/24 has been successfully filtered.

Caution

- In practical applications, if the autonomous system has 2 or more edge routers, directly redistributing routes between different routing protocols is not recommended. When configuration is necessary, routing control polices such as filtering and summarization are required on the edge routers of the autonomous system to avoid routing loops.

47.3.3 Configure the RIP Metric Offset

Network Requirements

- Run RIPv2 between Device1, Device2, Device3 and Device4 for interaction.
- Device1 learns the route 200.0.0.0/24 from both Device2 and Device3 at the same time.
- It is required to configure the routing metric offset in the receiving direction on Device1 to make Device1 first select the route advertised by Device2.

Network Topology

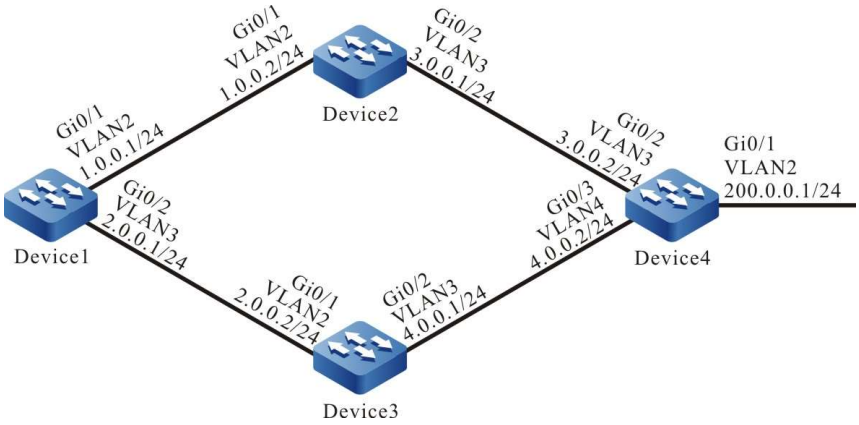


Figure 47 Network Topology for Configuring RIP Metric Offset

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure RIP.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router rip
Device1(config-rip)#version 2
Device1(config-rip)#network 1.0.0.0
Device1(config-rip)#network 2.0.0.0
Device1(config-rip)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 1.0.0.0
Device2(config-rip)#network 3.0.0.0
Device2(config-rip)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router rip
Device3(config-rip)#version 2
Device3(config-rip)#network 2.0.0.0
Device3(config-rip)#network 4.0.0.0
Device3(config-rip)#exit
```

#Configure Device4.

```
Device4#configure terminal
Device4(config)#router rip
Device4(config-rip)#version 2
Device4(config-rip)#network 3.0.0.0
Device4(config-rip)#network 4.0.0.0
Device4(config-rip)#network 200.0.0.0
Device4(config-rip)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan2
C   2.0.0.0/24 is directly connected, 00:22:56, vlan3
R   3.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan2
R   4.0.0.0/24 [120/1] via 2.0.0.2, 00:11:04, vlan3
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
R   200.0.0.0/24 [120/2] via 1.0.0.2, 00:08:31, vlan2
                 [120/2] via 2.0.0.2, 00:08:31, vlan3
```

According to the routing table of Device1, there are two routes leading to 200.0.0.0/24.

Step 4: Configure access lists.

#Configure Device1.

```
Device1(config)#ip access-list standard 1
Device1(config-std-nacl)#permit 200.0.0.0 0.0.0.255
Device1(config-std-nacl)#commit
Device1(config-std-nacl)#exit
```

Step 5: Configure metric offset.

#Configure offset list on Device1 to increase the metric value of the route which is learned from interface VLAN3 and matches ACL by 3.

```
Device1(config)#router rip
Device1(config-rip)#offset-list 1 in 3 vlan3
Device1(config-rip)#exit
```

Step 6: Check the result.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:33:59, vlan2
C   2.0.0.0/24 is directly connected, 00:33:50, vlan3
R   3.0.0.0/24 [120/1] via 1.0.0.2, 00:24:20, vlan2
R   4.0.0.0/24 [120/1] via 2.0.0.2, 00:21:57, vlan3
C   127.0.0.0/8 is directly connected, 77:01:54, lo0
R   200.0.0.0/24 [120/2] via 1.0.0.2, 00:19:25, vlan2
```

According to the routing table of Device1, the next hop output interface of route 200.0.0.0/24 is only VLAN2, which means that Device1 selects the route advertised by Device2.

Note

- The route offset list can be used on all interfaces or specified interfaces, and in the receiving or advertising direction of the device.

47.3.4 Configure RIP Route Filtration

Network Requirements

- Run RIPv2 between Device1 and Device2 for route interaction.
- The two routes 2.0.0.0/24 and 3.0.0.0/24 that are advertised by Device2 are learned on Device1, and then the latter route is filtered in the advertising direction of Device2.

Network Topology

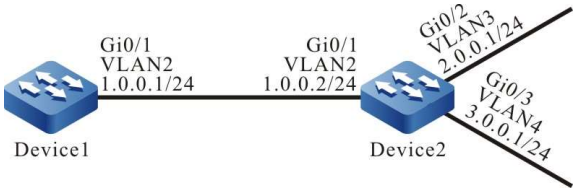


Figure 1 Network Topology for Configuring RIP Route Filtration

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure RIP.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router rip
Device1(config-rip)#version 2
Device1(config-rip)#network 1.0.0.0
Device1(config-rip)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 1.0.0.0
Device2(config-rip)#network 2.0.0.0
Device2(config-rip)#network 3.0.0.0
Device2(config-rip)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan2
R   2.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan2
R   3.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

According to the result, Device1 learns two routes distributed by Device2.

Step 4: Configure access lists.

#Configure Device2.

```
Device2(config)#ip access-list standard 1
Device2(config-std-nacl)#permit 2.0.0.0 0.0.0.255
Device2(config-std-nacl)#commit
Device2(config-std-nacl)#exit
```

Note

- When configuring route filtration, both the prefix list and ACL can create filtering rules. The difference is that the prefix list can exactly match the routing mask.

Step 5: Configure route filtration.

#Configure route filtration in the outgoing direction of the interface VLAN2 of Device2.

```
Device2(config)#router rip
Device2(config-rip)#distribute-list 1 out vlan2
Device2(config-rip)#exit
```

Step 6: Check the result.

#View the routing information of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan2
R   2.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

According to the result, Device2 will not advertise the route 3.0.0.0/24 to Device1. It is cleared from the routing table of Device1 only after timeout of the route.

Note

- The distribute-list can be used on all interfaces or specified interfaces, and in the receiving or advertising direction of the device.

47.3.5 Configure RIP Route Summarization

Network Requirements

- Run RIPv2 between Device1, Device2, Device3 and Device4 for route interaction.
- Device1 learns two routes, i.e. 100.1.0.0/24 and 100.2.0.0/24, from Device2. In order to reduce the size of the routing table of Device1, Device2 needs to distribute the summarized route of these two routes only to Device1.

Network Topology

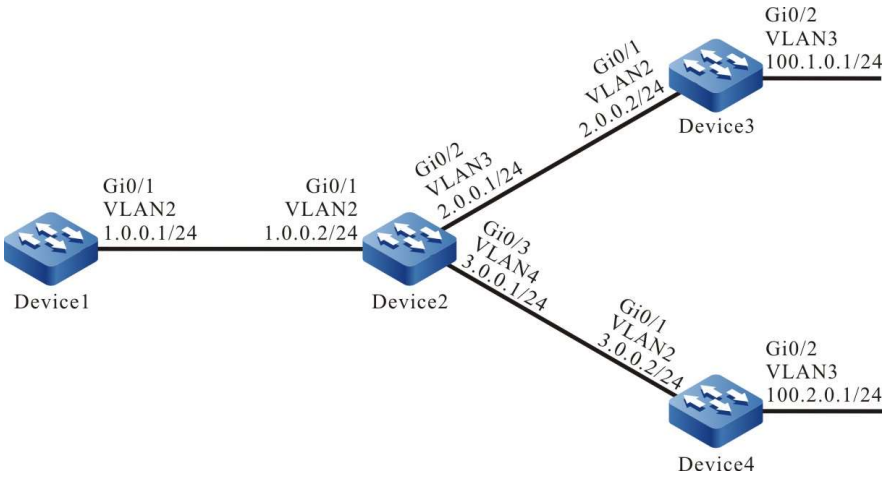


Figure 2 Network Topology for Configuring RIP Route Summarization

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure RIP.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router rip
Device1(config-rip)#version 2
Device1(config-rip)#network 1.0.0.0
Device1(config-rip)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 1.0.0.0
Device2(config-rip)#network 2.0.0.0
Device2(config-rip)#network 3.0.0.0
Device2(config-rip)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router rip
Device3(config-rip)#version 2
Device3(config-rip)#network 2.0.0.0
Device3(config-rip)#network 100.0.0.0
Device3(config-rip)#exit
```

#Configure Device4.

```
Device4#configure terminal
Device4(config)#router rip
Device4(config-rip)#version 2
Device4(config-rip)#network 3.0.0.0
Device4(config-rip)#network 100.0.0.0
Device4(config-rip)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan2
R    2.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan2
R   3.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan2
R   100.1.0.0/24 [120/2] via 1.0.0.2, 00:08:31, vlan2
R   100.2.0.0/24 [120/2] via 1.0.0.2, 00:08:31, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

Step 4: Configure interface route summarization.

#Configure the summarized route 100.0.0.0/8 on Device2.

```
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ip summary-address rip 100.0.0.0/8
Device2(config-if-vlan2)#exit
```

Step 5: Check the result.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:24:06, vlan2
R   2.0.0.0/24 [120/1] via 1.0.0.2, 00:14:26, vlan2
```

```
R   3.0.0.0/24 [120/1] via 1.0.0.2, 00:14:26, vlan2
R   100.0.0.0/8 [120/2] via 1.0.0.2, 00:00:31, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

According to the result, Device1 learns the summarized route 100.0.0.0/8 distributed by Device2. The two detail routes are cleared from the routing table only after time out.

Note

- RIP supports global automatic summarization and manual interface summarization. The global automatic summarization of RIPv2 is disabled by default.

47.3.6 Configure an RIP Standby Interface

Network Requirements

- Run RIPv2 between Device1, Device2 and Device3 for route interaction.
- Device1 learns the route 3.0.0.0/24 from both Device2 and Device3. By configuring route offset, it makes Device1 first select the route advertised by Device2. Then, the line between Device1 and Device2 is its main line; the line between Device1 and Device3 is its backup line.
- Configure RIP backup interface on Device1. When the main line is normal, if the main line through which the route passes fails, the route can quickly switch to the backup line.

Network Topology

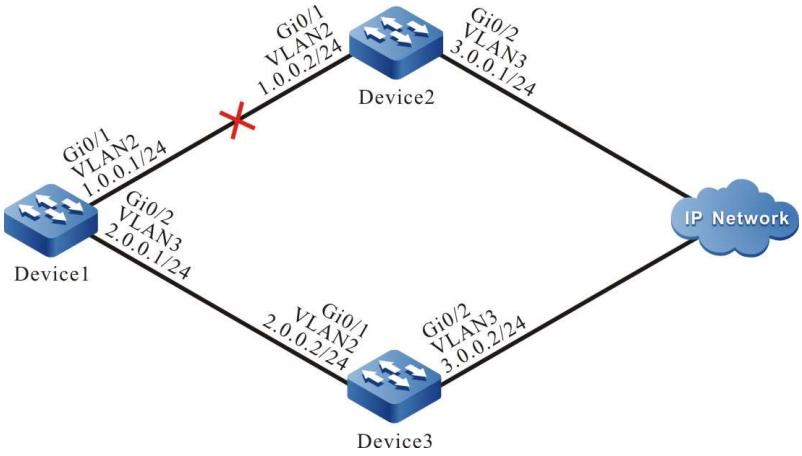


Figure 34 Network Topology for Configuring RIP Backup Interface

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure RIP.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router rip
Device1(config-rip)#version 2
Device1(config-rip)#network 1.0.0.0
Device1(config-rip)#network 2.0.0.0
Device1(config-rip)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 1.0.0.0
Device2(config-rip)#network 3.0.0.0
Device2(config-rip)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router rip
Device3(config-rip)#version 2
Device3(config-rip)#network 2.0.0.0
Device3(config-rip)#network 3.0.0.0
Device3(config-rip)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 01:30:23, vlan2
C   2.0.0.0/24 is directly connected, 01:30:14, vlan3
R   3.0.0.0/24 [120/1] via 1.0.0.2, 01:20:44, vlan2
               [120/1] via 2.0.0.2, 00:00:02, vlan3
C   127.0.0.0/8 is directly connected, 77:58:18, lo0
```

According to the result, Device1 learns the route 3.0.0.0/24 from both Device2 and Device3 at the same time.

Step 4: Configure route offset.

#Configure offset list in the incoming direction of interface VLAN3 on Device1 to increase the metric value of the route which matches ACL by 3.

```
Device1(config)#ip access-list standard 1
Device1(config-std-nacl)#permit 3.0.0.0 0.0.0.255
Device1(config-std-nacl)#commit
Device1(config)#exit
Device1(config)#router rip
Device1(config-rip)#offset-list 1 in 3 vlan3
Device1(config-rip)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 01:30:23, vlan2
C   2.0.0.0/24 is directly connected, 01:30:14, vlan3
R   3.0.0.0/24 [120/1] via 1.0.0.2, 01:20:44, vlan2
C   127.0.0.0/8 is directly connected, 77:58:18, lo0
```

According to the result, after configuring route offset, Device1 selects the route 3.0.0.0/24 advertised by Device2.

Step 5: Configure backup interface.

#On Device1, configure the interface VLAN3 as the RIP backup interface of VLAN2.

```
Device1(config)#interface vlan2
Device1(config-if-vlan2)#ip rip standby vlan3
Device1(config-if-vlan2)#exit
```

Step 6: Check the result.

#When the lines between Device1 and Device2 fail, the route can quickly switch to the backup line between Device1 and Device3.

#View the routing information on Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   2.0.0.0/24 is directly connected, 02:07:47, vlan3
R   3.0.0.0/24 [120/4] via 2.0.0.2, 00:01:14, vlan3
C   127.0.0.0/8 is directly connected, 78:35:51, lo0
```

47.3.7 Configure a Passive RIP Interface

Network Requirements

- Run RIPv2 between Device1 and Device2 for route interaction.
- Configure passive interface on Device1 so that it doesn't send update packets to Device2.

Network Topology

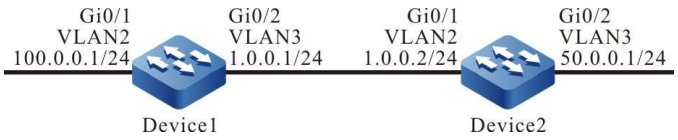


Figure 47 Network Topology for Configuring Passive RIP Interface

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure RIP.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router rip
Device1(config-rip)#version 2
Device1(config-rip)#network 1.0.0.0
Device1(config-rip)#network 100.0.0.0
Device1(config-rip)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 1.0.0.0
Device2(config-rip)#network 50.0.0.0
Device2(config-rip)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan3
R   50.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan3
C   100.0.0.0/24 is directly connected, 00:23:06, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan2
C   50.0.0.0/24 is directly connected, 00:23:06, vlan3
R   100.0.0.0/24 [120/1] via 1.0.0.1, 00:13:26, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

Step 4: Configure a passive interface.

#Configure Device1.

```
Device1(config)#router rip
Device1(config-rip)#passive-interface vlan3
Device1(config-rip)#exit
```

Configure VLAN3 as a passive interface on Device1 so that it doesn't send update packets to Device2, though it can still receive such packets.

Step 5: Check the result.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:23:06, vlan3
R   50.0.0.0/24 [120/1] via 1.0.0.2, 00:13:26, vlan3
C   100.0.0.0/24 is directly connected, 00:23:06, vlan2
C   127.0.0.0/8 is directly connected, 76:51:00, lo0
```

The routing information of 50.0.0.0/24 will still be saved on Device1. For Device2, the routing information of 100.0.0.0/24 will be removed from the routing table after the RIP route is deleted for time out.

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.0.0.0/24 is directly connected, 00:25:06, vlan2
C   50.0.0/24 is directly connected, 00:25:06, vlan3
C   127.0.0.0/8 is directly connected, 77:51:00, lo0
```

48 RIPng

48.1 Overview

RIPng, also known as the next generation of RIP protocol (RIP next generation), is a dynamic routing protocol used in IPv6 networks to provide routing information for IPv6 packet forwarding. RIPng is the result of extending RIP-2. Its working principle almost the same as RIP. In order to adapt to the IPv6 network, RIPng is different from the original RIP in the following aspects:

- UDP port number: RIPng uses the port number 521 of UDP to send and receive protocol packets;
- Multicast address: RIPng protocol uses FF02::9 as the multicast address of the RIPng router within the local scope of the link. It does not support broadcast;
- Prefix length: The RIPng protocol routing destination address has a 128-bit prefix length;
- Next hop address: RIPng uses a 128-bit IPv6 address;
- Source address: RIPng uses the local address FE80::/10 of the link as the source address

to send RIPng packets.

The RIPng-related protocol specifications include RFC2080 and RFC2081.

48.2 RIPng Function Configuration

Table 48 RIPng Function Configuration List

Configuration Task	
Configure RIPng Basic Functions	Globally Enable RIPng
Configure RIPng Route Generation	Configure RIPng to Distribute Default Route
	Configure RIPng Route Redistribution
Configure RIPng Route Control	Configure the RIPng Administrative Distance
	Configure RIPng Route Summarization
	Configure RIPng Metric Offset
	Configure RIPng Route Filtration
	Configure Metric Value of RIPng Interface
	Configure the Routing Flag for an RIPng Interface
	Configure the Maximum Load Balancing of RIPng
Configure RIPng Network Optimization	Configure RIPng Timers
	Configure Split Horizon and Toxicity Reverse of RIPng
	Configure a Static RIPng Neighbor
	Configure Passive RIPng Interface

48.2.1 Configure RIPng Basic Functions

Configuration Condition

Before configuring the basic functions of RIPng, ensure that:

- The link layer protocol has been configured to ensure normal communication at the link layer.

- Enable the IPv6 capability of the interface.

Globally Enable RIPng

To use RIPng, the following configurations are required:

- Create RIPng process;
- Gonfigure the interface to enable RIPng.

Table 48-2 Globally Enabling RIPng

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create RIPng process and enter RIPng configuration mode	**ipv6 router rip** *process-id*	Mandatory By default, RIPng process is disabled.
Return to global configuration mode	**exit**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Globally enable RIPng for the interface	**ipv6 rip enable** *process-id*	Mandatory By default, RIPng is disabled on the interface.

48.2.2 Configure RIPng Route Generation

Configuration Condition

Before configuring RIPng route generation, ensure that:

- Enable the IPv6 capability of the interface;
- Enable RIPng.

Configure RIPng to Distribute Default Route

Through configuration, the device sends default routes under all RIPng interfaces and sets itself as the default gateway of other adjacent devices.

Table 48-3 Configuring RIPng to Distribute Default Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter RIPng configuration mode	**ipv6 router rip** *process-id*	Mandatory By default, RIPng process is disabled.
Configure RIPng to Distribute Default Route	**default-information originate** [**metric** *value*]	Mandatory By default, RIPng doesn't distribute default route.

Note

- If a default route (0::/0) is learned, it will replace the default route (::/0) distributed by the device. When there is loop in the network, route oscillation may be caused. Thus, when using this command, be sure that several other devices in the same routing domain are not enabling it at the same time.

Configure RIPng Route Redistribution

The routes generated by other protocols can be imported into RIPng by configuring route redistribution.

Table 48-4 Configuring RIPng Route Redistribution

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter RIPng configuration mode	**ipv6 router rip** *process-id*	Mandatory By default, RIPng process is disabled.
Configure the default metric value of importing other routing protocol by RIPng	**default-metric** *metric-value*	Optional By default, the default metric value of importing other routing protocol is 1.

Step	Command	Description
Configure RIPng Route Redistribution	**redistribute** *protocol* [*protocol-id*] [**metric** *metric-value*] [**route-map** *route-map-name*] [**match** *route-sub-type*]	Mandatory By default, no route redistribution is configured.

Note

- In case of redistribution, after the metric command option is specified, the route redistributed will adopt this metric value.
- For RIPng, when configuring route redistribution application routing map, the match options supported include ipv6 address, route type, tag, interface, ipv6 nexthop, ipv6 route-source and metric, and the set options supported include metric and tag.

48.2.3 Configure RIPng Route Control

Configuration Condition

Before configuring RIPng route control, ensure that:

- Enable the IPv6 capability of the interface;
- Enable RIPng.

Configure the RIPng Administrative Distance

Multiple routing protocols can run in the device at the same time. The device selects the routes learned by each protocol through administrative distance. The smaller the administrative distance, the more like the route is selected.

Table 48-5 Configuring RIPng Administrative Distance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter RIPng configuration mode	**ipv6 router rip** *process-id*	-
Configure the RIPng Administrative Distance	**distance** *distance-value*	Mandatory

Step	Command	Description
		By default, RIPng administrative distance is 120.

Configure RIPng Route Summarization

RIPng route summarization means to configure a pair of destination address and mask combination, which will summarize the routes in the covered network segment.

After RIPng route summarization is configured, the device only advertises the summarized routes. This can significantly reduce the scale of adjacent RIPng routing tables in large and medium-sized networks and the consumption of network bandwidth by routing protocol packets.

The metric of the summarized route will be the minimum metric value among all subnet routes.

Table 48-6 Configuring RIPng Route Summarization Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the route summarization function of RIPng on the interface	**ipv6 rip summary-address** *prefix-address*	Mandatory By default, no route summarization function is configured.

Configure RIPng Metric Offset

By default, RIPng applies the route metric advertised by the neighbor device to the received routes. To modify the metric in some special application scenarios, you can configure the RIPng metric offset to correct the metric of the specified route.

If the metric in the incoming direction is configured, RIPng modifies the metric of the received routes and saves the routes into the routing table. When RIP advertises a metric to the neighbor devices, it uses the new metric. If the metric in the outgoing direction is configured, the metric is modified only when RIP advertises a metric to the neighbor devices.

Table 48-7 Configuring RIPng Matric Offset

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter RIPng configuration mode	**ipv6 router rip** *process-id*	Mandatory By default, RIPng process is disabled.
Configure RIPng to modify the metric of the specified route	**offset-list** *access-list-name* { **in** | **out** } *metric-offset* [*interface-name*]	Mandatory By default, no metric value of interface is configured.

Configure RIPng Route Filtration

A router can filter the received or advertised routes by configuring an Access Control List (ACL), prefix list or routing map. In receiving RIPng routes, you can filter some learnt routes; or in advertising RIPng routes, you can filter some routes that are advertised to neighbor devices.

Table 48-8 Configuring RIPng Route Filtration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter RIPng configuration mode	**ipv6 router rip** *process-id*	Mandatory By default, RIPng process is disabled.
Configure RIPng route filtration function	**distribute-list** { *access-list-name* | **prefix** *prefix-list-name* | **route-map** *route-map-name*} { **in | out** } [*interface-name*]	Mandatory By default, no route filtration function is configured. When the route filtration function is configured, if an interface is not specified, route filtration will be enabled for all RIPng interfaces.

Configure Metric Value of RIPng Interface

After RIPng is enabled for an interface, the corresponding direct route is generated in the database, with the default metric being 1. When the route is in the RIPng database or it is advertised to neighbor devices, if the interface is configured with a metric, the interface metric is used as the metric of the route.

If the interface metric is changed, the RIPng database immediately updates the corresponding direct route of RIPng and advertises the new metric to the neighbor devices.

Table 48-9 Configuring RIPng Interface Matric

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure RIPng interface metric	**ipv6 rip metric** *metric-value*	Mandatory By default, the matrix value of the RIPng interface is 1.

Note

- When the matrix value of the RIPng interface is configured, the matrix of the direct subnet on the interface instead of that of route learning will be affected.

Configure the Routing Flag for an RIPng Interface

The network administrator can attach tags to some routes. Then, in applying a routing policy, the network administrator can perform route filtration or route property advertisement based on the tags.

Table 48-10 Configuring RIPng Interface Routing Tag

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the routing tag on the direct subnet on the interface of RIPng	**ipv6 rip tag** *tag-value*	Mandatory By default, no routing tag is configured.

Configure the maximum number of load balancing entries of RIPng

This command helps you to control the number of RIPng load balancing entries for routing.

Table 48-11 Configuring Maximum Number of Load Balancing Entries of RIPng

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter RIPng configuration mode	**ipv6 router rip** *process-id*	Mandatory By default, RIPng process is disabled.
Configure the maximum number of load balancing entries of RIPng	**maximum-paths** *max-number*	Optional By default, the maximum number of load balancing entries of RIPnp is 4.

48.2.4 Configure RIPng Network Optimization

Configuration Condition

Before configuring RIPng network optimization, ensure that:

- Enable the IPv6 capability of the interface;
- Enable RIPng.

Configure RIPng Timers

RIPng does not maintain neighbor relations and it does not support route withdrawn; therefore, the protocol provides four configurable timers to control the network convergence speed. The four timers are: route update timer, route timeout timer, route dampening update timer, and route clear timer.

The route timeout time must be at least three times of the route update time. If no route update packet is received within the route timeout time, the route becomes invalid and it enters a dampening cycle. The length of the dampening cycle is determined by the dampening update time. During the cycle, the route will not be cleared. After the dampening cycle is completed, the route enters the clear cycle. During the cycle, the route can be updated. However, if no route update packet is received during the cycle, the route will be deleted.

Table 48-12 Configuring RIPng Timer

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter RIPng configuration mode	**ipv6 router rip** *process-id*	Mandatory By default, RIPng process is disabled.
Configure the time of RIPng timer	**timers** *update-interval invalid-interval holddown-interval flush-interval*	Optional By default, the RIPnp update interval is 30 seconds, the effective time of advertisement 180 seconds, the suppression time 0 seconds, and the clearing time 120 seconds.

Caution

- In the same RIPng routing domain, the **timer** configurations on all devices must be consistent to avoid network flapping.

Configure Split Horizon and Toxicity Reverse of RIPng

Split horizon and toxicity reverse are mechanisms that are used to prevent route loops.

1. Configure split horizon.

RIPng does not advertise routes that it has learnt from an interface to the interface, preventing routing loops.

Table 48-13 Configuring RIPng Split Horizon

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-

Step	Command	Description
Configure RIPng split horizon	**no ipv6 split-horizon** [**disable**]	Optional By default, the split horizon function is enabled.

2. Configure toxicity reverse.

RIPng announces routes that have been learnt from an interface to the interface, but the route metric is the maximum number of hops, 16, preventing routing loops.

Table 48-14 Configuring RIPng Toxicity Reverse

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure RIPng toxicity reverse	**ipv6 split-horizon poison-reverse**	Mandatory By default, the toxicity reverse function is disabled.

Note

- The split horizon and toxicity reverse functions are valid only for the learnt routes, direct routes on the RIPng, and the redistributed direct and static routes.
- The split horizon function and the toxicity reversion function cannot be used at the same time.

Configure a Static RIPng Neighbor

RIPng does not maintain neighbor relations, so it does not have the concept of neighbor. Here the neighbor refers to the neighbor RIPng routing device. After a static RIPng neighbor is specified, RIPng sends RIPng packets to the neighbor in unicast mode. The configuration is applied to a network that does not support broadcast or multicast, such as point-to-point links. If the configuration is applied to a multicast network, it may cause repeated RIPng packets in the network.

Table 48-15 Configuring Static RIPng Neighbor

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure the neighbor which advertises routing information in the form of unicast	**ipv6 rip neighbor** *ipv6-address*	Mandatory The parameter ipv6-address is the ipv6 address of the direct interface on the peer port.

Note

- The advertisement of routing information to static neighbors occurs only on the RIPng interface, and "**pv6 rip passive**" cannot prevent them from sending packets to static neighbors.

Configure Passive RIPng Interface

To decrease the network bandwidth consumed by the routing protocol, the dynamic routing protocol uses the passive interface function. RIPng receives only route update packets on a passive interface, and it does not send route update packets on the passive interface. In a low-speed network with small bandwidth, the passive interface function and the neighbor function cooperate to effectively reduce interactions of RIPng routes.

Table 48-16 Configuring Passive RIPng Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure Passive RIPng Interface	**ipv6 rip passive**	Mandatory

Step	Command	Description
		By default, no passive interface is configured.

Note

- The **ipv6 rip passive** function does not restrain an interface from sending unicast route updates to its neighbor devices. When the passive interface function is used with the **neighbor** command, the function does not restrain an interface from sending unicast route updates to its neighbor devices. This application mode controls a router so that it sends route updates only to some neighbor devices in unicast mode instead of sending route updates to all neighbor devices in multicast mode.

48.2.5 PIM-DM Monitoring and Maintaining

Table 48-17 Configuring RIPng Monitoring and Maintaining

Command	Description
clear ipv6 rip [*process-id*]{ **process** | **statistics** }	Clear the RIPng process and statistical information
show ipv6 rip [*process-id*]	Show the basic information of RIPng
show ipv6 rip [*process-id*] **database** [**detail** | *ipv6-address*/*mask-length* [**detail** | **longer-prefixes**]]	Show the RIPng routing database information
show ipv6 rip [*process-id*] **statistics** [*interface-name*]	Show the statistical information of RIPng interface
show ipv6 rip interface [*interface-name*]	Show RIPng interface information

48.3 RIPng Typical Configuration Example

48.3.1 Configure RIPng Basic Functions

Network Requirements

- Run RIPng between Device1 and Device2 for route interaction.

Network Topology

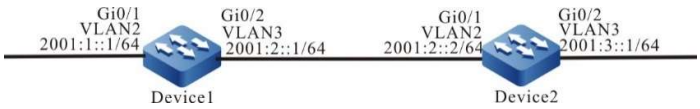


Figure 48 Network Topology for Configuring Basic Functions of RIPng

Configuration Steps

Step 1: Configure VLAN, and add ports to the required VLAN. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure RIPng.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 router rip 100
Device1(config-ripng)#exit
Device1(config)#interface vlan 2
Device1(config-if-vlan2)#ipv6 rip enable 100
Device1(config-if-vlan2)#exit
Device1(config)#interface vlan 3
Device1(config-if-vlan3)#ipv6 rip enable 100
Device1(config-if-vlan3)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 router rip 100
Device2(config-ripng)#exit
Device2(config)#interface vlan 2
Device2(config-if-vlan2)#ipv6 rip enable 100
Device2(config-if-vlan2)#exit
Device2(config)#interface vlan 3
Device2(config-if-vlan3)#ipv6 rip enable 100
Device2(config-if-vlan3)#exit
```

Step 4: Check the result.

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w4d:19:31:05, lo0
C   2001:1::/64 [0/0]
     via ::, 00:21:42, vlan2
L   2001:1::1/128 [0/0]
     via ::, 00:21:40, lo0
C   2001:2::/64 [0/0]
     via ::, 00:21:34, vlan3
L   2001:2::1/128 [0/0]
     via ::, 00:21:33, lo0
R   2001:3::/64 [120/2]
```

```
via fe80::201:7aff:fec3:38a4, 00:11:19, vlan3
```

#View the IPv6 routing table of Device 2.

```
Device2#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 3d:22:39:31, lo0
R   2001:1::/64 [120/2]
     via fe80::201:7aff:fe01:204, 00:12:00, vlan2
C   2001:2::/64 [0/0]
     via ::, 00:30:46, vlan2
L   2001:2::2/128 [0/0]
     via ::, 00:30:45, lo0
C   2001:3::/64 [0/0]
     via ::, 00:29:12, vlan3
L   2001:3::1/128 [0/0]
     via ::, 00:29:11, lo0
```

According to the routing table, the routing information advertised by the device uses 64-bit accurate mask.

48.3.2 Configure RIPng Route Redistribution

Network Requirements

- Run the IPv6 OSPF protocol between Device1 and Device2. Device2 learns the IPv6 OSPF routes 2001:1::/64 and 2001:2::/64 distributed by Device1.
- Run the RIPng protocol between Device2 and Device3. Device2 only redistributes the IPv6 OSPF route 2001:1::/64 into RIPng, and advertises such route to Device3.

Network Topology

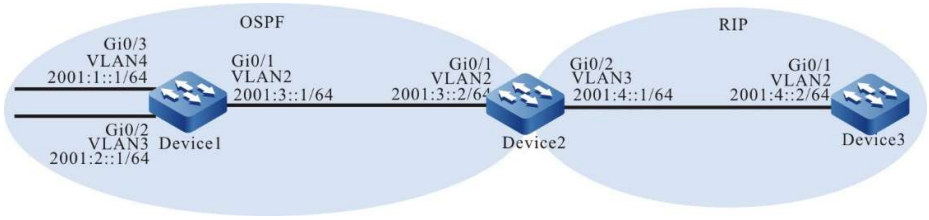


Figure 48 Network Topology for Configuring RIPng Route Redistribution

Configuration Steps

Step 1: Configure VLAN, and add ports to the required VLAN. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure IPv6 OSPF.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 router ospf 100
```

```
Device1(config-ospf6)# router-id 1.1.1.1
Device1(config-ospf6)#exit
Device1(config)#interface vlan 2
Device1(config-if-vlan2)#ipv6 router ospf tag 100 area 0
Device1(config-if-vlan2)#exit
Device1(config)#interface vlan 3
Device1(config-if-vlan3)#ipv6 router ospf tag 100 area 0
Device1(config-if-vlan3)#exit
Device1(config)#interface vlan 4
Device1(config-if-vlan4)#ipv6 router ospf tag 100 area 0
Device1(config-if-vlan4)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 router ospf 100
Device2(config-ospf6)#router-id 2.2.2.2
Device2(config-ospf6)#exit
Device2(config)#interface vlan 2
Device2(config-if-vlan2)#ipv6 router ospf tag 100 area 0
Device2(config-if-vlan2)#exit
```

#View the IPv6 routing table of Device 2.

```
Device2#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 4d:00:09:49, lo0
O   2001:1::/64 [110/2]
     via fe80::201:7aff:fe01:204, 00:12:16, vlan2
O   2001:2::/64 [110/2]
     via fe80::201:7aff:fe01:204, 00:12:16, vlan2
C   2001:3::/64 [0/0]
     via ::, 00:19:51, vlan2
L   2001:3::2/128 [0/0]
     via ::, 00:19:50, lo0
C   2001:4::/64 [0/0]
     via ::, 00:45:13, vlan3
L   2001:4::1/128 [0/0]
     via ::, 00:45:12, lo0
```

According to the routing table, Device2 learns the IPv6 OSPF route advertised by Device1.

Step 4: Configure RIPng.

#Configure Device2.

```
Device2(config)#ipv6 router rip 100
Device2(config-ripng)#exit
Device2(config)#interface vlan 3
Device2(config-if-vlan3)#ipv6 rip enable 100
Device2(config-if-vlan3)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#ipv6 router rip 100
Device3(config-ripng)#exit
Device3(config)#interface vlan 2
Device3(config-if-vlan2)#ipv6 rip enable 100
Device3(config-if-vlan2)#exit
```

Step 5: Configure routing policy.

#On Device2, configure route-map to invoke the prefix list to match 2001:1::/64 and filter 2001:2::/64.

```
Device2(config)#ipv6 prefix-list OSPF permit 2001:1::/64
Device2(config)#route-map OSPFtoRIP
Device2(config-route-map)#match ipv6 address prefix-list OSPF
Device2(config-route-map)#exit
```

Note

- When configuring a routing policy, both the prefix list and ACL can create filtering rules. The difference is that the prefix list can exactly match the routing mask.

Step 6: Configure RIPng redistribution of IPv6 OSPF route.

#Configure RIPng redistribution of IPv6 OSPF route.

```
Device2(config)#ipv6 router rip 100
Device2(config-ripng)#redistribute ospf 100 route-map OSPFtoRIP
Device2(config-ripng)#exit
```

Step 7: Check the result.

#View the RIPng database on Device2.

```
Device2#show ipv6 rip database
Type : N - Network interface, L - Learn, R - Redistribute, D - Default config,
       S - Static config
Proto: C - connected, S - static, R - RIP, O - OSPF, E - IRMP,
       o - SNSP, B - BGP, i-ISIS

RIPng process 100 routing database (VRF Kernel, Counter 2):
[Type/Proto]
[R/O] 2001:1::/64 metric 1
            via vlan2, fe80::201:7aff:fe01:204, no expires
[N/C] 2001:4::/64 metric 1, installed
            via vlan3, ::, no expires
```

Check the IPv6 routing table of Device3.

```
Device3#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w0d:20:00:11, lo0
R   2001:1::/64 [120/2]
     via fe80::201:7aff:fec3:38a5, 02:50:14, vlan2
C   2001:4::/64 [0/0]
     via ::, 03:56:24, vlan2
L   2001:4::2/128 [0/0]
     via ::, 03:56:23, lo0
```

After checking the database of Device2 and routing table of Device3, you will find that the route 2001:1::/64 on Device2 has been redistributed to RIPng and successfully advertised to Device3, while the route 2001:2::/64 has been successfully filtered.

Note

- In practical applications, if the autonomous system has 2 or more edge routers, directly redistributing routes between different routing protocols is not recommended. When configuration is necessary, routing control polices such as filtering and summarization are required on the edge routers of the autonomous system to avoid routing loops.

48.3.3 Configure RIPng Metric Offset

Network Requirements

- Run RIPng between Device1, Device2, Device3 and Device4 for interaction.
- Device1 learns the route 2001:5::/64 from both Device2 and Device3 at the same time.
- It is required to configure the routing metric offset in the receiving direction on Device1 to make Device1 first select the route advertised by Device2.

Network Topology

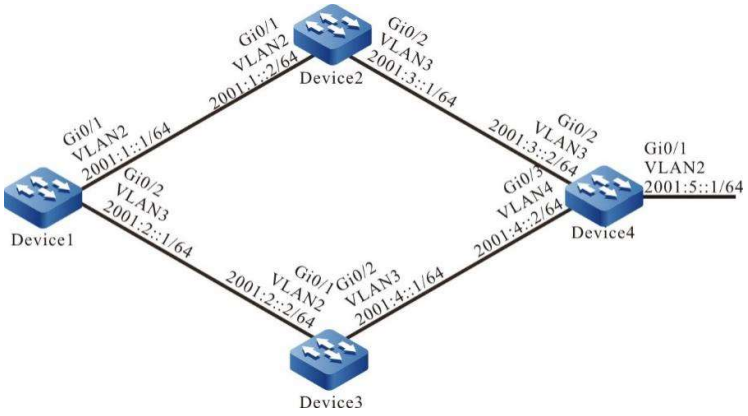


Figure 48 Network Topology for Configuring RIPng Metric Offset

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure RIPng.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 router rip 100
Device1(config-ripng)#exit
Device1(config)#interface vlan 2
Device1(config-if-vlan2)#ipv6 rip enable 100
```

```
Device1(config-if-vlan2)#exit
Device1(config)#interface vlan 3
Device1(config-if-vlan3)#ipv6 rip enable 100
Device1(config-if-vlan3)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 router rip 100
Device2(config-ripng)#exit
Device2(config)#interface vlan 2
Device2(config-if-vlan2)#ipv6 rip enable 100
Device2(config-if-vlan2)#exit
Device2(config)#interface vlan 3
Device2(config-if-vlan3)#ipv6 rip enable 100
Device2(config-if-vlan3)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#ipv6 router rip 100
Device3(config-ripng)#exit
Device3(config)#interface vlan 2
Device3(config-if-vlan2)#ipv6 rip enable 100
Device3(config-if-vlan2)#exit
Device3(config)#interface vlan 3
Device3(config-if-vlan3)#ipv6 rip enable 100
Device3(config-if-vlan3)#exit
```

#Configure Device4.

```
Device4#configure terminal
Device4(config)#ipv6 router rip 100
Device4(config-ripng)#exit
Device4(config)#interface vlan 2
Device4(config-if-vlan2)#ipv6 rip enable 100
Device4(config-if-vlan2)#exit
Device4(config)#interface vlan 3
Device4(config-if-vlan3)#ipv6 rip enable 100
Device4(config-if-vlan3)#exit
Device4(config)#interface vlan 4
Device4(config-if-vlan4)#ipv6 rip enable 100
Device4(config-if-vlan4)#exit
```

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w5d:06:21:24, lo0
C   2001:1::/64 [0/0]
     via ::, 00:02:05, vlan2
L   2001:1::1/128 [0/0]
     via ::, 00:02:04, lo0
C   2001:2::/64 [0/0]
     via ::, 00:02:02, vlan3
L   2001:2::1/128 [0/0]
     via ::, 00:02:01, lo0
R   2001:3::/64 [120/2]
     via fe80::201:7aff:fec3:38a4, 00:02:03, vlan2
R   2001:4::/64 [120/2]
     via fe80::201:7aff:fe11:2214, 00:00:48, vlan3
R   2001:5::/64 [120/3]
     via fe80::201:7aff:fec3:38a4, 00:02:03, vlan2
                [120/3]
     via fe80::201:7aff:fe11:2214, 00:00:48, vlan3
```

According to the routing table of Device1, there are two routes leading to 2001:5::/64.

Step 4: Configure access lists.

```
Device1(config)#ipv6 access-list extended RIPng
Device1(config-v6-list)#permit 10 2001:5::/64 any
Device1(config-v6-list)#commit
Device1(config-v6-list)#exit
```

Step 5: Configure metric offset.

#Configure offset list on Device1 to increase the metric value of the route which is learned from interface VLAN3 and matches ACL by 3.

```
Device1(config)# ipv6 router rip 100
Device1(config-ripng)#offset-list RIPng in 3 vlan 3
Device1(config-ripng)#exit
```

Step 6: Check the result.

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w5d:06:34:28, lo0
C   2001:1::/64 [0/0]
     via ::, 00:15:09, vlan2
L   2001:1::1/128 [0/0]
     via ::, 00:15:08, lo0
C   2001:2::/64 [0/0]
     via ::, 00:15:06, vlan3
L   2001:2::1/128 [0/0]
     via ::, 00:15:05, lo0
R   2001:3::/64 [120/2]
     via fe80::201:7aff:fec3:38a4, 00:03:10, vlan2
R   2001:4::/64 [120/2]
     via fe80::201:7aff:fe11:2214, 00:03:10, vlan3
R   2001:5::/64 [120/3]
     via fe80::201:7aff:fec3:38a4, 00:03:10, vlan2
```

According to the routing table of Device1, the next hop output interface of route 2001:5::/64 is only VLAN2, which means that Device1 selects the route advertised by Device2.

Note

- The route offset list can be used on all interfaces or specified interfaces, and in the receiving or advertising direction of the device.

48.3.4 Configure RIPng Route Filtration

Network Requirements

- Run RIPng between Device1 and Device2 for route interaction.
- The two routes 2001:2::/64 and 2001:3::/64 that are advertised by Device2 are learned on Device1, and then the latter route is filtered in the advertising direction of Device2.

Network Topology

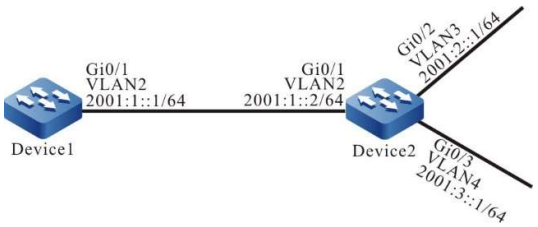


Figure 1 Network Topology for Configuring RIPng Route Filtration

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure RIPng.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 router rip 100
Device1(config-ripng)#exit
Device1(config)#interface vlan 2
Device1(config-if-vlan2)#ipv6 rip enable 100
Device1(config-if-vlan2)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 router rip 100
Device2(config-ripng)#exit
Device2(config)#interface vlan 2
Device2(config-if-vlan2)#ipv6 rip enable 100
Device2(config-if-vlan2)#exit
Device2(config)#interface vlan 3
Device2(config-if-vlan3)#ipv6 rip enable 100
Device2(config-if-vlan3)#exit
Device2(config)#interface vlan4
Device2(config-if-vlan4)#ipv6 rip enable 100
Device2(config-if-vlan4)#exit
```

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w5d:02:47:44, lo0
C   2001:1::/64 [0/0]
     via ::, 00:56:34, vlan2
L   2001:1::1/128 [0/0]
     via ::, 00:56:32, lo0
```

```
R   2001:2::/64 [120/2]
    via fe80::201:7aff:fec3:38a4, 00:27:11, vlan2
R   2001:3::/64 [120/2]
    via fe80::201:7aff:fec3:38a4, 00:27:11, vlan2
```

According to the result, Device1 learns two routes distributed by Device2.

Step 4: Configure IPv6 prefix list.

```
Device2(config)#ipv6 prefix-list RIPng deny 2001:3::/64
```

Step 5: Configure route filtration.

#Configure route filtration in the outgoing direction of the interface VLAN2 of Device2.

```
Device2(config)#ipv6 router rip 100
Device2(config-ripng)#distribute-list prefix RIPng out vlan 2
Device2(config-ripng)#exit
```

Step 6: Check the result.

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
    via ::, 2w5d:03:03:49, lo0
C   2001:1::/64 [0/0]
    via ::, 01:12:39, vlan2
L   2001:1::1/128 [0/0]
    via ::, 01:12:38, lo0
R   2001:2::/64 [120/2]
    via fe80::201:7aff:fec3:38a4, 00:43:16, vlan2
```

According to the result, Device2 will not advertise the route 2001:3::/64 to Device1. It is cleared from the routing table of Device1 only after timeout of the route.

Note

- The distribute-list can be used on all interfaces or specified interfaces, and in the receiving or advertising direction of the device.

48.3.5 Configure RIPng Route Summarization

Network Requirements

- Run RIPng between Device1, Device2, Device3 and Device4 for route interaction.
- Device1 learns two routes, i.e. 2001:4:1:1::/64 and 2001:4:1:2::/64, from Device2. In order to reduce the size of the routing table of Device1, Device2 needs to distribute the summarized route of these two routes only to Device1.

Network Topology

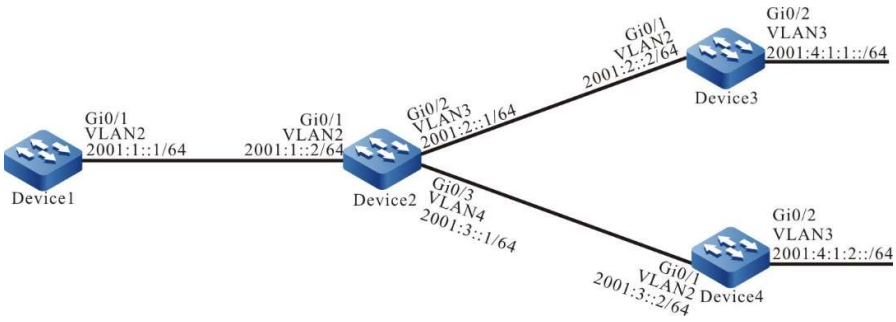


Figure 2 Network Topology for Configuring RIPng Route Summarization

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure RIPng.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 router rip 100
Device1(config-ripng)#exit
Device1(config)#interface vlan 2
Device1(config-if-vlan2)#ipv6 rip enable 100
Device1(config-if-vlan2)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 router rip 100
Device2(config-ripng)#exit
Device2(config)#interface vlan 2
Device2(config-if-vlan2)#ipv6 rip enable 100
Device2(config-if-vlan2)#exit
Device2(config)#interface vlan 3
Device2(config-if-vlan3)#ipv6 rip enable 100
Device2(config-if-vlan3)#exit
Device2(config)#interface vlan 4
Device2(config-if-vlan4)#ipv6 rip enable 100
Device2(config-if-vlan4)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#ipv6 router rip 100
Device3(config-ripng)#exit
Device3(config)#interface vlan 2
Device3(config-if-vlan2)#ipv6 rip enable 100
Device3(config-if-vlan2)#exit
Device3(config)#interface vlan 3
Device3(config-if-vlan3)#ipv6 rip enable 100
Device3(config-if-vlan3)#exit
```

#Configure Device4.

```
Device4#configure terminal
Device4(config)#ipv6 router rip 100
Device4(config-ripng)#exit
Device4(config)#interface vlan 2
```

```
Device4(config-if-vlan2)#ipv6 rip enable 100
Device4(config-if-vlan2)#exit
Device4(config)#interface vlan 3
Device4(config-if-vlan3)#ipv6 rip enable 100
Device4(config-if-vlan3)#exit
```

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w5d:02:27:40, lo0
C   2001:1::/64 [0/0]
     via ::, 00:36:29, vlan2
L   2001:1::1/128 [0/0]
     via ::, 00:36:28, lo0
R   2001:2::/64 [120/2]
     via fe80::201:7aff:fec3:38a4, 00:07:06, vlan2
R   2001:3::/64 [120/2]
     via fe80::201:7aff:fec3:38a4, 00:07:06, vlan2
R   2001:4:1:1::/64 [120/3]
     via fe80::201:7aff:fec3:38a4, 00:07:06, vlan2
R   2001:4:1:2::/64 [120/3]
     via fe80::201:7aff:fec3:38a4, 00:06:55, vlan2
```

Step 4: Configure interface route summarization.

#Configure the summarized route 2001:4:1::/48 on Device2.

```
Device2(config)#interface vlan 2
Device2(config-if-vlan2)#ipv6 rip summary-address 2001:4:1::/48
Device2(config-if-vlan2)#exit
```

Step 5: Check the result.

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w5d:02:35:44, lo0
C   2001:1::/64 [0/0]
     via ::, 00:44:33, vlan2
L   2001:1::1/128 [0/0]
     via ::, 00:44:32, lo0
R   2001:2::/64 [120/2]
     via fe80::201:7aff:fec3:38a4, 00:15:10, vlan2
R   2001:3::/64 [120/2]
     via fe80::201:7aff:fec3:38a4, 00:15:10, vlan2
R   2001:4:1::/48 [120/3]
     via fe80::201:7aff:fec3:38a4, 00:05:19, vlan2
```

According to the result, Device1 learns the summarized route 2001:4:1::/48 distributed by Device2. The two detail routes are cleared from the routing table only after time out.

48.3.6 Configure Passive RIPng Interface

Network Requirements

- Run RIPng between Device1 and Device2 for route interaction.
- Configure passive interface on Device1 so that it doesn't send update packets to Device2.

Network Topology

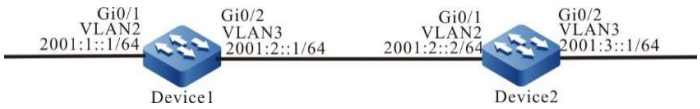


Figure 3 Network Topology for Configuring Passive RIPng Interface

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure RIPng.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ipv6 router rip 100
Device1(config-ripng)#exit
Device1(config)#interface vlan 2
Device1(config-if-vlan2)#ipv6 rip enable 100
Device1(config-if-vlan2)#exit
Device1(config)#interface vlan 3
Device1(config-if-vlan3)#ipv6 rip enable 100
Device1(config-if-vlan3)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ipv6 router rip 100
Device2(config-ripng)#exit
Device2(config)#interface vlan 2
Device2(config-if-vlan2)#ipv6 rip enable 100
Device2(config-if-vlan2)#exit
Device2(config)#interface vlan 3
Device2(config-if-vlan3)#ipv6 rip enable 100
Device2(config-if-vlan3)#exit
```

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w4d:19:31:05, lo0
C   2001:1::/64 [0/0]
     via ::, 00:21:42, vlan2
L   2001:1::1/128 [0/0]
     via ::, 00:21:40, lo0
C   2001:2::/64 [0/0]
     via ::, 00:21:34, vlan3
L   2001:2::1/128 [0/0]
     via ::, 00:21:33, lo0
R   2001:3::/64 [120/2]
     via fe80::201:7aff:fec3:38a4, 00:11:19, vlan3
```

#View the IPv6 routing table of Device 2.

```
Device2#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 3d:22:39:31, lo0
R   2001:1::/64 [120/2]
     via fe80::201:7aff:fe01:204, 00:12:00, vlan2
C   2001:2::/64 [0/0]
     via ::, 00:30:46, vlan2
L   2001:2::2/128 [0/0]
     via ::, 00:30:45, lo0
C   2001:3::/64 [0/0]
     via ::, 00:29:12, vlan3
L   2001:3::1/128 [0/0]
     via ::, 00:29:11, lo0
```

Step 4: Configure a passive interface.

#Configure Device1.

```
Device1(config)#interface vlan 3
Device1(config-if-vlan3)#ipv6 rip passive
Device1(config-if-vlan3)#exit
```

Configure vlan 3 as a passive interface on Device1 so that it doesn't send update packets to Device2, though it can still receive such packets.

Step 5: Check the result.

#View the IPv6 routing table of Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 2w4d:19:55:37, lo0
C   2001:1::/64 [0/0]
     via ::, 00:46:14, vlan2
L   2001:1::1/128 [0/0]
     via ::, 00:46:12, lo0
C   2001:2::/64 [0/0]
     via ::, 00:46:06, vlan3
L   2001:2::1/128 [0/0]
     via ::, 00:46:05, lo0
R   2001:3::/64 [120/2]
     via fe80::201:7aff:fec3:38a4, 00:35:51, vlan3
```

The routing information of 2001:3::/64 will still be saved on Device1. For Device2, the routing information of 2001:1::/64 will be removed from the routing table after the RIPng route is deleted for time out.

#View the IPv6 routing table of Device 2.

```
Device2#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management
```

```
L   ::1/128 [0/0]
    via ::, 3d:23:05:24, lo0
C   2001:2::/64 [0/0]
    via ::, 00:56:39, vlan2
L   2001:2::2/128 [0/0]
    via ::, 00:56:38, lo0
C   2001:3::/64 [0/0]
    via ::, 00:55:05, vlan3
L   2001:3::1/128 [0/0]
    via ::, 00:55:04, lo0
```

49 OSPF

49.1 Overview

OSPF protocol (Open Shortest Path First) is a dynamic routing protocol based on link status. It uses Dijkstra's shortest path precedence algorithm SPF to calculate routes in a single autonomous system (Autonomous System, hereinafter referred to as AS).

The OSPF protocol, developed by IETF, is mainly used to solve problems like slow convergence and loop formation in distance vector routing. It can be applied in large and medium-sized networks. The OSPF version 2 currently implemented complies with RFC2328 and supports the OSPF extended functions defined by other related RFCs.

In OSPF protocol, each device maintains a link status database which describes the AS network. Devices in the same area have the same database. After the database is fully synchronized, each device deems itself as the root and uses the SPF algorithm to calculate a loop-free shortest path tree to describe the shortest path it knows to reach each destination. Finally, each device builds its own routing table according to the SPF tree.

OSPF has the following characteristics:

- Fast convergence: Send update packets immediately after the topological structure of the network changes, and synchronize this change in the AS;
- No self-loop: OSPF runs SPF to calculate routes based on the link status database, which ensures that no routing loops will be formed through the algorithm itself;
- Division of areas: OSPF allows the AS to be divided into multiple areas, which reduces the occupation of network bandwidth and makes it possible to build a hierarchical network;
- Support authentication: Every time the OSPF device receives a routing protocol packet, it will verify the authentication information in the packet to avoid information leakage or malicious attacks in the network;
- Support subnets of different lengths: The route advertised by OSPF carries network masks to support subnets of different lengths;
- Support load balancing: Support multiple equal-cost routes leading to the same

destination address.

49.2 OSPF Function Configuration

Table 1 OSPF Function Configuration List

Configuration Task	
Configure OSPF Basic Functions	Configure OSPF Protocol
Configure OSPF Area	Configure OSPF NSSA
	Configure OSPF Stub Area
	Configure OSPF Virtual Link
Configure OSPF Network Type	Configure Network Type of OSPF Interface as Broadcast
	Configure Network Type of OSPF Interface as P2P
	Configure Network Type of OSPF Interface as NBMA
	Configure Network Type of OSPF Interface as P2MP
Configure OSPF Network Authentication	Configure OSPF Area Authentication
	Configure OSPF Interface Authentication
Configure OSPF Route Generation	Configure OSPF Route Redistribution
	Configure OSPF Default Route
	Configure OSPF Host Route
Configure OSPF Route Control	Configure OSPF Inter-area Summarization
	Configure OSPF External Route Summarization
	Configure OSPF Inter-area Route Filtration
	Configure OSPF External Route Filtration
	Configure OSPF Route Installation Filtration

Configuration Task	
	Configure Cost Value of OSPF Interface
	Configure OSPF Reference Bandwidth
	Configure OSPF Administrative Distance
	Configure the Maximum Number of Load Balancing Entries of OSPF
	Configure OSPF to be Compatible with RFC1583
Configure OSPF Network Optimization	Configure Keepalive Time of OSPF Neighbors
	Configure Passive OSPF Interface
	Configure OSPF Demand Circuit
	Configure OSPF Interface Priority
	Configure OSPF Interface MTU
	Configure Transfer Delay of OSPF Interface
	Configure OSPF LSA Retransmission
	Configure OSPF to Prohibit LSA Diffusion
	Configure OSPF SPF Calculation Time
	Configure OSPF Database Overflow
Configure OSPF to Coordinate with BFD	Configure OSPF to Coordinate with BFD
Configure OSPF GR	Configure OSPF GR Restarter
	Configure OSPF GR Helper

49.2.1 Configure OSPF Basic Functions

In the various configuration tasks of OSPF, you must first enable the OSPF protocol so that the configuration of the other function features can take effect.

Configuration Condition

Before configuring basic functions of OSPF, first complete the following tasks:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer.

Configure OSPF Protocol

To enable the OSPF function, you need to create an OSPF process first, specify the network address scope associated with this process and the area to which the address scope belongs; if an interface IP address is within the network segment of a certain area, the interface belongs to this area and enables the OSPF function, and OSPF will advertise the direct route of this interface.

The device where OSPF protocol is running must have a Router ID, which is used to uniquely identify a device in an OSPF AS. The uniqueness of the Router ID in the AS must be guaranteed. Otherwise, it will influence the neighbor establishment and route learning. A Router ID may be specified in the process of creating OSPF process. If no Router ID is specified, election will be conducted according to the following rules:

- Firstly, select the largest IP address from the Loopback interface as Router ID;
- If no Loopback interface is configured for IP address, select the largest IP addresses from other interfaces as Router ID;
- Only when the interface is UP can the interface address be selected as Router ID.

OSPF supports multiple processes that are identified with process number, and different processes are independent of each other.

Table 2 Enabling OSPF Protocol

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create OSPF process and enter OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	Mandatory Enable the OSPF process directly or from VRF. By

Step	Command	Description
		default, the OSPF protocol is disabled in the system. When OSPF is enabled from VRF, the OSPF process belonging to a certain VRF can manage the interfaces belonging to this VRF only.
Configure the network segment covered by OSPF area	**network** *ip-address wildcard-mask* **area** *area-id*	Mandatory By default, interface doesn't belong to any OSPF process or area. One interface can only belong to one OSPF process and area.
Configure Router ID of OSPF process	**router-id** *ip-address*	Optional By default, it is generated according to the electing rules of Router ID. Modifying the Router ID will not cause the OSPF neighbors to become invalid. To enable the newly configured Router ID to take effect, manual resetting of the process is required.

49.2.2 Configure OSPF Area

In order to reduce the CPU and memory usage by a large amount of database information, the OSPF AS is divided into multiple areas. The area is identified by a 32-bit area ID, which can be represented by a decimal number ranging from 0 to 4294967295 or an IP address within 0.0.0.0 - 255.255.255.255. Area 0 or 0.0.0.0 means the backbone area of OSPF, and others are non-backbone areas. All the inter-area routing information needs to be forwarded through backbone areas. Routing information cannot be directly exchanged between non-backbone areas.

OSPF defines several types of routers:

- Internal Router: The device whose all interfaces belong to the same area;

- Area Border Router (ABR): The device connecting to multiple areas;
- Automonous System Boundary Router (ASBR): The device which imports external route for OSPF AS.

Configuration Condition

Before configuring OSPF area, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer;
- Enable OSPF protocol.

Configure OSPF NSSA

Type-7 LSA instead of Type-5 LSA is allowed to be injected into the Not-So-Stub-Area (NSSA). By configuring redistribution to import external routes to the NSSA area. The ASBR in the NSSA area generates Type-7 LSA and floods it to the NSSA area. The ABR in the NSSA area will convert Type-7 LSAs into Type-5 LSAs, and then flood these Type-5 LSAs to the entire AS.

The OSPF NSSA area configured through the **area** *area-id* **nssa no-summary** command is called a totally NSSA area. The OSPF totally NSSA area prohibits inter-area routes from flooding. At this time, ABR will generate a default route and flood it into the NSSA area. Devices in the NSSA area will access the networks outside the area through this default route.

Table 3 Configuring OSPF NSSA Area

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure NSSA area	**area** *area-id* **nssa** [[**default-information-originate** [**metric** *metric-value* / **metric-type** *type-value*] / **no-redistribution** / **no-summary** / **translator-role** { **always** | **candidate** | **never** }] | [**translate-always** | **translate-candidate** | **translate-never**]]	Mandatory By default, it is not a NSSA area.

Note

- Backbone areas cannot be configured as NSSA areas.
- All devices in the same NSSA area must be configured as NSSA areas. Neighbor relations cannot be formed between the devices with inconsistent area types.

Configure OSPF Stub Area

The Stub area does not allow AS external routes to flood. This can reduce the size of the link status database. After an areas is configured as Stub, the ABR on the border of Stub will generate a default route and flood it into the Stub area. Devices in the Stub area will access the networks outside the AS through this default route.

The OSPF Stub area configured through the **area** *area-id* **stub no-summary** command is called a totally Stub area. The OSPF totally Stub area prohibits inter-area routes or external routes from flooding. Devices in the area will access the networks outside the area and the OSPF AS through the default route.

Table 4 Configuring OSPF Stub Area

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure Stub area	**area** *area-id* **stub** [**no-summary**]	Mandatory By default, it is not a Stub area.
Configure ABR in the Stub area to generate the cost value of default route	**area** *area-id* **default-cost** *cost-value*	Optional By default, the cost value of the default route generated by ABR in the Stub area is 1.

Note

- Backbone areas cannot be configured as Stub areas.
- All devices in the same Stub area must be configured as Stub areas. Neighbor relations cannot be formed between the devices with inconsistent area types.

Configure OSPF Virtual Link

In OSPF, non-backbone areas must complete database synchronization and data interaction through backbone areas. Therefore, all non-backbone areas must connect with backbone areas.

When this requirement cannot be satisfied in some circumstances, you may configure a virtual link. After a virtual link is configured, you can configure authentication method and modify Hello time interval for the virtual link. Meanings of these parameters are consistent with those of general OSPF interface parameters.

Table 5 Configuring OSPF Virtual Link

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF Virtual Link	**area** *transit-area-id* **virtual-link** *neighbor-id* [[**authentication** [**message-digest** | **null**] | **authentication-key** *key* | **message-digest-key** *key-id* **md5** *key*] / **dead-interval** *seconds* **hello-interval** *seconds* / **retransmit-interval** *seconds* / **transmit-delay** *seconds*]	Mandatory By default, no virtual link is created.

Note

- Virtual link must be configured between two ABRs.
- The two ABRs configured with virtual links must be within the same common area, which is called the Transit Area of the virtual link.
- This Transit Area shall not be a Stub or NSSA area.

49.2.3 Configure OSPF Network Type

Depending on the link protocol type, OSPF divides networks into four types:

- Broadcast Networks - When the link protocol is Ethernet or FDDI, the OSPF network

type is broadcast by default;

- P2P (Point To Point Network) - When the link protocol is PPP, LAPB or HDLC, the OSPF network type is P2P by default;
- NBMA (Non-Broadcast Multi-Access Network) - When the link protocol is ATM, frame relay or X.25, the OSPF network type is NBMA by default;
- P2MP (Point To Multi-Point Network) - No link protocol will be deemed as P2MP by OSPF by default. Generally, the NBMA network which is not fully connected is configured as an OSPF P2MP.

The network type of OSPF interface can be modified as needed. The network types of the interfaces that establish OSPF neighbors must be consistent, or the normal learning of routes will be affected.

Configuration Condition

Before configuring OSPF network type, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer;
- Enable OSPF protocol.

Configure Network Type of OSPF Interface as Broadcast

Broadcast network supports multiple (more than two) devices that can exchange information with all the devices on the network. OSPF uses Hello packets to dynamically find neighbors.

Table 6 Configuring Network Type of OSPF Interface as Broadcast

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure Network Type of OSPF Interface as Broadcast	**ip ospf network broadcast**	Mandatory By default, the network type of OSPF interface depends on the protocol in link layer.

Configure Network Type of OSPF Interface as P2P

Point-to-point network is the network composed of two devices, each of which is located at an end of the point-to-point link. OSPF uses Hello packets to dynamically find neighbors.

Table 7 Configuring Network Type of OSPF Interface as P2P

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure network type of OSPF as P2P	**ip ospf network point-to-point**	Mandatory By default, the network type of OSPF interface depends on the protocol in link layer.

Configure Network Type of OSPF Interface as NBMA

NBMA network supports multiple (more than two) devices. Yet it cannot broadcast, and neighbors need to be manually specified.

Table 8 Configuring Network Type of OSPF Interface as NBMA

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure network type of OSPF as NBMA	**ip ospf network non-broadcast**	Mandatory By default, the network type of OSPF interface depends on the protocol in link layer.
Enter the global configuration mode.	**exit**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-

Step	Command	Description
Configure NBMA network neighbors	**neighbor** *neighbor-ip-address* [**cost** *cost-value* / **priority** *priority-value* / **poll-interval** *interval-value*]	Mandatory In NBMA network, neighbors need to be manually specified.

Configure Network Type of OSPF Interface as P2MP

When NBMA is not fully connected, the network type can be configured as P2MP to save network cost. When the network type is configured as P2MP unicast, neighbors need to be manually specified.

Table 9 Configuring Network Type of OSPF Interface as P2MP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPF network type as P2MP	**ip ospf network point-to-multipoint** [**non-broadcast**]	Mandatory By default, the network type of OSPF interface depends on the protocol in link layer.
Enter the global configuration mode.	**exit**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure P2MP unicast network neighbors	**neighbor** *neighbor-ip-address* [**cost** *cost-value* / **priority** *priority-value* / **poll-interval** *interval-value*]	If the network type of interface is configured as P2MP, it is mandatory

49.2.4 Configure OSPF Network Authentication

In order to avoid information leakage or malicious attacks on OSPF devices, all packet interactions between OSPF neighbors can realize authentication. The authentication type can be NULL (no authentication), simple text authentication, MD5 authentication, SM3 authentication, or key-chain authentication.

After authentication is configured, when the OSPF interface receives OSPF protocol packets, authentication is required first. These packets can be received only when they pass the authentication. Therefore, for the OSPF interfaces that establish neighbor relations, their authentication method, Key ID, and authentication password must be consistent.

Authentication method and authentication password are separately configured. When the authentication password is configured, if no authentication method is configured, corresponding authentication method of the authentication password will be automatically configured.

The OSPF authentication method can be configured on area, interface or interface address. In particular, area authentication has a lower priority than interface authentication which is followed by interface address authentication. That is to say, you are required to first use interface address authentication and then interface authentication and area authentication.

Configuration Condition

Before configuring OSPF authentication, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer;
- Enable OSPF protocol.

Configure OSPF Area Authentication

OSPF area authentication simply configures the authentication method. It will completely take effect only after configuring corresponding authentication password under the interface.

Table 10 Configuring OSPF Area Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure area authentication	**area** *area-id* **authentication** [**message-digest** | **key-chain]**	Mandatory By default, area authentication is not configured.

Step	Command	Description
		In this command, configure the keyword **message-digest** which means MD5 authentication, or **key-chain** which means key-chain authentication. Otherwise, it will be simple text authentication.
Enter the interface configuration mode	**interface** *interface-name*	-
Configure simple text authentication password	**ip ospf** [*ip-address*] **authentication-key** { **0 | 7** } *password*	Mandatory By default, the simple text authentication password is not configured.
Configure MD5/SM3 authentication password	**ip ospf** [*ip-address*] **message-digest-key** *key-id {* **md5 | sm3}** { **0** | **7** } *password*	Mandatory By default, the MD5/SM3 authentication password is not configured.
Configure key-chain authentication	**ip ospf** [*ip-address*] **key-chain** *key-chain name*	Mandatory By default, **key-chain** authentication is not configured.

Configure OSPF Interface Authentication

When an OSPF interface has multiple IP addresses, you can separately specify authentication method or authentication password for an interface address. When no interface address is specified, all the addresses under the interface use the authentication method or authentication password configured.

Table 11 Configuring OSPF Interface Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure interface authentication method	**ip ospf** [*ip-address*] **authentication** [**key-chain | message-digest** | **null**]	Mandatory By default, no interface authentication method is configured. In this command, configure the keyword **message-digest** which means MD5 authentication, **key-chain** which means key-chain authentication, or **null** which means no authentication. Otherwise, it will be simple text authentication.
Configure simple text authentication password	**ip ospf** [*ip-address*] **authentication-key** { **0 | 7** } *password*	Mandatory By default, the simple text authentication password is not configured.
Configure MD5/SM3 authentication password	**ip ospf** [*ip-address*] **message-digest-key** *key-id* {**md5 | sm3}** { **0** | **7** } *password*	Mandatory By default, the MD5/SM3 authentication password is not configured.
Configure key-chain authentication	**ip ospf** [*ip-address*] **key-chain** *key-chain name*	Mandatory By default, **key-chain** authentication is not configured.

49.2.5 Configure OSPF Route Generation

In OSPF, the routes in direct network segment are covered via the command **network**, external routes can be redistributed, or host routes can be added through the command **host**.

Configuration Condition

Before configuring OSPF route generation, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer;
- Enable OSPF protocol.

Configure OSPF Route Redistribution

When multiple routing protocols are running on a device, routes of other protocols are imported into OSPF through redistribution to generate OSPF external type-2 routes by default, with the routing metric value being 20. When external routes are imported through redistribution, you can modify the type of external route, metric, and Tag fields, and specify corresponding routing policy for route control and management.

Table 12 Configuring OSPF Route Redistribution

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF Route Redistribution	**redistribute** *protocol* [*protocol-id*] [**metric** *metric-value* / **metric-type** *metric-type* / **tag** *tag-value* / **route-map** *route-map-name* / **match** *route-type*]	Mandatory By default, no OSPF route redistribution is configured.
Configure the metric value of OSPF external route	**default-metric** *metric-value*	Optional
Configure the restriction on the number of external routes redistributed by OSPF	**redistribute maximum-prefix maximum-prefix-value [threshold-value [warning-only] / warning-only]**	Optional By default, there is no restriction on the number of external routes redistributed by OSPF.

Note

- When **redistribute** *protocol* [*protocol-id*] **metric** and **default-metri**c are both configured to set the metric value of external route, the former has a higher priority.

Configure OSPF Default Route

After the OSPF Stub area and totally NSSA area are configured, a Type-3 default route will be automatically generated. Default route cannot be automatically generated in NSSA area. But a Type-7 default route can be imported to this area through the command **area** *area-id* **nssa default-information-originate**.

OSPF cannot import Type-5 default route through the **redistribute** command. When necessary, the **default-information originate [always]** command can be used to achieve this purpose.

Table 13 Configuring OSPF Default Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF to import default route	**default-information originate** [**always** / **metric** *metric-value* / **metric-type** *metric-type* / **route-map** *route-map-name*]	Mandatory By default, no external default route will be imported into OSPF AS. For the default route imported, the default metric value is 1, and the type is external type-2. **always** means that the default route is required to be generated in OSPF AS. Otherwise, it will be generated only when there is a default route in the local routing table.

Configure OSPF Host Route

Table 14 Configuring OSPF Host Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF Host Route	**host** *ip-address* **area** *area-id* [**cost** *cost*]	Mandatory By default, host route is not generated.

49.2.6 Configure OSPF Route Control

Configuration Condition

Before configuring OSPF route control, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer;
- Enable OSPF protocol.

Configure OSPF Inter-area Summarization

When the ABR in OSPF advertises inter-area routes to other areas, each route is advertised separately as Type-3 LSAs. You may use the inter-area route summarization function to summarize some contiguous network segments in the area into one route to advertise the summarized route only. This can reduce the size of the OSPF database.

Table 15 Configuring OSPF Inter-area Route Summarization

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF Inter-area Summarization	**area** *area-id* **range** *ip-address/mask-length*	Mandatory

Step	Command	Description
	[**advertise** [**cost** *cost*] | **cost** *cost* | **not-advertise**]	By default, ABR doesn't conduct inter-area route summarization.

Note

- The OSPF inter-area route summarization function takes effect on ABR only.
- By default, the minimum cost value of detail routes is selected as the cost value of summarized route.

Configure OSPF External Route Summarization

When OSPF redistributes external routes, each route is advertised separately in external link status advertisement. You may use the external route summarization function to summarize some contiguous network segments outside the AS into one route to advertise the summarized route only. This can reduce the size of the OSPF database.

After configuring the command **summary-address** on ASBR, you can summarize the Type-5 LSA and Type-7 LSA within the scope of summarized address.

Table 16 Configuring OSPF External Route Summarization

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF External Route Summarization	**summary-address** *ip-address mask* [**not-advertise** | **tag** *tag-value*]	Mandatory By default, ABR doesn't conduct external route summarization.

Note

- The OSPF external route summarization function takes effect on ASBR only.

Configure OSPF Inter-area Route Filtration

When ABR is receiving inter-area route, ACL or prefix list is used for filtration in the incoming function; when it is advertising inter-area route, ACL or prefix list is used for filtration in the outgoing function.

Table 17 Configuring OSPF Inter-area Route Filtration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF Inter-area Route Filtration	**area** *area-id* **filter-list** { **access** { *access-list-name* | *access-list-number* } | **prefix** *prefix-list-name* } { **in** | **out** }	Mandatory By default, ABR doesn't conduct inter-area route filtration.

Note

- When matching ACL filtration, only standard ACL is supported.
- The OSPF inter-area route filtration function takes effect on ABR only.

Configure OSPF External Route Filtration

Configure external route filtration, i.e. apply ACL or prefix list to allow or prohibit the flooding of routes into OSPF AS from outside.

Table 18 Configuring OSPF External Route Filtration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure distribution list to filter external routes	**distribute-list** { *access-list-name* | *access-list-number* | **prefix** *prefix-list-name* } **out** [*routing-protocol* [*process-id*]]	Mandatory By default, ASBR doesn't conduct external route filtration.

Note

- When matching ACL filtration, only standard ACL is supported.
- The OSPF external route filtration function takes effect on ASBR only.

Configure OSPF Route Installation Filtration

After OSPF calculates routes through LSA, the calculated OSPF protocol routing information can be filtered to prevent certain routes from being added to the routing table.

There are three ways of filtration:

- Based on prefix filtration, use ACL and prefix list to filter the destination address of route;
- Based on the next hop filtration, use prefix list to filter the next hop of route. The prefix list can also be used to filter both destination address and next hop of route at the same time;
- Based on routing policy, filter routes.

Table 19 Configuring OSPF Route Installation Filtration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-

Step	Command	Description
Configure OSPF to prohibit installation of routes	**distribute-list** { *access-list-name* | *access-lsit-number* | **gateway** *prefix-list-name1* | **prefix** *prefix-list-name2* [**gateway** *prefix-list-name3*] | **route-map** *route-map-name* } **in** [*interface-name*]	Mandatory By default, the routes installed are not filtered.

Note

- Make **prefix**, **gateway** and **route-map** filtration and ACL filtration mutually exclusive. For example, if **prefix** filtration has been configured, ACL filtration cannot be configured.
- Make **route-map** and **prefix** filtration and **gateway** filtration mutually exclusive.
- Make **prefix** filtration and **gateway** filtration cover each other.

Configure Cost Value of OSPF Interface

By default, the OSPF interface cost is calculated with the following methods: reference bandwidth/interface bandwidth.

Table 20 Configuring OSPF Interface Cost Value

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure Cost Value of OSPF Interface	**ip ospf** [*ip-address*] **cost** *cost-value*	Optional By default, the calculation is conducted according to the reference bandwidth/interface bandwidth.

Configure OSPF Reference Bandwidth

The reference bandwidth of interface is mainly used to calculate interface cost value which is 100Mbit/s by default. The OSPF interface cost is calculated with the following methods: reference bandwidth/interface bandwidth. When the calculation result is greater than 1, take the integer part; when it is less than 1, take 1. Therefore, in a network with a bandwidth higher than 100Mbit/s, the optimal route cannot be correctly selected. To solve this problem, the **auto-cost reference-bandwidth** command can be used to configure appropriate reference bandwidth.

Table 21 Configuring OSPF Reference Bandwidth

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure reference bandwidth of OSPF interface	**auto-cost reference-bandwidth** *reference-bandwidth*	Optional By default, the reference bandwidth is 100Mbit/s.

Configure OSPF Administrative Distance

Administrative distance indicates the reliability of routing protocol. When the routes that reach the same destination network are learned from different routing protocols, they are selected according to the administrative distance. Those with a small administrative distance are selected first.

Table 22 Configuring OSPF Administrative Distance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF Administrative Distance	**distance** { *distance* [*ip-address wildcard-mask*] [*access-list-name* | *access-list-number*] | **ospf** { **external** *distance* | **inter-area** *distance* | **intra-area** *distance* } }	Optional By default, the administrative distance of intra-area and inter-area routes of OSPF is

Step	Command	Description
		110, and that of external routes is 150.

Configure the Maximum Number of Load Balancing Entries of OSPF

If there are multiple equal-cost paths leading to the same destination address, the paths form load balancing, which can improve the link utility rate and reduce the load of links.

Table 23 Configuring Maximum Number of OSPF Load Balancing Entries

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure the Maximum Number of Load Balancing Entries of OSPF	**maximum-path** *max-number*	Optional By default, the maximum number of OSPF load balancing entries is 4.

Configure OSPF to be Compatible with RFC1583

When there are multiple paths that reach ASBR or external route forwarding address, RFC1583 and RFC2328 define different routing rules. To be compatible with RFC1583, first select the intra-area or inter-area paths within the backbone area; to be incompatible with RFC1583, first select the intra-area paths within the non-backbone area.

Table 24 Configuring OSPF Compatible with RFC1583

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-

Step	Command	Description
Configure OSPF to be Compatible with RFC1583	**compatible rfc1583**	Mandatory By default, it is incompatible with RFC1583.

Note

- In OSFP AS, all devices must have the same routing rules. Namely, they shall all be either compatible with or incompatible with RFC1583 to avoid routing loops.

49.2.7 Configure OSPF Network Optimization

Configuration Condition

Before configuring OSPF network optimization, ensure that:

- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer;
- Enable OSPF protocol.

Configure Keepalive Time of OSPF Neighbors

OSPF Hello packets are used to establish and keep alive neighbor relations. The default time interval of sending Hello packets depends on the network type. In broadcast and P2P networks, it is 10 seconds, and in P2MP and NBMA networks, it is 30 seconds.

The failure time of neighbor is used to identify the validity of the neighbor. By default, it is 4 times the Hello time interval. If the OSPF device does not receive the Hello packets from the neighbor after time out of its failure time, the neighbor is considered invalid and deleted.

Table 25 Configuring OSPF Neighbor Keepalive Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-

Step	Command	Description
Configure OSPF Hello interval	**ip ospf** [*ip-address*] **hello-interval** *interval-value*	Optional The default value is determined based on network class. For broadcast and P2P networks, it's 10 seconds; for P2MP and NBMA networks, it's 30 seconds.
Configure failure time of OSPF neighbors	**ip ospf** [*ip-address*] **dead-interval** *interval-value*	Optional The default value is 4 times the Hello interval.

Note

- The Hello interval between adjacent OSPF devices must be the same as the failure time of neighbor. Otherwise, neighbor relation cannot be established.
- When modifying Hello interval, if the failure time of current neighbor is 4 times the Hello interval, the failure time of neighbor will also be automatically modified so that it is 4 times the Hello interval; if the failure time of current neighbor is not 4 times the Hello interval, the failure time of neighbor will remain unchanged.
- Modifying the failure time of neighbor will not affect the Hello interval.

Configure Passive OSPF Interface

Dynamic routing protocol uses passive interface, which can effectively reduce the consumption of network bandwidth by routing protocol. Configure passive OSPF interface to advertise the route of the direct network segment where the interface is located through the command **network**. But it will suppress the receiving and sending of OSPF protocol packets on this interface.

Table 26 Configuring Passive OSPF Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure Passive OSPF Interface	**passive-interface** { *interface-name* [*ip-address*] | **default** }	Mandatory By default, no passive OSPF interface is configured.

Configure OSPF Demand Circuit

On P2P and P2MP links, to reduce line costs, you can configure OSPF demand circuit to suppress the periodic sending of Hello packets and periodic refresh of LSA packets. It is mainly applied in paid links, such as ISDN, SVC and X.25.

Table 27 Configuring OSPF Demand Circuit

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPF Demand Circuit	**ip ospf** [*ip-address*] **demand-circuit**	Mandatory By default, the OSPF demand circuit is disabled.

Configure OSPF Interface Priority

Interface priority is mainly applied in the election of DR (Designed Router) and BDR (Backup Designed Router) in broadcast and NBMA networks. The value ranges from 0 to 255. The larger the value, the higher the priority. The default value is 1.

DR and BDR are elected by all the devices in the same network segment according to interface priority and Router ID through Hello packets. The rules are shown below:

- Firstly, the device with the highest interface priority is elected as the DR, and that with the second interface priority as the BDR. The device with the priority of 0 does not participate in the election;

- If the interface priorities are the same, the device with the highest router ID is elected as the DR, and that with the second router ID as the BDR;
- After the DR fails, BRD will become a DR immediately, and a new BDR will be elected.

Table 28 Configuring OSPF Interface Priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPF Interface Priority	**ip ospf priority** *priority-value*	Optional By default, the OSPF interface priority is 1.

Note

- Priority affects the election process only. When DR and BDR have been elected in the network, modifying interface priority will affect the next election result only. Therefore, DR is not necessarily the device with the highest interface priority, and DBR is not necessarily the device with the second high interface priority.

Configure OSPF Interface MTU

When encapsulating OSPF packets, to avoid fragmentation, the packet size must be no more than the MTU value of interface. When adjacent OSPF devices exchange DD packets with each other, they will check whether the MTUs are the same by default. If different, a neighbor relation cannot be established. After OSPF is configured to ignore interface MTU check, even if the MTUs are different, the neighbor relation can be established.

Table 29 Configuring OSPF Interface MTU

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-

Step	Command	Description
Configure OSPF Interface MTU	**ip ospf mtu** *mtu-value*	Optional
Configure OSPF Interface to ignore MTU consistency check	**ip ospf** [*ip-address*] **mtu-ignore**	Mandatory By default, MTU check will be conducted. consistency check

Configure Transfer Delay of OSPF Interface

LSA transfer delay means the period during which LSA floods to other devices. The device sending LSA will add the interface transfer delay time to the aging time of the LSA to be sent. By default, when the flooded LSA passes through a device, the aging time increases by 1. The transfer delay of LSA can be configured according to network conditions, from 1 to 840. It is generally used on low-speed links.

Table 30 Configuring OSPF Interface LSA Transfer Delay

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure Transfer Delay of OSPF Interface	**ip ospf transmit-delay** *delay-value*	Optional By default, the LSA transfer delay is 1 second.

Configure OSPF LSA Retransmission

In order to ensure the reliability of data interaction, OSPF uses the acknowledgement mechanism. When an LSA is flooded on the device interface, it will be added to the neighbor's retransmission list. If confirmation is not received from the neighbor after the retransmission time expires, this LSA will be retransmitted until the confirmation is received.

Table 31 Configuring OSPF LSA Redistribution

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPF LSA retransmission interval	**ip ospf retransmit-interval** *interval-value*	Optional By default, the retransmission interval is 5 seconds.

Configure OSPF to Prohibit LSA Diffusion

In practical network applications, redundant links are used between OSPF neighbors sometimes. This configuration can reduce the spreading of OSPF update packets on redundant links.

Table 32 Configuring OSPF to Prohibit LSA Diffusion

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPF interface to prohibit LS-UPD diffusion	**ip ospf database-filter all out**	Mandatory By default, OSPF interface doesn't prohibit LSA diffusion.

Note

- Configuring OSPF to prohibit LSA diffusion may result in loss of some routing information.

Configure OSPF SPF Calculation Time

When the OSPF network topology changes, recalculation of routes is required. When the network keeps changing, frequent routing calculation will occupy a large amount of system resources. The consumption of system resources by frequent network changes can be suppressed by adjusting the time parameters of SPF calculation.

Table 33 Configuring OSPF SPF Calculation Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF SPF Calculation Time	**timers throttle spf** *delay-time hold-time max-time*	Optional By default, the delay-time, hold-time and max-time are 5000 ms, 10000 ms, and 10000 ms, respectively.

Note

- *Delay-time* means the initial calculation delay, *hold-time* the suppression time, and *max-time* the maximum waiting time for two SPF calculations. When there are infrequent network changes, the continuous route calculation interval is decreased to *delay-time*. In the case of frequent network changes, adjustment should be made accordingly by increasing the *hold-time*×2^{n-2} (n is the times of continuously triggering route calculation) to prolong the waiting time by the increment of the *hold-time* configured, *max-time* at most.

Configure OSPF Database Overflow

OSPF database overflow is used to restrict the number of Type-5 LSA in the database.

Table 34 Configuring OSPF Database Overflow

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF Database Overflow	**overflow database external** *max-number seconds*	Mandatory By default, the OSPF database overflow function is disabled.

Caution

- Enabling the database overflow function may cause inconsistency between the databases in the OSPF area and loss of some routes.

49.2.8 Configure OSPF GR

GR (Graceful Restart) is used to keep the routing information in the forwarding layer of this device and neighbor device unchanged during the switch between host and standby devices to ensure the forwarding process is not affected; after the device is switched for re-running, the two devices synchronize routing information and update forwarding layer in the protocol layer so that the data can keep forwarding during the process of device switch.

There are two types of roles in the GR process:

- GR Restarter end: The device for graceful restart of protocol.
- GR Helper end: The device which helps with the graceful restart of protocol.

The distributed device can act as GR Restarter and GR Helper, while the centralized device only serves as GR Helper to help the Restarter complete GR.

Configuration Condition

Before configuring OSPF GR, ensure that:

- Configure interface IP addresses so that neighbor nodes are reachable.
- Enable OSPF protocol.

Configure OSPF GR Restarter

Table 35 Configuring OSPF GR Restarter

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF GR	**nsf ietf**	Mandatory By default, the GR function is disabled. After this function takes effect, the protocol needs to support the Opaque-LSA function, and it supports the Opaque-LSA function by default.
Configure OSPF GR period	**nsf interval** *grace-period*	Optional By default, the GR period is 95 seconds.

Note

- The OSPF GR function can only be used in the stacking environment or a dual-master environment.

Configure OSPF GR Helper

GR Helper can help the Restarter end complete GR. By default, the device enables this function. Users can disable this function via the command **nsf ietf helper disable**. The command **nsf ietf helper strict-lsa-checking** is used to enable the Helper end to strictly check LSA in the GR process. If any change of LSA is found, the GR Helper mode will be exited.

Table 36 Configuring OSPF GR Helper

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the OSPF configuration mode	**router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPF GR Helper	**nsf ietf helper** [**disable** | **strict-lsa-checking**]	Optional By default, the Helper function is enabled, but it doesn't check LSA.

49.2.9 OSPF Monitoring and Maintaining

Table 37 OSPF Monitoring and Maintaining

Command	Description
clear ip ospf [*process-id*] **process**	Reset OSPF process
clear ip ospf *process-id* **neighbor** *neighbor-ip-address* [*neighbor-router-id*]	Reset OSPF neighbors
clear ip ospf statistics [*interface-name*]	Clear interface statistics of OSPF
clear ip ospf [*process-id*] **redistribution**	Re-advertise external route
clear ip ospf [*process-id*] **route**	Recalculate OSPF route
show ip ospf [*process-id*]	Show basic information of OSPF
show ip ospf [*process-id*] **border-routers**	Show information of the route reaching edge device in OSPF
show ip ospf [*process-id*] **buffers**	Show size of OSPF packet sending and receiving cache
show ip ospf [*process-id*] **database** [**adv-router** *router-id* | **age** *lsa_age* | **database-summary | max-age |** [**asbr-summary | external | network | nssa-external | opaque-area | opaque-as | opaque-link | router | self-originate | summary**] [[*link-state-id*] [**adv-router** *advertising-router-id*] | **self-originate | summary**]]	Show the information of OSPF database

Command	Description
show ip ospf interface [*interface-name* [**detail**]]	Show OSPF interface information
show ip ospf [*process-id*] **neighbor** [*neighbor-id* | **all** | **detail** [**all**] | **interface** *ip-address* [**detail**] | **statistic**]	Show the information of OSPF neighbors
show ip ospf [*process-id*] **route** [*ip-address mask* | *ip-address/mask-length* | **external** | **inter-area** | **intra-area** | **statistic**]	Show the routing information of OSPF protocol
show ip ospf [*process-id*] **virtual-links**	Show the information of OSPF virtual link
show ip ospf [*process-id*] **sham-links**	Show the OSPF pseudo-class link interface information configured, including interface status, cost value, and neighbor status

49.3 Typical Configuration Example of OSPF

49.3.1 Configure OSPF Basic Functions

Network Requirements

- All devices are configured with OSPF protocol, and there are three areas, i.e. area 0, 1 and 2. Upon completion of the configuration, all the devices can learn routes from each other.
- On the back-to-back Ethernet interface, in order to speed up the the process of establishing OSPF neighbors, the network type of OSPF interface can be changed to point-to-point. Modify the network type of the interface in area 2 as point-to-point. Upon completion of the configuration, all the devices can learn routes from each other.

Network Topology

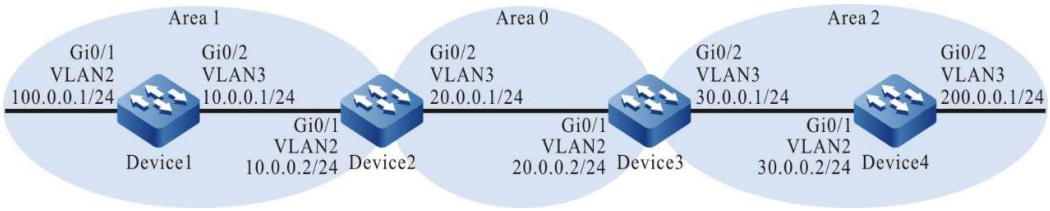


Figure 49-1 Network Topology for Configuring Basic Functions of OSPF

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF process and make different areas cover corresponding interfaces.

#On Device1, configure OSPF process and make area 1 cover the interface.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#network 10.0.0.0 0.0.0.255 area 1
Device1(config-ospf)#network 100.0.0.0 0.0.0.255 area 1
Device1(config-ospf)#exit
```

#On Device2, configure OSPF process and make area 0 and 1 cover corresponding interfaces.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#network 20.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#network 10.0.0.0 0.0.0.255 area 1
Device2(config-ospf)#exit
```

#On Device3, configure OSPF process and make area 0 and 2 cover corresponding interfaces.

```
Device3#configure terminal
Device3(config)#router ospf 100
Device3(config-ospf)#router-id 3.3.3.3
Device3(config-ospf)#network 20.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#network 30.0.0.0 0.0.0.255 area 2
Device3(config-ospf)#exit
```

#On Device4, configure OSPF process and make area 2 cover the interface.

```
Device4#configure terminal
Device4(config)#router ospf 100
Device4(config-ospf)#router-id 4.4.4.4
Device4(config-ospf)#network 30.0.0.0 0.0.0.255 area 2
Device4(config-ospf)#network 200.0.0.0 0.0.0.255 area 2
Device4(config-ospf)#exit
```

Note

- Router ID can be manually configured or automatically generated. If the Router ID is not manually configured, the device will automatically select it. The largest IP address in Loopback interfaces is first selected as Router ID; if no Loopback interface address is configured on the device, the largest IP address in general interfaces is selected as Router ID. Only when the interface is up can the interface address be selected as Router ID.
- When using the command **network**, the reverse mask doesn't have to accurately match the length of the interface IP address mask. The network segment **network** simply needs to cover the interface IP address. For example, **network** 0.0.0.0

255.255.255.255 means all the interfaces are covered.

#View OSPF neighbors' information and routing table on Device1.

```
Device1#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   Full/DR         00:00:36    10.0.0.2        vlan3

Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 02:26:21, vlan3
O   20.0.0.0/24 [110/2] via 10.0.0.2, 02:25:36, vlan3
O   30.0.0.0/24 [110/3] via 10.0.0.2, 02:25:36, vlan3
C   100.0.0.0/24 is directly connected, 02:26:23, vlan2
C   127.0.0.0/8 is directly connected, 18:09:44, lo0
O   200.0.0.0/24 [110/4] via 10.0.0.2, 02:25:36, vlan3
```

#View the OSPF neighbors and routing table on Device2.

```
Device2#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           1   Full/Backup     00:00:37    10.0.0.1        vlan2
3.3.3.3           1   Full/DR         00:00:38    20.0.0.2        vlan3

Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 02:31:15, vlan2
C   20.0.0.0/24 is directly connected, 02:31:50, vlan3
O   30.0.0.0/24 [110/2] via 20.0.0.2, 02:31:40, vlan3
O   100.0.0.0/24 [110/2] via 10.0.0.1, 02:30:29, vlan2
C   127.0.0.0/8 is directly connected, 240:21:34, lo0
O   200.0.0.0/24 [110/3] via 20.0.0.2, 02:31:40, vlan3
```

#View the OSPF LSDB (Link State Database) on Device2.

```
Device2#show ip ospf database

          OSPF Router with ID (2.2.2.2) (Process ID 100)

              Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
2.2.2.2         2.2.2.2         1777 0x8000000c 0xcb20 1
3.3.3.3         3.3.3.3         309 0x8000000a 0x9153 1

              Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
20.0.0.2        3.3.3.3         369 0x80000006 0xec12

              Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Route
10.0.0.0        2.2.2.2         1757 0x80000005 0xcc59 10.0.0.0/24
100.0.0.0       2.2.2.2         1356 0x80000005 0x408a 100.0.0.0/24
30.0.0.0        3.3.3.3         9 0x80000006 0xa765 30.0.0.0/24
200.0.0.0       3.3.3.3         149 0x80000006 0x075a 200.0.0.0/24
```

```
            Router Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         1775 0x80000009 0xbbda 2
2.2.2.2         2.2.2.2         1737 0x80000008 0x2dd5 1

            Net Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum
10.0.0.2        2.2.2.2           34 0x80000006 0x39db

            Summary Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum  Route
20.0.0.0        2.2.2.2          144 0x80000006 0x48d2 20.0.0.0/24
30.0.0.0        2.2.2.2         1186 0x80000005 0xd13f 30.0.0.0/24
200.0.0.0       2.2.2.2           14 0x80000006 0x2f35 200.0.0.0/24
```

For Device2, both 30.0.0.0/24 and 200.0.0.0/24 are inter-area routes. LSA information of relevant routes can be seen from Summary Link States (Area 0). For intra-area route, **show ip ospf database router** is required to see the LSA information of relevant routes.

Step 4: Configure the network type of OSPF interface as point-to-point.

#On Device3, change the OSPF network type of VLAN3 to point-to-point.

```
Device3(config)#interface vlan3
Device3(config-if-vlan3)#ip ospf network point-to-point
Device3(config-if-vlan3)#exit
```

#On Device4, change the OSPF network type of VLAN2 to point-to-point.

```
Device4(config)#interface vlan2
Device4(config-if-vlan2)#ip ospf network point-to-point
Device4(config-if-vlan2)#exit
```

Step 5: Check the result.

#View the OSPF neighbors and routing table on Device3.

```
Device3#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   Full/Backup     00:00:36    20.0.0.1        vlan2
4.4.4.4           1   Full/ -         00:00:39    30.0.0.2        vlan3

Device3#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

O   10.0.0.0/24 [110/2] via 20.0.0.1, 00:02:53, vlan2
C   20.0.0.0/24 is directly connected, 03:20:36, vlan2
C   30.0.0.0/24 is directly connected, 03:20:26, vlan3
O   100.0.0.0/24 [110/3] via 20.0.0.1, 00:01:51, vlan2
C   127.0.0.0/8 is directly connected, 262:01:24, lo0
O   200.0.0.0/24 [110/2] via 30.0.0.2, 00:00:11, vlan3
```

Note

- When OSPF neighbor relations are established in point-to-point networks, there is no DR or BDR election.

#View the OSPF neighbors and routing table on Device4.

```
Device4#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           1   Full/ -         00:00:39    30.0.0.1        vlan2

Device4#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

O   10.0.0.0/24 [110/3] via 30.0.0.1, 00:01:04, vlan2
O   20.0.0.0/24 [110/2] via 30.0.0.1, 00:01:04, vlan2
C   30.0.0.0/24 is directly connected, 03:20:25, vlan2
O   100.0.0.0/24 [110/4] via 30.0.0.1, 00:01:04, vlan2
C   127.0.0.0/8 is directly connected, 22:52:36, lo0
C   200.0.0.0/24 is directly connected, 03:20:13, vlan3
```

According to the result, after the network type of OSPF interface is changed to point-to-point, neighbors can be normally established, and routes can be learned normally.

Note

- When the network type of OSPF interface is configured, the network type of OSPF interfaces at both sides of the neighbor must be consistent. Otherwise, it will affect the normal learning and flooding of route. By default, the network type of OSPF interface depends on the network type of physical interface.

49.3.2 Configure OSPF Authentication

Network Requirements

- OSPF is running on all devices that are configured with area authentication. Area 0 is configured with simple text authentication, and area 1 with MD5 authentication.
- Configure OSPF interface authentication: simple text authentication for area 0 and MD5 authentication for area 1.
- Upon completion of the configuration, the device can normally establish neighbors and learn routes from each other.

Network Topology

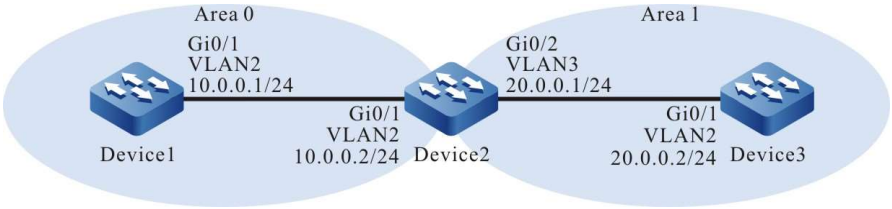


Figure 49-2 Network Topology for Configuring OSPF Authentication

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF process, make different areas cover corresponding interfaces, and enable area authentication. In particular, area 0 uses simple text authentication, and area 1 MD5 authentication.

#On Device1, configure OSPF process and area authentication function.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#area 0 authentication
Device1(config-ospf)#network 10.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#On Device2, configure OSPF process and area authentication function.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#area 0 authentication
Device2(config-ospf)#area 1 authentication message-digest
Device2(config-ospf)#network 10.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#network 20.0.0.0 0.0.0.255 area 1
Device2(config-ospf)#exit
```

#On Device3, configure OSPF process and area authentication function.

```
Device3#configure terminal
Device3(config)#router ospf 100
Device3(config-ospf)#router-id 3.3.3.3
Device3(config-ospf)#area 1 authentication message-digest
Device3(config-ospf)#network 20.0.0.0 0.0.0.255 area 1
Device3(config-ospf)#exit
```

#View the information of OSPF process on Device1.

```
Device1#show ip ospf 100
 Routing Process "ospf 100" with ID 1.1.1.1
 Process bound to VRF default
 Process uptime is 30 minutes
 IETF NSF restarter support disabled
```

```
IETF NSF helper support enabled
Conforms to RFC2328, and RFC1583Compatibility flag is disabled
Supports only single TOS(TOS0) routes
Supports opaque LSA
Supports Graceful Restart
Initial SPF schedule delay 5000 msecs
Minimum hold time between two consecutive SPFs 10000 msecs
Maximum wait time between two consecutive SPFs 10000 msecs
Refresh timer 10 secs
Number of external LSA 0. Checksum Sum 0x000000
Number of opaque AS LSA 0. Checksum Sum 0x000000
Number of non-default external LSA is 0
External LSA database is unlimited.
Not Support Demand Circuit lsa number is 0, autonomy system support flood DoNotAge Lsa
Number of areas attached to this router: 1
  Area 0 (BACKBONE)       Number of interfaces in this area is 1(1)
     Number of fully adjacent neighbors in this area is 1
     Number of fully adjacent sham-link neighbors in this area is 0
      Area has simple password authentication
     SPF algorithm last executed 00:27:43.916 ago
     SPF algorithm executed 3 times
     Number of LSA 4. Checksum Sum 0x0160f7
     Not Support Demand Circuit lsa number is 0,
     Indication lsa (by other routers) number is: 0,
     Area support flood DoNotAge Lsa
```

According to the result, area authentication is a simple text method.

#View OSPF neighbors' information and routing table on Device1.

```
Device1#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   Full/DR         00:00:38    10.0.0.2        vlan2

Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:14:01, vlan2
O   20.0.0.0/24 [110/2] via 10.0.0.2, 00:10:38, vlan2
C   127.0.0.0/8 is directly connected, 20:55:08, lo0
```

On Device1, neighbors are normally established, and route learning is normal.

#View OSPF process information on Device3.

```
Device3#show ip ospf 100
 Routing Process "ospf 100" with ID 3.3.3.3
 Process bound to VRF default
 Process uptime is 28 minutes
 IETF NSF restarter support disabled
 IETF NSF helper support enabled
 Conforms to RFC2328, and RFC1583Compatibility flag is disabled
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Graceful Restart
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Refresh timer 10 secs
 Number of external LSA 0. Checksum Sum 0x000000
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of non-default external LSA is 0
 External LSA database is unlimited.
 Not Support Demand Circuit lsa number is 0, autonomy system support flood DoNotAge Lsa
 Number of areas attached to this router: 1
   Area 1        Number of interfaces in this area is 1(1)
```

```
Number of fully adjacent neighbors in this area is 1
Number of fully adjacent sham-link neighbors in this area is 0
Number of fully adjacent virtual neighbors through this area is 0
 Area has message digest authentication
SPF algorithm last executed 00:24:01.783 ago
SPF algorithm executed 5 times
Number of LSA 4. Checksum Sum 0x0337cf
Not Support Demand Circuit lsa number is 0,
Indication lsa (by other routers) number is: 0,
Area support flood DoNotAge Lsa
```

According to the result, area authentication is a MD5 authentication method.

#View OSPF neighbors' information and routing table on Device3.

```
Device3#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   Full/Backup     00:00:33    20.0.0.1        vlan2

Device3#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

O   10.0.0.0/24 [110/2] via 20.0.0.1, 00:09:31, vlan2
C   20.0.0.0/24 is directly connected, 00:20:36, vlan2
C   127.0.0.0/8 is directly connected, 24:00:06, lo0
```

On Device3, neighbors are normally established, and route learning is normal.

Step 4: Configure OSPF interface authentication.

#On Device1, the interface VLAN2 uses simple text authentication, with the password being admin.

```
Device1(config)#interface vlan2
Device1(config-if-vlan2)#ip ospf authentication
Device1(config-if-vlan2)#ip ospf authentication-key 0 admin
Device1(config-if-vlan2)#exit
```

#On Device2, the interface VLAN2 uses simple text authentication, with the password being admin; the interface VLAN3 uses MD5 authentication, with the Key ID being 1 and the password being admin.

```
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ip ospf authentication
Device2(config-if-vlan2)#ip ospf authentication-key 0 admin
Device2(config-if-vlan2)#exit
Device2(config)#interface vlan3
Device2(config-if-vlan3)#ip ospf authentication message-digest
Device2(config-if-vlan3)#ip ospf message-digest-key 1 md5 0 admin
Device2(config-if-vlan3)#exit
```

#On Device3, the interface VLAN2 uses MD5 authentication, with the Key ID being 1 and the password being admin.

```
Device3(config)#interface vlan2
Device3(config-if-vlan2)#ip ospf authentication message-digest
Device3(config-if-vlan2)#ip ospf message-digest-key 1 md5 0 admin
Device3(config-if-vlan2)#exit
```

Step 5: Check the result.

#View the information of OSPF neighbors on Device2.

```
Device2#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           1   Full/Backup     00:00:33    10.0.0.1        vlan2
3.3.3.3           1   Full/DR         00:00:39    20.0.0.2        vlan3
```

#View the information of OSPF interface on Device2.

```
Device2#show ip ospf interface vlan2
vlan2 is up, line protocol is up
  Internet Address 10.0.0.2, 10.0.0.255( a[10.0.0.2] d[10.0.0.255]) Area 0, MTU 1500
  Process ID 100, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State DR, Priority 1, TE Metric 0
  Designated Router (ID) 2.2.2.2, Interface Address 10.0.0.2
  Backup Designated Router (ID) 1.1.1.1, Interface Address 10.0.0.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:04
  Neighbor Count is 1, Adjacent neighbor count is 1
   Crypt Sequence Number is 0
  Graceful restart proxy id is 0x0
  Hello received 406 sent 454, DD received 8 sent 6
  LS-Req received 2 sent 2, LS-Upd received 11(LSA: 15) sent 10(LSA: 14)
  LS-Ack received 10 sent 0, Discarded 0

Device2#show ip ospf interface vlan3
vlan3 is up, line protocol is up
  Internet Address 20.0.0.1, 20.0.0.255( a[20.0.0.1] d[20.0.0.255]) Area 1, MTU 1500
  Process ID 100, Router ID 2.2.2.2, Network Type BROADCAST, Cost: 1
  Transmit Delay is 1 sec, State Backup, Priority 1, TE Metric 0
  Designated Router (ID) 3.3.3.3, Interface Address 20.0.0.2
  Backup Designated Router (ID) 2.2.2.2, Interface Address 20.0.0.1
  Timer intervals configured, Hello 10, Dead 40, Wait 40, Retransmit 5
    Hello due in 00:00:00
  Neighbor Count is 1, Adjacent neighbor count is 1
   Crypt Sequence Number is 485
  Graceful restart proxy id is 0x0
  Hello received 412 sent 454, DD received 9 sent 12
  LS-Req received 3 sent 3, LS-Upd received 9(LSA: 10) sent 13(LSA: 16)
  LS-Ack received 13 sent 8, Discarded 0
```

Crypt Sequence Number will be generated after configuring MD5 authentication; simple text authentication doesn't generate this sequence number.

Note

- When configuring OSPF authentication, you can configure area authentication or interface authentication only, or configure both area and interface authentication.
- When area authentication and interface authentication are configured at the same time, the latter takes effect first.

49.3.3 Configure OSPF Route Redistribution

Network Requirements

- OSPF protocol is run between Device1 and Device2, and RIPv2 protocol is run between Device2 and Device3.
- Device2 redistributes RIP route to OSPF, and uses routing policy control to redistribute the route 100.0.0.0/24 only.

Network Topology

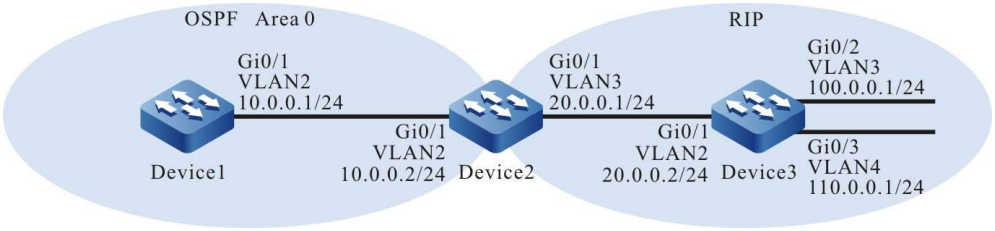


Figure 49-3 Network Topology for Configuring OSPF Route Redistribution

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure the OSPF protocol of Device1 and Device2; configure the RIPv2 protocol of Device2 and Device3.

#Configure the OSPF protocol of Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#network 10.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#Configure the OSPF and RIPv2 protocols of Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#network 10.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#exit
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 20.0.0.0
Device2(config-rip)#exit
```

#Configure the RIPv2 protocol of Device3.

```
Device3#configure terminal
Device3(config)#router rip
Device3(config-rip)#version 2
Device3(config-rip)#network 20.0.0.0
Device3(config-rip)#network 100.0.0.0
Device3(config-rip)#network 110.0.0.0
Device3(config-rip)#exit
```

#View the information of OSPF neighbors on Device1.

```
Device1#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
2.2.2.2           1   Full/DR         00:00:32    10.0.0.2        vlan2
```

#View the information of OSPF neighbors on Device2.

```
Device2#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           1   Full/Backup     00:00:32    10.0.0.1        vlan2
```

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:21:17, vlan2
C   20.0.0.0/24 is directly connected, 00:21:33, vlan3
R   100.0.0.0/24 [120/1] via 20.0.0.2, 00:10:58, vlan3
R   110.0.0.0/24 [120/1] via 20.0.0.2, 00:10:58, vlan3
C   127.0.0.0/8 is directly connected, 30:20:17, lo0
```

Device2 learns RIP routes.

Step 4: Configure routing policy.

#Configure Device2.

```
Device2(config)#ip access-list standard 1
Device2(config-std-nacl)#permit 100.0.0.0 0.0.0.255
Device2(config-std-nacl)#exit
Device2(config)#route-map RIPtoOSPF
Device2(config-route-map)#match ip address 1
Device2(config-route-map)#exit
```

Configure route-map to invoke ACL to match 100.0.0.0/24 only, and filter other network segments, such as 20.0.0.0/24 and 110.0.0.0/24.

Step 5: Configure OSPF to redistribute RIP routes and associate routing policy.

#Configure Device2.

```
Device2(config)#router ospf 100
Device2(config-ospf)#redistribute rip route-map RIPtoOSPF
Device2(config-ospf)#exit
```

When redistributing RIP routes, invoke the match rules of route-map for filtration.

Step 6: Check the result.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set
```

```
C   10.0.0.0/24 is directly connected, 00:47:27, vlan2
OE  100.0.0.0/24 [150/20] via 10.0.0.2, 00:21:39, vlan2
C   127.0.0.0/8 is directly connected, 21:40:06, lo0
```

The routing table of Device1 only learns 100.0.0.0/24, an OSPF external route. The two routes 20.0.0.0/24 and 110.0.0.0/24 are filtered out.

#View the information of OSPF process and database on Device2.

```
Device2#show ip ospf 100
 Routing Process "ospf 100" with ID 2.2.2.2
 Process bound to VRF default
 Process uptime is 1 hour 4 minutes
 IETF NSF restarter support disabled
 IETF NSF helper support enabled
 Conforms to RFC2328, and RFC1583Compatibility flag is disabled
 Supports only single TOS(TOS0) routes
 Supports opaque LSA
 Supports Graceful Restart
 This router is an ASBR (injecting external routing information)
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Refresh timer 10 secs
 Number of external LSA 2. Checksum Sum 0x0161F5
 Number of opaque AS LSA 0. Checksum Sum 0x000000
 Number of non-default external LSA is 2
 External LSA database is unlimited.
 Not Support Demand Circuit lsa number is 0, autonomy system support flood DoNotAge Lsa
 Number of areas attached to this router: 1
   Area 0 (BACKBONE)       Number of interfaces in this area is 1(1)
      Number of fully adjacent neighbors in this area is 1
      Number of fully adjacent sham-link neighbors in this area is 0
      Area has no authentication
      SPF algorithm last executed 00:37:52.833 ago
      SPF algorithm executed 3 times
      Number of LSA 3. Checksum Sum 0x00e746
      Not Support Demand Circuit lsa number is 0,
      Indication lsa (by other routers) number is: 0,
      Area support flood DoNotAge Lsa

Device2#show ip ospf 100 database

          OSPF Router with ID (2.2.2.2) (Process ID 100)

              Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         191 0x80000004 0x70a0 1
2.2.2.2         2.2.2.2         537 0x80000005 0x36ce 1

              Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
10.0.0.2        2.2.2.2         818 0x80000003 0x3fd8

              AS External Link States

Link ID         ADV Router      Age Seq#       CkSum  Route
100.0.0.0       2.2.2.2         718 0x80000002 0x72be E2 100.0.0.0/24  [0x0]
```

According to the information of OSPF 100 process, Device2 has become an ASBR, and only an external LSA is generated in the database.

Note

- In practical applications, if the autonomous system has 2 or more edge routers, directly redistributing routes between different routing protocols is not recommended. When necessary, routing policy needs to be configured to avoid routing loops.

49.3.4 Configure OSPF Multiprocess

Network Requirements

- All devices run OSPF protocol. Two OSPF processes are enabled on Device2. Neighbors are established between the OSPF 100 processes of Device1 and Device2, and between the OSPF 200 processes of Device3 and Device2.
- The two OSPF processes on Device2 redistribute routes to each other. OSPF 100 process uses routing policy control to redistribute the route 110.0.0.0/24 only; OSPF 200 process uses routing policy control to redistribute the route 100.0.0.0/24 only.

Network Topology

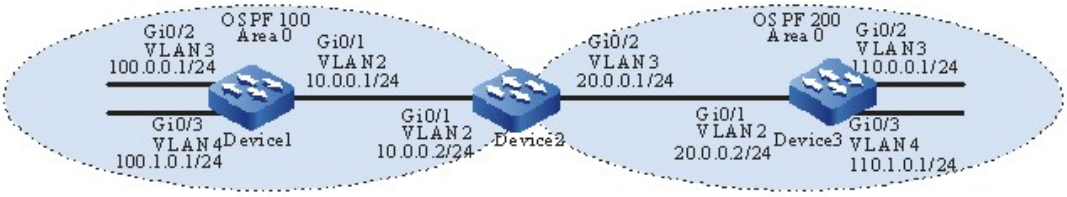


Figure 49-4 Network Topology for Configuring OSPF Multiprocess

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF protocol.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#network 10.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#network 100.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#network 100.1.0.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#On Device2, create 2 OSPF processes, i.e. process 100 and process 200.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#network 10.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#exit
Device2(config)#router ospf 200
Device2(config-ospf)#router-id 2.2.2.3
Device2(config-ospf)#network 20.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router ospf 200
Device3(config-ospf)#router-id 3.3.3.3
Device3(config-ospf)#network 20.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#network 110.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#network 110.1.0.0 0.0.0.255 area 0
Device3(config-ospf)#exit
```

Note

- When there are multiple OSPF processes, it is recommended to configure different Router IDs between OSPF processes to avoid Router ID conflict.

#View the information of LSDB and neighbors on Device2.

```
Device2#show ip ospf neighbor
OSPF process 100:
Neighbor ID     Pri   State           Dead Time   Address         Interface
1.1.1.1           1   Full/Backup     00:00:30    10.0.0.1        vlan2
OSPF process 200:
Neighbor ID     Pri   State           Dead Time   Address         Interface
3.3.3.3           1   Full/DR         00:00:33    20.0.0.2        vlan3

Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

          Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1           19 0x80000016 0x53bf 3
2.2.2.2         2.2.2.2           15 0x80000010 0x1ae1 1

          Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
10.0.0.2        2.2.2.2           21 0x80000001 0x43d6

        OSPF Router with ID (2.2.2.3) (Process ID 200)

          Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
2.2.2.3         2.2.2.3           14 0x8000000f 0xb235 1
3.3.3.3         3.3.3.3           15 0x8000001b 0x696b 3

          Net Link States (Area 0)
```

```
Link ID         ADV Router      Age Seq#       CkSum
20.0.0.2        3.3.3.3         15 0x80000002 0x03fe
```

On Device2 which owns the OSPF database by itself, the OSPF process 100 establishes neighbor relation with the process 200.

#View the OSPF routing table of Device2.

```
Device2#show ip ospf route
OSPF process 100:
Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2

O  10.0.0.0/24 [1] is directly connected, vlan2, Area 0
O  100.0.0.0/24 [2] via 10.0.0.1, vlan2, Area 0
O  100.1.0.0/24 [2] via 10.0.0.1, vlan2, Area 0
OSPF process 200:
Codes: C - connected, D - Discard, O - OSPF, IA - OSPF inter area
       N1 - OSPF NSSA external type 1, N2 - OSPF NSSA external type 2
       E1 - OSPF external type 1, E2 - OSPF external type 2

O  20.0.0.0/24 [1] is directly connected, vlan3, Area 0
O  110.0.0.0/24 [2] via 20.0.0.2, vlan3, Area 0
O  110.1.0.0/24 [2] via 20.0.0.2, vlan3, Area 0
```

The OSPF process 100 and 200 calculate their respective routes.

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:05:34, vlan2
C   20.0.0.0/24 is directly connected, 00:05:28, vlan3
O   100.0.0.0/24 [110/2] via 10.0.0.1, 00:04:42, vlan2
O   100.1.0.0/24 [110/2] via 10.0.0.1, 00:04:42, vlan2
O   110.0.0.0/24 [110/2] via 20.0.0.2, 00:04:41, vlan3
O   110.1.0.0/24 [110/2] via 20.0.0.2, 00:04:41, vlan3
C   127.0.0.0/8 is directly connected, 48:40:33, lo0
```

Step 4: Configure routing policy.

#Configure Device2.

```
Device2(config)#ip prefix-list 1 permit 110.0.0.0/24
Device2(config)#ip prefix-list 2 permit 100.0.0.0/24
Device2(config)#route-map OSPF200to100
Device2(config-route-map)#match ip address prefix-list 1
Device2(config-route-map)#exit
Device2(config)#route-map OSPF100to200
Device2(config-route-map)#match ip address prefix-list 2
Device2(config-route-map)#exit
```

Configure route-map to invoke prefix list 1 and 2 to match the network segment 110.0.0.0/24 and 100.0.0.0/24.

Note

- When configuring a routing policy, both the prefix list and ACL can create filtering rules. The difference is that the prefix list can exactly match the routing mask.

Step 5: Configure to redistribute routes between OSPF processes and associate routing policy.

#Configure Device2.

```
Device2(config)#router ospf 100
Device2(config-ospf)#redistribute ospf 200 route-map OSPF200to100
Device2(config-ospf)#exit
Device2(config)#router ospf 200
Device2(config-ospf)#redistribute ospf 100 route-map OSPF100to200
Device2(config-ospf)#exit
```

Step 6: Check the result.

#View the OSPF LSDB of Device2.

```
Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

          Router Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum  Link count
1.1.1.1       1.1.1.1         1663 0x80000016 0x53bf 3
2.2.2.2       2.2.2.2         216 0x80000011 0x1eda 1

          Net Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum
10.0.0.2      2.2.2.2         1664 0x80000001 0x43d6

          AS External Link States

Link ID       ADV Router      Age Seq#       CkSum  Route
110.0.0.0     2.2.2.2         216 0x80000001 0x3dfc E2 110.0.0.0/24  [0x0]

        OSPF Router with ID (2.2.2.3) (Process ID 200)

          Router Link States (Area 0)


Link ID       ADV Router      Age Seq#       CkSum  Link count
2.2.2.3       2.2.2.3         205 0x80000010 0xb62e 1
3.3.3.3       3.3.3.3         1658 0x8000001b 0x696b 3

          Net Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum
20.0.0.2      3.3.3.3         1658 0x80000002 0x03fe

          AS External Link States

Link ID       ADV Router      Age Seq#       CkSum  Route
100.0.0.0     2.2.2.3         205 0x80000001 0xb989 E2 100.0.0.0/24  [0x0]
```

It can be seen that the OSPF process 100 has the LSA of 110.0.0.0/24 only, and other routes 110.1.0.0/24 and 20.0.0.0/24 have been filtered out by the routing policy OSPF200to100; the OSPF process 200 has the LSA of 100.0.0.0/24 only, and other routes 100.1.0.0/24 and 10.0.0.0/24 have been filtered out by the routing policy OSPF100to200.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:40:20, vlan2
C   100.0.0.0/24 is directly connected, 03:11:36, vlan3
C   100.1.0.0/24 is directly connected, 01:00:22, vlan4
OE  110.0.0.0/24 [150/2] via 10.0.0.2, 00:15:27, vlan2
C   127.0.0.0/8 is directly connected, 97:08:23, lo0
```

Device1 learns the route 110.0.0.0/24 only.

#Check the routing table of Device3.

```
Device3#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   20.0.0.0/24 is directly connected, 00:42:44, vlan2
OE  100.0.0.0/24 [150/2] via 20.0.0.1, 00:17:45, vlan2
C   110.0.0.0/24 is directly connected, 01:02:03, vlan3
C   110.1.0.0/24 is directly connected, 01:02:14, vlan4
C   127.0.0.0/8 is directly connected, 41:02:01, lo0
```

Device3 learns the route 100.0.0.0/24 only.

Caution

- In practical applications, if the autonomous system has 2 or more edge routers, directly redistributing routes between different OSPF processes is not recommended. When necessary, route filtration policy needs to be configured to avoid routing loops.

49.3.5 Configure OSPF External Route Summarization

Network Requirements

- OSPF protocol is run between Device1 and Device2, and RIPv2 protocol is run between Device2 and Device3.
- Device2 redistributes RIP routes to OSPF. In order to reduce the number of routes on Device1, the RIP routes redistributed on ASBR are summarized as 20.0.0.0/16.

Network Topology

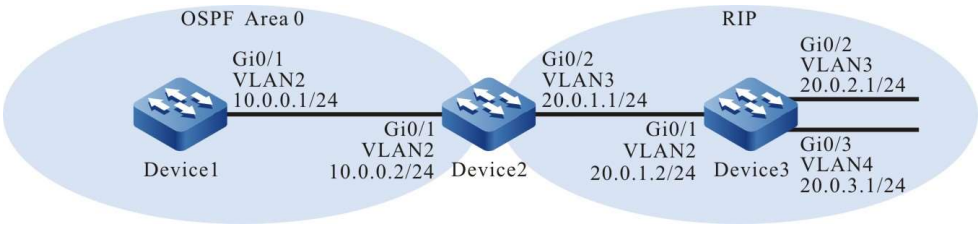


Figure 49-5 Network Topology for Configuring OSPF External Route Summarization

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF and RIPv2 protocols.

#Configure the OSPF protocol of Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#network 10.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#Configure the OSPF and RIPv2 protocols of Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#network 10.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#exit
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 20.0.0.0
Device2(config-rip)#exit
```

#Configure the RIPv2 protocol of Device3.

```
Device3#configure terminal
Device3(config)#router rip
Device3(config-rip)#version 2
Device3(config-rip)#network 20.0.0.0
Device3(config-rip)#exit
```

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
     D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:15:46, vlan2
C   20.0.1.0/24 is directly connected, 00:15:23, vlan3
R   20.0.2.0/24 [120/1] via 20.0.1.2, 00:12:17, vlan3
R   20.0.3.0/24 [120/1] via 20.0.1.2, 00:12:06, vlan3
C   127.0.0.0/8 is directly connected, 03:34:27, lo0
```

Step 4: Configure OSPF to redistribute RIP routes.

#Configure Device2.

```
Device2(config)#router ospf 100
Device2(config-ospf)#redistribute rip
Device2(config-ospf)#exit
```

#View the OSPF LSDB of Device2.

```
Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         1071 0x80000003 0x729f 1
2.2.2.2         2.2.2.2         873 0x80000004 0x38cd 1

            Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
10.0.0.2        2.2.2.2         1070 0x80000001 0x43d6

            AS External Link States

Link ID         ADV Router      Age Seq#       CkSum  Route
20.0.1.0        2.2.2.2         365 0x80000001 0x7d04 E2 20.0.1.0/24  [0x0]
20.0.2.0        2.2.2.2         365 0x80000001 0x720e E2 20.0.2.0/24  [0x0]
20.0.3.0        2.2.2.2         365 0x80000001 0x6718 E2 20.0.3.0/24  [0x0]
```

According to the OSPF database, 3 external LSAs have been generated. This indicates that RIP routes have been redistributed to OSPF.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:56:40, vlan2
OE  20.0.1.0/24 [150/20] via 10.0.0.2, 00:02:40, vlan2
OE  20.0.2.0/24 [150/20] via 10.0.0.2, 00:02:40, vlan2
OE  20.0.3.0/24 [150/20] via 10.0.0.2, 00:02:40, vlan2
C   127.0.0.0/8 is directly connected, 115:12:28, lo0
```

Device1 learns the RIP route redistributed by Device1.

Step 5: OSPF external route summarization is configured on ASBR. At this moment, Device2 acts as an ASBR.

#On Device2, summarize the RIP routes redistributed as 20.0.0.0/16.

```
Device2(config)#router ospf 100
Device2(config-ospf)#summary-address 20.0.0.0 255.255.0.0
Device2(config-ospf)#exit
```

Step 6: Check the result.

#View the OSPF LSDB of Device2.

```
Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

          Router Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum  Link count
1.1.1.1       1.1.1.1         1437 0x80000003 0x729f 1
2.2.2.2       2.2.2.2         1240 0x80000004 0x38cd 1

          Net Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum
10.0.0.2      2.2.2.2          144 0x80000002 0x41d7

          AS External Link States

Link ID       ADV Router      Age Seq#       CkSum  Route
20.0.0.0      2.2.2.2          84 0x80000001 0x88f9 E2 20.0.0.0/16  [0x0]
```

By comparing to step 3, you can see that the original 3 external LSAs in the database have been deleted, and a summarized external LSA is generated.

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:28:03, vlan2
O   20.0.0.0/16 [110/1] is directly connected, 00:04:48, null0
C   20.0.1.0/24 is directly connected, 00:27:40, vlan3
R   20.0.2.0/24 [120/1] via 20.0.1.2, 00:24:34, vlan3
R   20.0.3.0/24 [120/1] via 20.0.1.2, 00:24:23, vlan3
C   127.0.0.0/8 is directly connected, 03:46:44, lo0
```

Note

- A summarized route 20.0.0.0/16 which has an output interface pointing to Null0 will be automatically added in the routing table of Device2. This route can prevent loops from being produced.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:58:40, vlan2
OE  20.0.0.0/16 [150/20] via 10.0.0.2, 00:15:26, vlan2
```

```
C   127.0.0.0/8 is directly connected, 115:17:28, lo0
```

The routing table of Device1 learns the summarized route 20.0.0.0/16 only.

49.3.6 Configure OSPF Inter-area Summarization

Network Requirements

- All devices are configured with OSPF protocol, and there are two areas, i.e. area 0 and 1.
- In order to reduce the number of inter-area routes, inter-area summarization should be done on ABR to summarize the routes in area 0 as 10.0.0.0/16 and those in area 1 as 20.0.0.0/16.

Network Topology

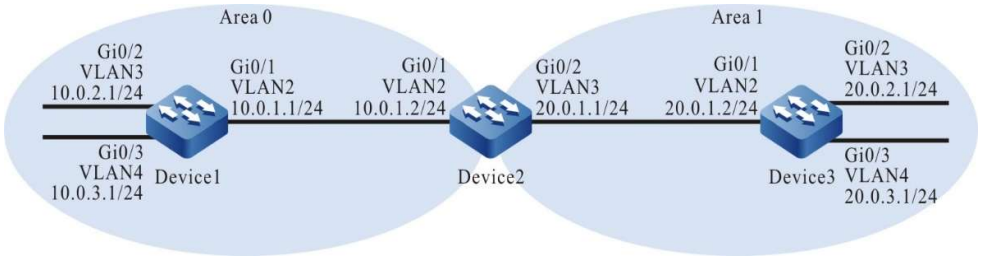


Figure 49-6 Network Topology for Configuring OSPF Inter-area Route Summarization

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF process and make different areas cover corresponding interfaces.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#network 10.0.1.0 0.0.0.255 area 0
Device1(config-ospf)#network 10.0.2.0 0.0.0.255 area 0
Device1(config-ospf)#network 10.0.3.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#network 10.0.1.0 0.0.0.255 area 0
Device2(config-ospf)#network 20.0.1.0 0.0.0.255 area 1
Device2(config-ospf)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router ospf 100
Device3(config-ospf)#router-id 3.3.3.3
Device3(config-ospf)#network 20.0.1.0 0.0.0.255 area 1
Device3(config-ospf)#network 20.0.2.0 0.0.0.255 area 1
Device3(config-ospf)#network 20.0.3.0 0.0.0.255 area 1
Device3(config-ospf)#exit
```

#View the OSPF LSDB and routing table on Device2.

```
Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         1419 0x80000007 0x4f81 3
2.2.2.2         2.2.2.2         1414 0x80000004 0x4bb9 1

            Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
10.0.1.2        2.2.2.2         1419 0x80000001 0x38e0

            Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Route
20.0.1.0        2.2.2.2         1437 0x80000001 0x47d7 20.0.1.0/24
20.0.2.0        2.2.2.2         1363 0x80000001 0x46d6 20.0.2.0/24
20.0.3.0        2.2.2.2         1363 0x80000001 0x3be0 20.0.3.0/24

            Router Link States (Area 1)


Link ID         ADV Router      Age Seq#       CkSum  Link count
2.2.2.2         2.2.2.2         1368 0x80000004 0xe70b 1
3.3.3.3         3.3.3.3         1341 0x80000006 0x6138 3

            Net Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum
20.0.1.1        2.2.2.2         1368 0x80000001 0x24e3

            Summary Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum  Route
10.0.1.0        2.2.2.2         1442 0x80000001 0xc95f 10.0.1.0/24
10.0.2.0        2.2.2.2         1409 0x80000001 0xc85e 10.0.2.0/24
10.0.3.0        2.2.2.2         1409 0x80000001 0xbd68 10.0.3.0/24

Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.1.0/24 is directly connected, 00:30:31, vlan2
O   10.0.2.0/24 [110/2] via 10.0.1.1, 00:23:37, vlan2
O   10.0.3.0/24 [110/2] via 10.0.1.1, 00:23:37, vlan2
C   20.0.1.0/24 is directly connected, 02:09:10, vlan3
O   20.0.2.0/24 [110/2] via 20.0.1.2, 00:22:51, vlan3
O   20.0.3.0/24 [110/2] via 20.0.1.2, 00:22:51, vlan3
C   127.0.0.0/8 is directly connected, 05:28:14, lo0
```

3 inter-area LSAs are generated in area 0 and 1 of OSPF database on Device2. The intra-area routes in each area are also added to the routing table.

#View the OSPF LSDB and routing table on Device1.

```
Device1#show ip ospf database

        OSPF Router with ID (1.1.1.1) (Process ID 100)

          Router Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum  Link count
1.1.1.1       1.1.1.1         249 0x80000008 0x4d82 3
2.2.2.2       2.2.2.2         191 0x80000005 0x49ba 1

          Net Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum
10.0.1.2      2.2.2.2         471 0x80000002 0x36e1

          Summary Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum  Route
20.0.1.0      2.2.2.2         251 0x80000002 0x45d8 20.0.1.0/24
20.0.2.0      2.2.2.2         1988 0x80000001 0x46d6 20.0.2.0/24
20.0.3.0      2.2.2.2         1988 0x80000001 0x3be0 20.0.3.0/24

Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.1.0/24 is directly connected, 00:25:11, vlan2
C   10.0.2.0/24 is directly connected, 00:24:58, vlan3
C   10.0.3.0/24 is directly connected, 00:24:44, vlan4
O   20.0.1.0/24 [110/2] via 10.0.1.2, 00:14:59, vlan2
O   20.0.2.0/24 [110/3] via 10.0.1.2, 00:14:12, vlan2
O   20.0.3.0/24 [110/3] via 10.0.1.2, 00:14:12, vlan2
C   127.0.0.0/8 is directly connected, 116:19:42, lo0
```

There are 3 inter-area LSAs in the OSPF database of Device1, which are also added to the routing table.

#View the OSPF LSDB and routing table on Device3.

```
Device3#show ip ospf database

        OSPF Router with ID (3.3.3.3) (Process ID 100)

          Router Link States (Area 1)

Link ID       ADV Router      Age Seq#       CkSum  Link count
2.2.2.2       2.2.2.2         532 0x80000005 0xe50c 1
3.3.3.3       3.3.3.3         506 0x80000007 0x5f39 3

          Net Link States (Area 1)

Link ID       ADV Router      Age Seq#       CkSum
20.0.1.1      2.2.2.2         532 0x80000002 0x22e4

          Summary Link States (Area 1)

Link ID       ADV Router      Age Seq#       CkSum  Route
10.0.1.0      2.2.2.2          82 0x80000002 0xc760 10.0.1.0/24
10.0.2.0      2.2.2.2         382 0x80000002 0xc65f 10.0.2.0/24
10.0.3.0      2.2.2.2         262 0x80000002 0xbb69 10.0.3.0/24

Device3#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

O   10.0.1.0/24 [110/2] via 20.0.1.1, 00:24:04, vlan2
O   10.0.2.0/24 [110/3] via 20.0.1.1, 00:24:04, vlan2
```

```
O   10.0.3.0/24 [110/3] via 20.0.1.1, 00:24:04, vlan2
C   20.0.1.0/24 is directly connected, 02:09:51, vlan2
C   20.0.2.0/24 is directly connected, 02:07:21, vlan3
C   20.0.3.0/24 is directly connected, 02:07:09, vlan4
C   127.0.0.0/8 is directly connected, 360:20:45, lo0
```

Likewise, there are 3 inter-area LSAs in the OSPF database of Device3, which are also added to the routing table.

Step 4: Inter-area route summarization is configured on ASBR. At this moment, Device2 acts as an ABR.

#On Device2, summarize the routes in area 0 as 10.0.0.0/16 and those in area 1 as 20.0.0.0/16.

```
Device2(config)#router ospf 100
Device2(config-ospf)#area 0 range 10.0.0.0/16
Device2(config-ospf)#area 1 range 20.0.0.0/16
Device2(config-ospf)#exit
```

Step 5: Check the result.

#View the OSPF LSDB and routing table on Device2.

```
Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         305 0x80000009 0x4b83 3
2.2.2.2         2.2.2.2         297 0x80000006 0x47bb 1

            Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
10.0.1.2        2.2.2.2         527 0x80000003 0x34e2

            Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Route
20.0.0.0        2.2.2.2          23 0x80000001 0x52cd 20.0.0.0/16

            Router Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum  Link count
2.2.2.2         2.2.2.2         277 0x80000006 0xe30d 1
3.3.3.3         3.3.3.3         332 0x80000008 0x5d3a 3

            Net Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum
20.0.1.1        2.2.2.2         317 0x80000003 0x20e5

            Summary Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum  Route
10.0.0.0        2.2.2.2          26 0x80000001 0xd455 10.0.0.0/16

Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS
```

```
Gateway of last resort is not set

O   10.0.0.0/16 [110/1] is directly connected, 00:00:31, null0
C   10.0.1.0/24 is directly connected, 00:40:31, vlan2
O   10.0.2.0/24 [110/2] via 10.0.1.1, 00:33:37, vlan2
O   10.0.3.0/24 [110/2] via 10.0.1.1, 00:33:37, vlan2
O   20.0.0.0/16 [110/1] is directly connected, 00:00:27, null0
C   20.0.1.0/24 is directly connected, 02:19:10, vlan3
O   20.0.2.0/24 [110/2] via 20.0.1.2, 00:32:51, vlan3
O   20.0.3.0/24 [110/2] via 20.0.1.2, 00:32:51, vlan3
C   127.0.0.0/8 is directly connected, 05:38:14, lo0
```

By comparing to step 2, you can see that a summarized inter-area LSA is generated in area 0 and 1 of OSPF database on Device2. Likewise, a summarized route pointing to Null0 interface will be automatically added to the routing table.

#View the OSPF LSDB and routing table on Device1.

```
Device1#show ip ospf database

        OSPF Router with ID (1.1.1.1) (Process ID 100)

          Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         1338 0x80000009 0x4b83 3
2.2.2.2         2.2.2.2         1332 0x80000006 0x47bb 1

          Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
10.0.1.2        2.2.2.2         1563 0x80000003 0x34e2

          Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Route
20.0.0.0        2.2.2.2          90 0x80000001 0x52cd 20.0.0.0/16

Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.1.0/24 is directly connected, 00:40:11, vlan2
C   10.0.2.0/24 is directly connected, 00:39:58, vlan3
C   10.0.3.0/24 is directly connected, 00:39:44, vlan4
O   20.0.0.0/16 [110/2] via 10.0.1.2, 00:02:18, vlan2
C   127.0.0.0/8 is directly connected, 116:44:42, lo0
```

According to the Device1, there is summarized inter-area LSA only in the OSPF database, and the routing table can only learn the route 20.0.0.0/16 summarized in area 1; Device3 can also learn the route 10.0.0.0/16 summarized in area 0.

49.3.7 Configure OSPF Inter-area Route Filtration

Network Requirements

- All devices are configured with OSPF protocol, and there are two areas, i.e. area 0 and 1.
- Filter inter-area routes on ABR. The route 20.0.3.0/24 is not allowed to be injected into area 0, and the route 10.0.3.0/24 is not allowed to flood to other areas.

Network Topology

Figure 49-7 Network Topology for Configuring Filtration of OSPF Inter-area Routes

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF process and make different areas cover corresponding interfaces.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#network 10.0.1.0 0.0.0.255 area 0
Device1(config-ospf)#network 10.0.2.0 0.0.0.255 area 0
Device1(config-ospf)#network 10.0.3.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#network 10.0.1.0 0.0.0.255 area 0
Device2(config-ospf)#network 20.0.1.0 0.0.0.255 area 1
Device2(config-ospf)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router ospf 100
Device3(config-ospf)#router-id 3.3.3.3
Device3(config-ospf)#network 20.0.1.0 0.0.0.255 area 1
Device3(config-ospf)#network 20.0.2.0 0.0.0.255 area 1
Device3(config-ospf)#network 20.0.3.0 0.0.0.255 area 1
Device3(config-ospf)#exit
```

#View the OSPF LSDB and routing table on Device2.

```
Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         329 0x8000005b 0xa6d5 3
2.2.2.2         2.2.2.2         324 0x80000051 0xb007 1
```

```
            Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
10.0.1.2        2.2.2.2         324 0x8000004e 0x9d2e

            Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Route
20.0.1.0        2.2.2.2         324 0x8000004e 0xac25 20.0.1.0/24
20.0.2.0        2.2.2.2         324 0x8000004d 0xad23 20.0.2.0/24
20.0.3.0        2.2.2.2         259 0x80000001 0x3be0 20.0.3.0/24

            Router Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum  Link count
2.2.2.2         2.2.2.2         334 0x80000055 0x4f51 1
3.3.3.3         3.3.3.3         335 0x80000059 0xca7a 3

            Net Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum
20.0.1.2        3.3.3.3         340 0x80000001 0xeb17

            Summary Link States (Area 1)

Link ID         ADV Router      Age Seq#       CkSum  Route
10.0.1.0        2.2.2.2         365 0x80000001 0xc95f 10.0.1.0/24
10.0.2.0        2.2.2.2         319 0x80000001 0xc85e 10.0.2.0/24
10.0.3.0        2.2.2.2         256 0x80000001 0xbd68 10.0.3.0/24

Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.1.0/24 is directly connected, 00:06:13, vlan2
O   10.0.2.0/24 [110/2] via 10.0.1.1, 00:05:22, vlan2
O   10.0.3.0/24 [110/2] via 10.0.1.1, 00:05:22, vlan2
C   20.0.1.0/24 is directly connected, 00:06:19, vlan3
O   20.0.2.0/24 [110/2] via 20.0.1.2, 00:05:32, vlan3
O   20.0.3.0/24 [110/2] via 20.0.1.2, 00:05:32, vlan3
C   127.0.0.0/8 is directly connected, 94:42:22, lo0
```

3 inter-area LSAs are generated in area 0 and 1 of OSPF database on Device2. The routes in each area are also added to the routing table.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.1.0/24 is directly connected, 00:08:41, vlan2
C   10.0.2.0/24 is directly connected, 37:59:10, vlan3
C   10.0.3.0/24 is directly connected, 38:05:36, vlan4
O   20.0.1.0/24 [110/2] via 10.0.1.2, 00:07:55, vlan2
O   20.0.2.0/24 [110/3] via 10.0.1.2, 00:07:55, vlan2
O   20.0.3.0/24 [110/3] via 10.0.1.2, 00:06:50, vlan2
C   127.0.0.0/8 is directly connected, 70:07:32, lo0
```

Device1 learns the routes in area 1 only.

#Check the routing table of Device3.

```
Device3#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
```

```
D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

O   10.0.1.0/24 [110/2] via 20.0.1.1, 00:08:44, vlan2
O   10.0.2.0/24 [110/3] via 20.0.1.1, 00:08:33, vlan2
O   10.0.3.0/24 [110/3] via 20.0.1.1, 00:07:30, vlan2
C   20.0.1.0/24 is directly connected, 00:09:31, vlan2
C   20.0.2.0/24 is directly connected, 37:59:57, vlan3
C   20.0.3.0/24 is directly connected, 38:03:35, vlan4
C   127.0.0.0/8 is directly connected, 61:26:38, lo0
```

Device3 learns the routes in area 0 only.

Step 4: Configure route filtration policy.

#Configure Device2.

```
Device2(config)#ip prefix-list 1 deny 10.0.3.0/24
Device2(config)#ip prefix-list 1 permit 0.0.0.0/0 le 32
Device2(config)#ip prefix-list 2 deny 20.0.3.0/24
Device2(config)#ip prefix-list 2 permit 0.0.0.0/0 le 32
Device2(config)#exit
```

Prefix list 1 means to filter the network 10.0.3.0/24 and allow all the other networks; 2 means to filter the network 20.0.3.0/24 and allow all the other networks.

Step 5: Configure inter-area route filtration on ASBR, and invoke the match rules of prefix list.

#Configure Device2.

```
Device2(config)#router ospf 100
Device2(config-ospf)#area 0 filter-list prefix 1 out
Device2(config-ospf)#area 0 filter-list prefix 2 in
Device2(config-ospf)#exit
```

Step 6: Check the result.

#View the OSPF LSDB of Device2.

```
Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

            Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         679 0x8000005b 0xa6d5 3
2.2.2.2         2.2.2.2         673 0x80000051 0xb007 1

            Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
10.0.1.2        2.2.2.2         673 0x8000004e 0x9d2e

            Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Route
20.0.1.0        2.2.2.2         673 0x8000004e 0xac25 20.0.1.0/24
20.0.2.0        2.2.2.2         673 0x8000004d 0xad23 20.0.2.0/24
```

```
            Router Link States (Area 1)

Link ID       ADV Router      Age Seq#       CkSum  Link count
2.2.2.2       2.2.2.2          683 0x80000055 0x4f51 1
3.3.3.3       3.3.3.3          684 0x80000059 0xca7a 3

            Net Link States (Area 1)

Link ID       ADV Router      Age Seq#       CkSum
20.0.1.2      3.3.3.3          689 0x80000001 0xeb17

            Summary Link States (Area 1)

Link ID       ADV Router      Age Seq#       CkSum  Route
10.0.1.0      2.2.2.2          714 0x80000001 0xc95f 10.0.1.0/24
10.0.2.0      2.2.2.2          668 0x80000001 0xc85e 10.0.2.0/24
```

By comparing to the result of step 2, you can see that the LSAs of the networks 20.0.3.0/24 and 10.0.3.0/24 in OSPF database have been deleted from area 0 and 1.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.1.0/24 is directly connected, 00:12:57, vlan2
C   10.0.2.0/24 is directly connected, 38:03:25, vlan3
C   10.0.3.0/24 is directly connected, 38:09:52, vlan4
O   20.0.1.0/24 [110/2] via 10.0.1.2, 00:12:11, vlan2
O   20.0.2.0/24 [110/3] via 10.0.1.2, 00:12:11, vlan2
C   127.0.0.0/8 is directly connected, 70:11:48, lo0
```

There has been no 20.0.3.0/24 in the routing table of Device1.

#Check the routing table of Device3.

```
Device3#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

O   10.0.1.0/24 [110/2] via 20.0.1.1, 00:13:09, vlan2
O   10.0.2.0/24 [110/3] via 20.0.1.1, 00:12:58, vlan2
C   20.0.1.0/24 is directly connected, 00:13:56, vlan2
C   20.0.2.0/24 is directly connected, 38:04:22, vlan3
C   20.0.3.0/24 is directly connected, 38:08:00, vlan4
C   127.0.0.0/8 is directly connected, 64:31:03, lo0
```

There has been no 10.0.3.0/24 in the routing table of Device3 either.

49.3.8 Configure a Full Stub Area for OSPF

Network Requirements

- All devices are configured with OSPF protocol, and there are three areas, i.e. area 0, 1 and 2. In particular, area 1 is a totally Stub area.
- On Device4, redistribute a static route to OSPF. Upon completion of the configuration, the totally Stub area cannot learn inter-area and external routes, those devices in

other areas can learn them.

Network Topology

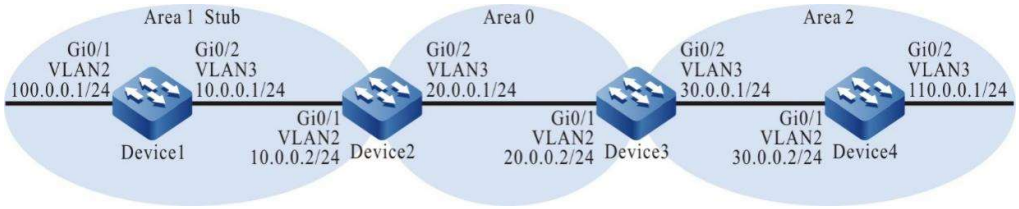


Figure 49-8 Network Topology for Configuring OSPF Totally Stub Area

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF process and make areas cover corresponding interfaces.

#On Device1, configure area 1 as Stub area.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#area 1 stub
Device1(config-ospf)#network 10.0.0.0 0.0.0.255 area 1
Device1(config-ospf)#network 100.0.0.0 0.0.0.255 area 1
Device1(config-ospf)#exit
```

#On Device2, configure area 1 as a totally Stub area. Device2 as an ABR. No-summary cannot take effect unless it is configured on ABR.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#area 1 stub no-summary
Device2(config-ospf)#network 10.0.0.0 0.0.0.255 area 1
Device2(config-ospf)#network 20.0.1.0 0.0.0.255 area 0
Device2(config-ospf)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router ospf 100
Device3(config-ospf)#router-id 3.3.3.3
Device3(config-ospf)#network 20.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#network 30.0.0.0 0.0.0.255 area 2
Device3(config-ospf)#exit
```

#Configure Device4.

```
Device4#configure terminal
Device4(config)#router ospf 100
Device4(config-ospf)#router-id 4.4.4.4
Device4(config-ospf)#network 30.0.0.0 0.0.0.255 area 2
Device4(config-ospf)#network 110.0.0.0 0.0.0.255 area 2
Device4(config-ospf)#exit
```

Step 4: Configure a static route for Device4 and redistribute it to OSPF.

#Configure Device4.

```
Device4(config)#ip route 200.1.1.0 255.255.255.0 110.0.0.2
Device4(config)#router ospf 100
Device4(config-ospf)#redistribute static
Device4(config-ospf)#exit
```

Step 5: Check the result.

#View the OSPF LSDB and routing table on Device1.

```
Device1#show ip ospf database

        OSPF Router with ID (1.1.1.1) (Process ID 100)

            Router Link States (Area 1 [Stub])

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1           19 0x80000009 0x8513 2
2.2.2.2         2.2.2.2           22 0x80000005 0x51b6 1

            Net Link States (Area 1 [Stub])

Link ID         ADV Router      Age Seq#       CkSum
10.0.0.2        2.2.2.2           22 0x80000001 0x61ba

            Summary Link States (Area 1 [Stub])

Link ID         ADV Router      Age Seq#       CkSum  Route
0.0.0.0         2.2.2.2           55 0x80000002 0x73c1 0.0.0.0/0

Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is 10.0.0.2 to network 0.0.0.0

O   0.0.0.0/0 [110/2] via 10.0.0.2, 00:00:19, vlan3
C   10.0.0.0/24 is directly connected, 00:01:04, vlan3
C   100.0.0.0/24 is directly connected, 00:11:55, vlan2
C   127.0.0.0/8 is directly connected, 30:46:57, lo0
```

According to the OSPF database, there are no inter-area LSA or external route LSA except for an inter-area LSA of 0.0.0.0/0 in area 1. The ABR in Stub area will generate an inter-area route of 0.0.0.0/0 which floods in the totally Stub area. The data leading to the outside of area and AS are all forwarded through this default route.

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:01:02, vlan2
C   20.0.0.0/24 is directly connected, 00:00:59, vlan3
```

```
O   30.0.0.0/24 [110/2] via 20.0.0.2, 00:00:17, vlan3
O   100.0.0.0/24 [110/2] via 10.0.0.1, 00:00:10, vlan2
O   110.0.0.0/24 [110/3] via 20.0.0.2, 00:00:17, vlan3
C   127.0.0.0/8 is directly connected, 56:07:04, lo0
OE  200.1.1.0/24 [150/20] via 20.0.0.2, 00:00:16, vlan3
```

According to the result, Device2 can learn inter-area routes and external routes.

Note

- When the command **area** *area-id* **stub** is configured on the ABR of the Stub area only without adding **no-summary**, the devices in this area can learn inter-area routes instead of external routes, and they still access the network outside the AS through the default route.

49.3.9 Configure OSPF NSSA

Network Requirements

- All devices are configured with OSPF protocol, and there are three areas, i.e. area 0, 1 and 2. In particular, area 1 and 2 are NSSA areas.
- On Device4, redistribute a static route to OSPF. Upon completion of the configuration, all devices can learn intra-area and inter-area routes, yet external routes cannot be injected to area 1.
- Import a default route on the ABR of area 1 so that Device1 can access external network through the default route.

Network Topology

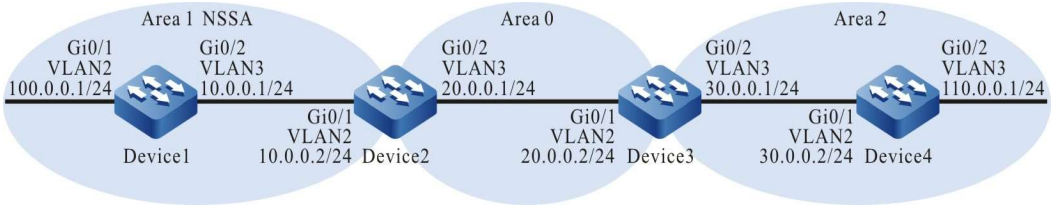


Figure 49-9 Network Topology for Configuring OSPF NSSA Area

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF process and make areas cover corresponding interfaces.

#On Device1, configure area 1 as NSSA area.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#area 1 nssa
Device1(config-ospf)#network 10.0.0.0 0.0.0.255 area 1
Device1(config-ospf)#network 100.0.0.0 0.0.0.255 area 1
Device1(config-ospf)#exit
```

#On Device2, configure area 1 as NSSA area.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#area 1 nssa
Device2(config-ospf)#network 10.0.0.0 0.0.0.255 area 1
Device2(config-ospf)#network 20.0.1.0 0.0.0.255 area 0
Device2(config-ospf)#exit
```

#On Device3, configure area 2 as NSSA area.

```
Device3#configure terminal
Device3(config)#router ospf 100
Device3(config-ospf)#router-id 3.3.3.3
Device3(config-ospf)#area 2 nssa
Device3(config-ospf)#network 20.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#network 30.0.0.0 0.0.0.255 area 2
Device3(config-ospf)#exit
```

#On Device4, configure area 2 as NSSA area.

```
Device4#configure terminal
Device4(config)#router ospf 100
Device4(config-ospf)#router-id 4.4.4.4
Device4(config-ospf)#area 2 nssa
Device4(config-ospf)#network 30.0.0.0 0.0.0.255 area 2
Device4(config-ospf)#network 110.0.0.0 0.0.0.255 area 2
Device4(config-ospf)#exit
```

Step 4: Configure a static route for Device4 and redistribute it to OSPF.

#Configure Device4.

```
Device4(config)#ip route 200.1.1.0 255.255.255.0 110.0.0.2
Device4(config)#router ospf 100
Device4(config-ospf)#redistribute static
Device4(config-ospf)#exit
```

#View the OSPF LSDB of Device3.

```
Device3#show ip ospf database

        OSPF Router with ID (3.3.3.3) (Process ID 100)

          Router Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Link count
2.2.2.2         2.2.2.2         179 0x80000004 0xe110 1
3.3.3.3         3.3.3.3         177 0x80000004 0xa345 1

          Net Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
20.0.0.2        3.3.3.3         182 0x80000001 0xf60d
```

```
            Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum  Route
10.0.0.0        2.2.2.2          214 0x80000001 0xd455 10.0.0.0/24
100.0.0.0       2.2.2.2          173 0x80000001 0x4886 100.0.0.0/24
30.0.0.0        3.3.3.3          208 0x80000001 0xb160 30.0.0.0/24
110.0.0.0       3.3.3.3          171 0x80000001 0xa719 110.0.0.0/24

            ASBR-Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
4.4.4.4         3.3.3.3          171 0x80000001 0x72ac

            Router Link States (Area 2 [NSSA])

Link ID         ADV Router      Age Seq#       CkSum  Link count
3.3.3.3         3.3.3.3          175 0x80000004 0x686f 1
4.4.4.4         4.4.4.4          177 0x80000005 0xe46a 2

            Net Link States (Area 2 [NSSA])

Link ID         ADV Router      Age Seq#       CkSum
30.0.0.2        4.4.4.4          177 0x80000001 0xc827

            Summary Link States (Area 2 [NSSA])

Link ID         ADV Router      Age Seq#       CkSum  Route
10.0.0.0        3.3.3.3          172 0x80000001 0xde48 10.0.0.0/24
20.0.0.0        3.3.3.3          214 0x80000001 0x52cb 20.0.0.0/24
100.0.0.0       3.3.3.3          172 0x80000001 0x5279 100.0.0.0/24

            NSSA-external Link States (Area 2 [NSSA])


Link ID         ADV Router      Age Seq#       CkSum  Route
200.1.1.0       4.4.4.4          247 0x80000001 0x6cde N2 200.1.1.0/24 [0x0]

            AS External Link States

Link ID         ADV Router      Age Seq#       CkSum  Route
200.1.1.0       3.3.3.3          176 0x80000001 0x0156 E2 200.1.1.0/24  [0x0]
```

According to the OSPF database, the NSSA-external LSA can be transformed into AS External LSA on the ABR of NSSA area (area 2) so that other areas can normally learn the external routes redistributed from NSSA area (area 2).

#View the routing table of Device 2.

```
Device2#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:02:53, vlan2
C   20.0.0.0/24 is directly connected, 00:02:51, vlan3
O   30.0.0.0/24 [110/2] via 20.0.0.2, 00:02:04, vlan3
O   100.0.0.0/24 [110/2] via 10.0.0.1, 00:02:04, vlan2
O   110.0.0.0/24 [110/3] via 20.0.0.2, 00:02:02, vlan3
C   127.0.0.0/8 is directly connected, 06:47:22, lo0
OE  200.1.1.0/24 [150/20] via 20.0.0.2, 00:02:02, vlan3
```

Device2 has learned the external routes redistributed from NSSA area (area 2).

#View the routing table of Device1.

```
Device1#show ip route
```

```
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   10.0.0.0/24 is directly connected, 00:02:29, vlan3
O   20.0.0.0/24 [110/2] via 10.0.0.2, 00:01:44, vlan3
O   30.0.0.0/24 [110/3] via 10.0.0.2, 00:01:41, vlan3
C   100.0.0.0/24 is directly connected, 01:53:00, vlan2
O   110.0.0.0/24 [110/4] via 10.0.0.2, 00:01:40, vlan3
C   127.0.0.0/8 is directly connected, 383:45:55, lo0
```

According to the result, there is no 200.1.1.0/24 in the routing table of Device1. This indicates that the external routes redistributed from Device4 are not injected into the NSSA area (area 1), and other inter-area routes have been added into the routing table.

Step 5: Configure Device2 to import default route to area 1.

#Configure Device2 which is the ABR of area 1.

```
Device2(config)#router ospf 100
Device2(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#area 1 nssa default-information-originate
Device2(config-ospf)#exit
```

Note

- After the command **area** *area-id* **nssa no-summary** is configured on the ABR of NSSA area, this area is also called a totally NSSA area. At this moment, ABR also generates a default route and floods to the NSSA area. Configuring this command can further reduce summary LSA and corresponding inter-area routes. Then the networks outside the area and AS are accessed through this default route.

Step 6: Check the result.

#View the OSPF LSDB of Device2.

```
Device2#show ip ospf database

        OSPF Router with ID (2.2.2.2) (Process ID 100)

          Router Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum  Link count
2.2.2.2       2.2.2.2         455 0x80000004 0xe110 1
3.3.3.3       3.3.3.3         455 0x80000004 0xa345 1

          Net Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum
20.0.0.2      3.3.3.3         461 0x80000001 0xf60d

          Summary Link States (Area 0)

Link ID       ADV Router      Age Seq#       CkSum  Route
```

```
10.0.0.0        2.2.2.2         492 0x80000001 0xd455 10.0.0.0/24
100.0.0.0       2.2.2.2         449 0x80000001 0x4886 100.0.0.0/24
30.0.0.0        3.3.3.3         487 0x80000001 0xb160 30.0.0.0/24
110.0.0.0       3.3.3.3         449 0x80000001 0xa719 110.0.0.0/24

            ASBR-Summary Link States (Area 0)

Link ID         ADV Router      Age Seq#       CkSum
4.4.4.4         3.3.3.3         449 0x80000001 0x72ac

            Router Link States (Area 1 [NSSA])

Link ID         ADV Router      Age Seq#       CkSum  Link count
1.1.1.1         1.1.1.1         456 0x80000005 0x8d0f 2
2.2.2.2         2.2.2.2         457 0x80000004 0x59ad 1

            Net Link States (Area 1 [NSSA])

Link ID         ADV Router      Age Seq#       CkSum
10.0.0.2        2.2.2.2         457 0x80000001 0x61ba

            Summary Link States (Area 1 [NSSA])

Link ID         ADV Router      Age Seq#       CkSum  Route
20.0.0.0        2.2.2.2         492 0x80000001 0x70b1 20.0.0.0/24
30.0.0.0        2.2.2.2         449 0x80000001 0xf71f 30.0.0.0/24
110.0.0.0       2.2.2.2         448 0x80000001 0xedd7 110.0.0.0/24

            NSSA-external Link States (Area 1 [NSSA])


Link ID         ADV Router      Age Seq#       CkSum  Route
0.0.0.0         2.2.2.2         31 0x80000001 0x5b42 N2 0.0.0.0/0 [0x0]

            AS External Link States

Link ID         ADV Router      Age Seq#       CkSum  Route
200.1.1.0       3.3.3.3         454 0x80000001 0x0156 E2 200.1.1.0/24  [0x0]
```

OSPF generates a NSSA-external LSA for the default route.

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

OE  0.0.0.0/0 [150/1] via 10.0.0.2, 00:00:22, vlan3
C   10.0.0.0/24 is directly connected, 00:07:29, vlan3
O   20.0.0.0/24 [110/2] via 10.0.0.2, 00:06:44, vlan3
O   30.0.0.0/24 [110/3] via 10.0.0.2, 00:06:41, vlan3
C   100.0.0.0/24 is directly connected, 01:58:00, vlan2
O   110.0.0.0/24 [110/4] via 10.0.0.2, 00:06:40, vlan3
C   127.0.0.0/8 is directly connected, 383:50:55, lo0
```

The routing table of Device1 also learns the default route 0.0.0.0/0. The communication with the external routes of AS is achieved through this default route.

50 OSPFv3

50.1 Overview

OSPFv3 is the shortened form of OSPF (Open Shortest Path First) version 3.Supporting IPv6, it follows RFC2328 and RFC2740, and allows the OSPF extension defined by other relevant RFC.

The principle of OSPFv3 is almost the same as that of OSPFv2. It simply modifies some different IP protocols and address families. Their differences are shown below:

- OSPFv3 runs based on link, while OSPFv2 runs based on network segment;
- Each link of OSPFv3 supports multiple instances;
- OSPFv3 identifies neighbors with Router ID, while SPFv2 identifies neighbors with IP address;

50.2 OSPFv3 Function Configuration

Table 50 OSPFv3 Function Configuration List

Configuration Task	
Configure Basic Functions of OSPFv3	Enable OSPFv3 Protocol
Configure OSPFv3 Area	Configure OSPFv3 NSSA Area
	Configure OSPFv3 Stub Area
	Configure OSPFv3 Virtual Link
Configure Network Type of OSPFv3	Configure Network Type of OSPFv3 Interface as Broadcast
	Configure Network Type of OSPFv3 Interface as P2P
	Configure Network Type of OSPFv3 Interface as NBMA

Configuration Task	
	Configure Network Type of OSPFv3 Interface as P2MP
Configure OSPFv3 Network Authentication	Configure OSPFv3 Area Authentication
	Configure OSPFv3 Interface Authentication
Configure OSPFv3 Route Generation	Configure OSPFv3 Route Redistribution
	Configure OSPFv3 Default Route
Configure OSPFv3 Route Control	Configure OSPFv3 Inter-area Route Summarization
	Configure OSPFv3 External Route Summarization
	Configure OSPFv3 Inter-area Route Filtration
	Configure OSPFv3 External Route Filtration
	Configure OSPFv3 Route Installation Filtration
	Configure OSPFv3 Interface Cost Value
	Configure OSPFv3 Reference Bandwidth
	Configure OSPFv3 Administrative Distance
	Configure the Maximum Number of OSPFv3 Load Balancing Entries
Configure OSPFv3 Network Optimization	Configure Keepalive Time of OSPFv3 Neighbors
	Configure Passive OSPFv3 Interface
	Configure OSPFv3 Demand Circuit
	Configure OSPFv3 Interface Priority
	Configure OSPFv3 Interface to Ignore MTU

Configuration Task	
	Configure LSA Transfer Delay of OSPFv3 Interface
	Configure OSPFv3 LSA retransmission
	Configure OSPFv3 SPF Calculation Time
Configure OSPFv3 GR	Configure OSPFv3 GR Restarter
	Configure OSPFv3 GR Helper
Configure Coordination of OSPFv3 with BFD	Configure Coordination of OSPFv3 with BFD

50.2.1 Configure Basic Functions of OSPFv3

In the various configuration tasks of OSPFv3, you must first enable the OSPFv3 protocol so that the configuration of the other function features can take effect.

Configuration Condition

Before configuring the basic OSPFv3 functions, do the following:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Enable the IPv6 forwarding function.

Enable OSPFv3 Protocol

To enable the OSPFv3 function, first create an OSPFv3 process, specify the router ID of this process, and enable the OSPFv3 protocol on the interface.

The device where OSPFv3 protocol is running must have a Router ID, which is used to uniquely identify a device in an OSPFv3 AS. The uniqueness of the Router ID in the AS must be guaranteed. Otherwise, it will influence the neighbor establishment and route learning. In OSPFv3, an IPv4 address format and Router ID are required to be manually configured.

OSPFv3 supports multiple processes that are identified with process number, and different processes are independent of each other.

Table 1 Enabling OSPFv3 Protocol

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create OSPFv3 process and enter OSPF configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	Mandatory Enable the OSPFv3 process directly or from VRF. By default, the OSPFv3 protocol is disabled in the system. When OSPFv3 is enabled from VRF, the OSPFv3 process belonging to a certain VRF can manage the interfaces belonging to this VRF only.
Configure the Router ID of OSPFv3 process	**router-id** *ipv4-address*	Mandatory
Return to the global configuration mode	**exit**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Enable the OSPFv3 protocol on the interface	**ipv6 router ospf** *process-id* **area** *area-id* [**instance-id** *instance-id*]	Mandatory By default, the OSPFv3 protocol is disabled on the interface.

50.2.2 Configure OSPFv3 Area

In order to reduce the CPU and memory usage by a large amount of database information, the OSPFv3 AS is divided into multiple areas. The area is identified by a 32-bit area ID, which can be represented by a decimal number ranging from 0 to 4294967295 or an IP address within 0.0.0.0 - 255.255.255.255. Area 0 or 0.0.0.0 means the backbone area of OSPFv3, and others are non-backbone areas. All the inter-area routing information needs to be forwarded through backbone areas. Routing information cannot be directly exchanged between non-backbone areas.

OSPFv3 defines several types of routers:

- Internal Router: The device whose all interfaces belong to the same area;

- Area Border Router (ABR): The device connecting to multiple areas;
- Automonous System Boundary Router (ASBR): The device which imports external route for OSPFv3 AS.

Configuration Condition

Before configuring OSPFv3 area, ensure that:

- Enable the IPv6 forwarding function.
- Enable the OSPFv3 protocol.

Configure OSPFv3 NSSA Area

Type-7 LSA instead of Type-5 LSA is allowed to be injected into the Not-So-Stub-Area (NSSA). By configuring redistribution to import external routes to the NSSA area. The ASBR in the NSSA area generates Type-7 LSA and floods it to the NSSA area. The ABR in the NSSA area will convert Type-7 LSAs into Type-5 LSAs, and then flood these Type-5 LSAs to the entire AS.

The OSPFv3 NSSA area configured through the command **area** *area-id* **nssa no-summary** is called a totally NSSA area. The OSPFv3 totally NSSA area prohibits inter-area routes from flooding. At this time, ABR will generate a default route and flood it into the NSSA area. Devices in the NSSA area will access the networks outside the area through this default route.

Table 50 Configuring OSPFv3 NSSA Area

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure NSSA area	**area** *area-id* **nssa** [**no-redistribution** / **no-summary** / **default-information-originate** [**metric** *metric-value* / **metric-type** *type-value*]]	Mandatory By default, OSPFv3 area is not a NSSA area.

Note

- Backbone areas cannot be configured as NSSA areas.
- All devices in the same NSSA area must be configured as NSSA areas. Neighbor relations cannot

be formed between the devices with inconsistent area types.

Configure OSPFv3 Stub Area

The Stub area does not allow AS external routes to flood. This can reduce the size of the link status database. After an areas is configured as Stub, the ABR on the border of Stub will generate a default route and flood it into the Stub area. Devices in the Stub area will access the networks outside the AS through this default route.

The OSPFv3 Stub area configured through the command **area** *area-id* **stub no-summary** is called a totally Stub area. The OSPFv3 totally Stub area prohibits inter-area routes or external routes from flooding. Devices in the area will access the networks outside the area and the OSPFv3 AS through the default route.

Table 2 Configuring OSPFv3 Stub Area

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure Stub area	**area** *area-id* **stub** [**no-summary**]	Mandatory By default, OSPFv3 area is not a Stub area.

Note

- Backbone areas cannot be configured as Stub areas.
- All devices in the same Stub area must be configured as Stub areas. Neighbor relations cannot be formed between the devices with inconsistent area types.

Configure OSPFv3 Virtual Link

In OSPFv3, non-backbone areas must complete database synchronization and data interaction through backbone areas. Therefore, all non-backbone areas must connect with backbone areas.

When this requirement cannot be satisfied in some circumstances, you may configure a virtual link. After a virtual link is configured, you can configure authentication method and modify Hello time interval for the virtual link. Meanings of these parameters are consistent with those of general OSPFv3 interface parameters.

Table 3 Configuring OSPFv3 Virtual Link

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure virtual link	**area** *transit-area-id* **virtual-link** *neighbor-id* [**dead-interval** *seconds* / **hello-interval** *seconds* / **retransmit-interval** *seconds* / **transmit-delay** *seconds*]	Mandatory By default, no virtual link is created.

Note

- Virtual link must be configured between two ABRs.
- The two ABRs configured with virtual links must be within the same common area, which is called the Transit Area of the virtual link.
- This Transit Area shall not be a Stub or NSSA area.

50.2.3 Configure Network Type of OSPFv3

Depending on the link protocol type, OSPFv3 divides networks into four types:

- Broadcast Networks - When the link protocol is Ethernet or FDDI, the OSPFv3 network type is broadcast by default.
- P2P (Point To Point Network) - When the link protocol is PPP, LAPB or HDLC, the OSPFv3 network type is P2P by default.
- NBMA (Non-Broadcast Multi-Access Network) - When the link protocol is ATM, frame relay or X.25, the OSPFv3 network type is NBMA by default.
- P2MP (Point To Multi-Point Network) - No link protocol will be deemed as P2MP by OSPFv3 by default. Generally, the NBMA network which is not fully connected is configured as an OSPFv3 P2MP.

The network type of OSPFv3 interface can be modified as needed. The network types of the interfaces that establish OSPFv3 neighbors must be consistent, or the normal learning of routes will be affected.

Configuration Condition

Before configuring OSPFv3 network type, ensure that:

- Enable the IPv6 forwarding function.
- Enable the OSPFv3 protocol.

Configure Network Type of OSPFv3 Interface as Broadcast

Broadcast network supports multiple (more than two) devices that can exchange information with all the devices on the network. OSPFv3 uses Hello packets to dynamically find neighbors.

Table 4 Configuring Network Type of OSPFv3 Interface as Broadcast

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure Network Type of OSPFv3 Interface as Broadcast	**ipv6 ospf network broadcast**	Mandatory By default, the network type of OSPFv3 interface depends on the protocol in link layer.

Configure Network Type of OSPFv3 Interface as P2P

Point-to-point network is the network composed of two devices, each of which is located at an end of the point-to-point link. OSPFv3 uses Hello packets to dynamically find neighbors.

Table 50 Configuring Network Type of OSPFv3 Interface as P2P

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure Network Type of OSPFv3 Interface as P2P	**ipv6 ospf network point-to-point**	Mandatory By default, the network type of OSPFv3 interface depends on the protocol in link layer.

Configure Network Type of OSPFv3 Interface as NBMA

NBMA network supports multiple (more than two) devices. Yet it cannot broadcast, and neighbors need to be manually specified.

Table 5 Configuring Network Type of OSPFv3 Interface as NBMA

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure Network Type of OSPFv3 Interface as NBMA	**ipv6 ospf network non-broadcast**	Mandatory By default, the network type of OSPFv3 interface depends on the protocol in link layer.
Configure NBMA network neighbors	**ipv6 ospf neighbor** *neighbor-ipv6-address* [**priority** *priority-value* / **poll-interval** *interval-value* / **cost** *cost-value*] [**instance-id** *instance-id*]	Mandatory In NBMA network, neighbors need to be manually specified.

Configure Network Type of OSPFv3 Interface as P2MP

When NBMA is not fully connected, the network type can be configured as P2MP to save network cost. When the network type is configured as P2MP unicast, neighbors need to be manually specified.

Table 6 Configuring Network Type of OSPFv3 Interface as P2MP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure Network Type of OSPFv3 Interface as P2MP	**ipv6 ospf network point-to-multipoint** [**non-broadcast**]	Mandatory By default, the network type of OSPFv3 interface depends on the protocol in link layer.

Step	Command	Description
Configure P2MP unicast network neighbors	**ipv6 ospf neighbor** *neighbor-ipv6-address* [**priority** *priority-value* / **poll-interval** *interval-value* / **cost** *cost-value*] [**instance-id** *instance-id*]	If the network type of interface is configured as P2MP, it is mandatory

50.2.4 Configure OSPFv3 Network Authentication

In order to avoid information leakage or malicious attacks on OSPFv3 devices, all packet interactions between OSPFv3 neighbors can realize encryption and authentication. The encryption & authentication type and algorithm can be NULL (no authentication), SHA1 authentication, and MD5 authentication specified by the IPSec encryption & authentication policy.

After authentication is configured, the IPSec security feature can encrypt and authenticate OSPFv3 protocol packets. The OSPFv3 protocol can receive packets only when they pass decryption and authentication. Therefore, for the OSPFv3 interfaces that establish neighbor relations, their authentication method, Spi ID, and the IPSec encryption & authentication policy configured for authentication password must be consistent. The OSPFv3 authentication method can be configured on areas and interfaces. In particular, area authentication has a lower priority than interface authentication. That is to say, you are required to first use interface authentication and then area authentication.

Configuration Condition

Before configuring OSPFv3 network authentication, ensure that:

- Enable the IPv6 forwarding function.
- Enable the OSPFv3 protocol.

Configure OSPFv3 Area Authentication

Configuring area authentication in the OSPFv3 process area can make all interfaces in the area use area authentication. This can effectively avoid repeated configuration of the same network authentication method for the interface.

Table 7 Configuring OSPFv3 Area Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-

Configure area authentication	**area** *area-id* **ipsec-tunnel** *tunnel-name*	Mandatory By default, no OSPFv3 area authentication is configured.

Configure OSPFv3 Interface Authentication

When an interface has multiple OSPFv3 instances, you can specify authentication method and password for an instance separately. The authentication method specified under the area is applicable to the instances where interface authentication is not specified under the interface.

Table 8 Configuring OSPFv3 Interface Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure interface authentication method	**ipv6 ospf ipsec-tunnel** *tunnel-name*{instance-id *instance-id*}	Mandatory By default, no OSPFv3 interface authentication is configured.

50.2.5 Configure OSPFv3 Route Generation

Configuration Condition

Before configuring OSPFv3 route generation, ensure that:

- Enable the IPv6 forwarding function.
- Enable the OSPFv3 protocol.

Configure OSPFv3 Route Redistribution

When multiple routing protocols are running on a device, routes of other protocols are imported into OSPFv3 through redistribution to generate OSPFv3 external type-2 routes by default, with the routing metric value being 20. When external routes are imported through redistribution, you can modify the type of external route, metric, and Tag fields, and associate the specified routing policy for route control and management.

Table 9 Configuring OSPFv3 Route Redistribution

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 Route Redistribution	**redistribute** *routing-protocol* [*protocol-id-or-name*] [**metric** *metric-value* / **metric-type** *type-value* / **tag** *tag-value* / **route-map** *map-name* / **match** *route-type*]	Mandatory By default, no OSPFv3 route redistribution is configured.
Configure the metric value of OSPFv3 external route	**default-metric** *metric-value*	Optional

Note

- When redistribute protocol [protocol-id] metric and default-metric are both configured to set the metric value of external route, the former has a higher priority.

Configure OSPFv3 Default Route

After the OSPFv3 Stub area and totally NSSA area are configured, a Type-3 default route will be automatically generated. Default route cannot be automatically generated in NSSA area. But a Type-7 default route can be imported to this area through the command **area** *area-id* **nssa default-information-originate**.

OSPFv3 cannot import Type-5 default route through the **redistribute** command. When necessary, the **default-information originate [always]** command can be used to achieve this purpose.

Table 10 Configuring OSPFv3 Default Route

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-

Step	Command	Description
Configure OSPFv3 Default Route	**default-information originate** [**always** / **metric** *metric-value* / **metric-type** *metric-type* / **route-map** *route-map-name*]	Mandatory By default, no external default route will be imported into OSPFv3 AS. For the default route imported, the default metric value is 1, and the type is external type-2. **always** means that the default route is required to be generated in OSPFv3 AS. Otherwise, it will be generated only when there is a default route in the local routing table.

50.2.6 Configure OSPFv3 Route Control

Configuration Condition

Before configuring OSPFv3 route control, ensure that:

- Enable the IPv6 forwarding function.
- Enable the OSPFv3 protocol.

Configure OSPFv3 Inter-area Route Summarization

When the ABR in OSPFv3 advertises inter-area routes to other areas, each route is advertised separately as Type-3 LSAs. You may use the inter-area route summarization function to summarize some contiguous network segments in the area into one route to advertise the summarized route only. This can reduce the size of the OSPFv3 database.

Table 11 Configuring OSPFv3 Inter-area Route Summarization

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-

Step	Command	Description
Configure OSPFv3 Inter-area Route Summarization	**area** *area-id* **range** ipv6-*prefix*/*prefix-length* [**advertise** | **not-advertise**]	Mandatory By default, ABR doesn't conduct inter-area route summarization.

Note

- The OSPFv3 inter-area route summarization function takes effect on ABR only.
- By default, the minimum cost value of detail routes is selected as the cost value of summarized route.

Configure OSPFv3 External Route Summarization

When OSPFv3 redistributes external routes, each route is advertised separately in external link status advertisement. You may use the external route summarization function to summarize some contiguous network segments outside the AS into one route to advertise the summarized route only. This can reduce the size of the OSPFv3 database.

After configuring the command **summary-address** on ASBR, you can summarize the Type-5 LSA and Type-7 LSA within the scope of summarized address.

Table 12 Configuring OSPFv3 External Route Summarization

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 External Route Summarization	**summary-prefix** *ipv6-prefix*/*prefix-length* [**not-advertise** | **tag** *tag-value*]	Mandatory By default, ABR doesn't conduct external route summarization.

Note

- The OSPFv3 external route summarization function takes effect on ASBR only.

Configure OSPFv3 Inter-area Route Filtration

When ABR is receiving inter-area route, ACL or prefix list is used for filtration in the incoming function; when it is advertising inter-area route, ACL or prefix list is used for filtration in the outgoing function.

Table 13 Configuring OSPFv3 Inter-area Route Filtration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 Inter-area Route Filtration	**area** *area-id* **filter-list** { **access** { *access-list-name* | *access-list-number* } | **prefix** *prefix-list-name* } { **in** | **out** }	Mandatory By default, ABR doesn't conduct inter-area route filtration.

Note

- The OSPFv3 inter-area route filtration function takes effect on ABR only.

Configure OSPFv3 External Route Filtration

Configure external route filtration, i.e. apply ACL or prefix list to allow or prohibit the flooding of routes into OSPFv3 AS from outside.

Table 14 Configuring OSPFv3 External Route Filtration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 External Route Filtration	**distribute-list** { **access** { *access-list-name* | *access-list-number* } | **prefix** *prefix-*	Mandatory

Step	Command	Description
	list-name } **out** [*routing-protocol* [*process-id*]]	By default, ASBR doesn't conduct external route filtration.

Note

- The OSPFv3 external route filtration function takes effect on ASBR only.

Configure OSPFv3 Route Installation Filtration

After OSPFv3 calculates routes through LSA, the calculated OSPFv3 protocol routing information can be filtered to prevent certain routes from being added to the routing table.

Table 15 Configuring OSPFv3 Route Installation Filtration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 Route Installation Filtration	**distribute-list** { **access** { *access-list-name* | *access-list-number* } | **gateway** *prefix-list-name1* | **prefix** *prefix-list-name2* [**gateway** *prefix-list-name3*] | **route-map** *route-map-name*} **in** **[** *interface-name* **]**	Mandatory By default, no OSPFv3 route installation filtration is configured.

Note

- Make prefix, gateway and route-map filtration and ACL filtration mutually exclusive. For example, if prefix filtration has been configured, ACL filtration cannot be configured.
- Make route-map and prefix filtration and gateway filtration mutually exclusive.

- Make prefix filtration and gateway filtration cover each other.

Configure OSPFv3 Interface Cost Value

By default, the OSPFv3 interface cost is calculated with the following methods: reference bandwidth/interface bandwidth.

Table 16 Configuring OSPFv3 Interface Cost Value

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPFv3 Interface Cost Value	**ipv6 ospf cost** *cost* [**instance-id** *instance-id*]	Optional By default, the calculation is conducted according to the reference bandwidth/interface bandwidth.

Configure OSPFv3 Reference Bandwidth

The reference bandwidth of interface is mainly used to calculate interface cost value which is 100Mbit/s by default. The OSPFv3 interface cost is calculated with the following methods: reference bandwidth/interface bandwidth. When the calculation result is greater than 1, take the integer part; when it is less than 1, take 1. Therefore, in a network with a bandwidth higher than 100Mbit/s, the optimal route cannot be correctly selected. To solve this problem, the **auto-cost reference-bandwidth** command can be used to configure appropriate reference bandwidth.

Table 17 Configuring OSPFv3 Reference Bandwidth

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 Reference Bandwidth	**auto-cost reference-bandwidth** *reference-bandwidth*	Optional By default, the reference bandwidth is 100Mbit/s.

Configure OSPFv3 Administrative Distance

Administrative distance indicates the reliability of routing protocol. When the routes that reach the same destination network are learned from different routing protocols, they are selected according to the administrative distance. Those with a small administrative distance are selected first.

Table 18 Configuring OSPFv3 Administrative Distance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 Administrative Distance	**distance [ospf** { **external** *distance* / **inter-area** *distance* / **intra-area** *distance* } | *distance*]	Optional By default, the administrative distance of intra-area and inter-area routes of OSPFv3 is 110, and that of external routes is 150.

Configure the Maximum Number of OSPFv3 Load Balancing Entries

If there are multiple equal-cost paths leading to the same destination address, the paths form load balancing, which can improve the link utility rate and reduce the load of links.

Table 19 Configuring Maximum Number of Load Balancing Entries of OSPFv3

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure the Maximum Number of OSPFv3 Load Balancing Entries	**maximum-paths** *max-number*	Optional By default, the maximum number of load balancing entries of OSPFv3 is 4.

50.2.7 Configure OSPFv3 Network Optimization

Configuration Condition

Before configuring OSPFv3 network optimization, ensure that:

- Enable the IPv6 forwarding function.
- Enable the OSPFv3 protocol.

Configure Keepalive Time of OSPFv3 Neighbors

OSPFv3 Hello packets are used to establish and keep alive neighbor relationships. The default time interval of sending Hello packets depends on the network type. In broadcast and P2P networks, it is 10 seconds, and in P2MP and NBMA networks, it is 30 seconds.

The failure time of neighbor is used to identify the validity of the neighbor. By default, it is 4 times the Hello time interval. If the OSPFv3 device does not receive the Hello packets from the neighbor after time out of its failure time, the neighbor is considered invalid and deleted.

Table 20 Configuring Keepalive Time of OSPFv3 Neighbor

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPFv3 Hello time interval	**ipv6 ospf hello-interval** *interval-value* [**instance-id** *instance-id*]	Optional The default value is determined based on network class. For broadcast and P2P networks, it's 10 seconds; for P2MP and NBMA networks, it's 30 seconds.
Configure failure time interval of OSPFv3 neighbors	**ipv6 ospf dead-interval** *interval-value* [**instance-id** *instance-id*]	Optional The default value is 4 times the Hello interval.

Note

- The Hello interval between adjacent OSPFv3 devices must be the same as the failure time of neighbor. Otherwise, the neighbor relationship cannot be established.
- When modifying Hello interval, if the failure time of current neighbor is 4 times the Hello interval, the failure time of neighbor will also be automatically modified so that it is 4 times the Hello interval; if the failure time of current neighbor is not 4 times the Hello interval, the failure time of neighbor will remain unchanged.
- Modifying the failure time of neighbor will not affect the Hello interval.

Configure Passive OSPFv3 Interface

Dynamic routing protocol uses passive interface, which can effectively reduce the consumption of network bandwidth by routing protocol. Configure passive OSPFv3 interface to enable the command to advertise the route of the direct network segment where the interface is located. But it will suppress the receiving and sending of OSPFv3 protocol packets on this interface.

Table 21 Configuring Passive OSPFv3 Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure Passive OSPFv3 Interface	**passive-interface** {*interface-name*|**default**}	Mandatory By default, no passive OSPF interface is configured.

Configure OSPFv3 Demand Circuit

On P2P and P2MP links, to reduce line costs, you can configure OSPFv3 demand circuit to suppress the periodic sending of Hello packets and periodic refresh of LSA packets. It is mainly applied in paid links, such as ISDN, SVC and X.25.

Table 22 Configuring OSPFv3 Demand Circuit

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-

Step	Command	Description
Configure OSPFv3 Demand Circuit	**ipv6 ospf demand-circuit** [**instance-id** *instance-id*]	Mandatory By default, the OSPFv3 demand circuit is disabled.

Configure OSPFv3 Interface Priority

Interface priority is mainly applied in the election of DR (Designed Router) and BDR (Backup Designed Router) in broadcast and NBMA networks. The value ranges from 0 to 255. The larger the value, the higher the priority. The default value is 1.

DR and BDR are elected by all the devices in the same network segment according to interface priority and Router ID through Hello packets. The rules are shown below:

- Firstly, the device with the highest interface priority is elected as the DR, and that with the second interface priority as the BDR. The device with the priority of 0 does not participate in the election.
- If the interface priorities are the same, the device with the highest router ID is elected as the DR, and that with the second router ID as the BDR.

After the DR fails, BRD will become a DR immediately, and a new BDR will be elected.

Table 23 Configuring OSPFv3 Interface Priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPFv3 Interface Priority	**ipv6 ospf priority** *priority-value* [**instance-id** *instance-id*]	Optional By default, the OSPFv3 interface priority is 1.

Note

- Priority affects the election process only. When DR and BDR have been elected in the network, modifying interface priority will affect the next election result only. Therefore, DR is not necessarily the device with the highest interface priority, and DBR is not necessarily the device with the second high interface priority.

Configure OSPFv3 Interface to Ignore MTU

When adjacent OSPFv3 devices exchange DD packets with each other, they will check whether the MTUs are the same by default. If different, a neighbor relation cannot be established. After OSPFv3 is configured to ignore interface MTU check, even if the MTUs are different, the neighbor relation can be established.

Table 24 Configuring OSPFv3 Interface to Ignore MTU

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPFv3 Interface to Ignore MTU	**ipv6 ospf mtu-ignore** [**instance-id** *instance-id*]	Mandatory By default, MTU check will be conducted. consistency check

Configure LSA Transfer Delay of OSPFv3 Interface

LSA transfer delay means the period during which LSA floods to other devices. The device sending LSA will add the interface transfer delay time to the aging time of the LSA to be sent. By default, when the flooded LSA passes through a device, the aging time increases by 1. The transfer delay of LSA can be configured according to network conditions, from 1 to 840. It is generally used on low-speed links.

Table 25 Configuring OSPFv3 Interface LSA Transfer Delay

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure LSA Transfer Delay of OSPFv3 Interface	**ipv6 ospf transmit-delay** *delay-value* **instance-id** [*instance-id*]	Optional By default, the LSA transfer delay is 1 second.

Configure OSPFv3 LSA retransmission

In order to ensure the reliability of data interaction, OSPFv3 uses the acknowledgement mechanism. When an LSA is flooded on the device interface, it will be added to the neighbor's retransmission list. If

confirmation is not received from the neighbor after the retransmission time expires, this LSA will be retransmitted until the confirmation is received.

Table 26 Configuring OSPFv3 LSA Retransmission

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure OSPFv3 LSA retransmission interval	**ipv6 ospf retransmit-interval** *interval-value* [**instance-id** *instance-id*]	Optional By default, the LSA retransmission interval is 5 seconds.

Configure OSPFv3 SPF Calculation Time

When the OSPFv3 network topology changes, recalculation of routes is required. When the network keeps changing, frequent routing calculation will occupy a large amount of system resources. The consumption of system resources by frequent network changes can be suppressed by adjusting the time parameters of SPF calculation.

Table 27 Configuring OSPFv3 SPF Calculation Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 SPF Calculation Time	**timers throttle spf** *delay-time hold-time max-time*	Optional By default, the *delay-time*, *hold-time* and *max-time* are 5000 milliseconds, 10000 milliseconds, and 10000 milliseconds, respectively.

- Delay-time means the initial calculation delay, hold-time the suppression time, and max-time the maximum waiting time for two SPF calculations. When there are infrequent network changes, the continuous route calculation interval is decreased to delay-time. In the case of frequent network changes, adjustment should be made accordingly by increasing the hold-time×2^{n-2} (n is the times of continuously triggering route calculation) to prolong the waiting time by the increment of the hold-time configured, max-time at most.

50.2.8 Configure OSPFv3 GR

GR (Graceful Restart) is used to keep the routing information in the forwarding layer of this device and neighbor device unchanged during the switch between host and standby devices to ensure the forwarding process is not affected; after the device is switched for re-running, the two devices synchronize routing information and update forwarding layer in the protocol layer so that the data can keep forwarding during the process of device switch.

There are two types of roles in the GR process:

- GR Restarter end: The device for graceful restart of protocol.
- GR Helper end: The device which helps with the graceful restart of protocol.

The distributed device can act as GR Restarter and GR Helper, while the centralized device only serves as GR Helper to help the Restarter complete GR.

Configuration Condition

Before configuring OSPFv3 GR, ensure that:

- Enable the IPv6 forwarding function.
- Enable the OSPFv3 protocol.

Configure OSPFv3 GR Restarter

Table 28 Configuring OSPFv3 GR Restarter

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 GR	**nsf ietf**	Mandatory By default, the GR function is disabled.

Step	Command	Description
		After this function takes effect, the protocol needs to support the Opaque-LSA function, and it supports the Opaque-LSA function by default.
Configure OSPFv3 GR period	**nsf interval** *grace-period*	Optional By default, the GR period is 95 seconds.

Note

- The OSPFv3 GR function can only be used in the stacking environment or a dual-master environment.

Configure OSPFv3 GR Helper

GR Helper can help the Restarter end complete GR. By default, the device enables this function. Users can disable this function via the command **nsf ietf helper disable**. The command **nsf ietf helper strict-lsa-checking** is used to enable the Helper end to strictly check LSA in the GR process. If any change of LSA is found, the GR Helper mode will be exited.

Table 29 Configuring OSPFv3 GR Helper

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter OSPFv3 configuration mode	**ipv6 router ospf** *process-id* [**vrf** *vrf-name*]	-
Configure OSPFv3 GR Helper	**nsf ietf helper** [**disable** | **strict-lsa-checking**]	Optional By default, the Helper function is enabled, but it doesn't check LSA.

50.2.9 OSPFv3 Monitoring and Maintaining

Table 30 OSPFv3 Monitoring and Maintaining

Command	Description
clear ipv6 ospf err-statistic	Clear error statistics of OSPFv3
clear ipv6 ospf [*process-id*] **process**	Reset OSPFv3 process
clear ipv6 ospf [*process-id*] **redistribution**	Re-advertise external route
clear ipv6 ospf [*process-id*] **route**	Recalculate OSPFv3 route
clear ipv6 ospf statistics [*interface-name*]	Clear interface statistics of OSPFv3
show ipv6 ospf [*process-id*]	Show basic information of OSPFv3
show ipv6 ospf [*process-id*] **border-routers**	Show information of the route reaching edge device in OSPFv3
show ipv6 ospf core-info	Show core information of OSPFv3 process
show ipv6 ospf [*process-id*] **database** [**database-summary** | **external /** inter-prefix | **inter-router** | **intra-prefix** | **link** | **network** | **nssa-external | grace** | **router** | **adv-router** *router-id* | **age** *lsa_age* | **max-age | self-originate**]	Show database information of OSPFv3
show ipv6 ospf error-statistic	Show error statistics of OSPFv3
show ipv6 ospf event-list	Show OSPFv3 packet receive queue information
show ipv6 ospf interface [*interface-name* [**detail**]]	Show information of OSPFv3 interface
show ipv6 ospf [*process-id*] **neighbor** [*neighbor-id* / **all** / **detail** [**all**] | **interface** *interface-name* [**detail**] | **statistics**]	Show information of OSPFv3 neighbor
show ipv6 ospf [*process-id*] **route** [*ipv6-prefix*/*prefix-length* | **connected** / **external** / **inter-area** / **intra-area** | **statistic**]	Show information of OSPFv3 route

Command	Description
show ipv6 ospf [*process-id*] **sham-links**	Show the OSPFv3 pseudo-class link interface information configured, including interface status, cost value, and neighbor status
show ipv6 ospf [*process-id*] **topology area** [*area-id*]	Show information of OSPFv3 topology
show ipv6 ospf [*process- id*] **virtual-links**	Show information of OSPFv3 virtual link
show ipv6 ospf [**vrf** *vrf-name*]	Show all OSPFv3 process information and parameters in the specified vrf
show running-config ipv6 router ospf	Show current running configuration of OSPFv3

50.3 Typical Configuration Example of OSPFv3

50.3.1 Configure Basic Functions of OSPFv3

Network Requirements

- All devices are configured with OSPFv3 protocol, and there are three areas, i.e. area 0, 1 and 2. Upon completion of the configuration, all the devices can learn routes from each other.
- On the back-to-back Ethernet interface, in order to speed up the the process of establishing OSPF neighbors, the network type of OSPFv3 interface can be changed to point-to-point. Modify the network type of the interface in area 2 as point-to-point. Upon completion of the configuration, all the devices can learn routes from each other.

Network Topology

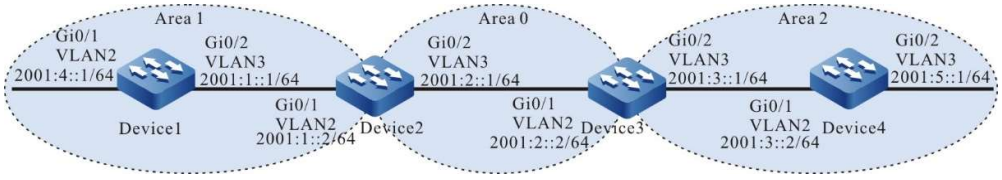


Figure 50 Network Topology for Configuring Basic Functions of OSPFv3

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IPv6 addresses for the ports. (Omitted)

Step 3: Configure OSPFv3 process and make different areas cover corresponding interfaces.

#On Device1, configure OSPFv3 process and make area 1 cover the interface.

```
Device1#configure terminal
Device1(config)#ipv6 router ospf 100
Device1(config-ospf6)#router-id 1.1.1.1
Device1(config-ospf6)#exit
Device1(config)#interface vlan2
Device1(config-if-vlan2)#ipv6 router ospf 100 area 1
Device1(config-if-vlan2)#exit
Device1(config)#interface vlan3
Device1(config-if-vlan3)#ipv6 router ospf 100 area 1
Device1(config-if-vlan3)#exit
```

#On Device2, configure OSPFv3 process and make area 0 and 1 cover corresponding interfaces.

```
Device2#configure terminal
Device2(config)#ipv6 router ospf 100
Device2(config-ospf6)#router-id 2.2.2.2
Device2(config-ospf6)#exit
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ipv6 router ospf 100 area 1
Device2(config-if-vlan2)#exit
Device2(config)#interface vlan3
Device2(config-if-vlan3)#ipv6 router ospf 100 area 0
Device2(config-if-vlan3)#exit
```

#On Device3, configure OSPFv3 process and make area 0 and 2 cover corresponding interfaces.

```
Device3#configure terminal
Device3(config)#ipv6 router ospf 100
Device3(config-ospf6)#router-id 3.3.3.3
Device3(config-ospf6)#exit
Device3(config)#interface vlan2
Device3(config-if-vlan2)#ipv6 router ospf 100 area 0
Device3(config-if-vlan2)#exit
Device3(config)#interface vlan3
Device3(config-if-vlan3)#ipv6 router ospf 100 area 2
Device3(config-if-vlan3)#exit
```

#On Device4, configure OSPFv3 process and make area 2 cover the interface.

```
Device4#configure terminal
Device4(config)#ipv6 router ospf 100
Device4(config-ospf6)#router-id 4.4.4.4
Device4(config-ospf6)#exit
Device4(config)#interface vlan2
Device4(config-if-vlan2)#ipv6 router ospf 100 area 2
Device4(config-if-vlan2)#exit
Device4(config)#interface vlan3
Device4(config-if-vlan3)#ipv6 router ospf 100 area 2
Device4(config-if-vlan3)#exit
```

Note

- In OSPFv3, Router ID must be manually configured, and the Router IDs of any routers in the AS must be different.
- When the interface is enabled to OSPFv3, it's necessary to specify which interface instance is enabled to the OSPFv3 process, and the instance numbers on both sides must be the same, in instance 0 by default.

#View OSPFv3 neighbors' information and routing table on Device1.

```
Device1#show ipv6 ospf neighbor
OSPFv3 Process (100)
Neighbor ID     Pri   State           Dead Time   Interface                 Instance ID
2.2.2.2           1   Full/DR         00:00:38    vlan3                     0

Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management


L   ::1/128 [0/0]
     via ::, 00:41:07, lo0
C   2001:1::/64 [0/0]
     via ::, 00:32:19, vlan3
L   2001:1::1/128 [0/0]
     via ::, 00:32:18, lo0
```

```
O   2001:2::/64 [110/2]
    via fe80::201:7aff:fe5e:6d45, 00:23:06, vlan3
O   2001:3::/64 [110/3]
    via fe80::201:7aff:fe5e:6d45, 00:23:00, vlan3
C   2001:4::/64 [0/0]
    via ::, 00:16:46, vlan2
L   2001:4::1/128 [0/0]
    via ::, 00:16:45, lo0
O   2001:5::/64 [110/4]
    via fe80::201:7aff:fe5e:6d45, 00:01:42, vlan3
```

#View the OSPFv3 neighbors and routing table on Device2.

```
Device2#show ipv6 ospf neighbor
OSPFv3 Process (100)
Neighbor ID     Pri   State           Dead Time   Interface                 Instance ID
1.1.1.1           1   Full/Backup     00:00:34    vlan2                0
3.3.3.3           1   Full/DR         00:00:33    vlan3                0

Device2#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
    via ::, 00:50:36, lo0
C   2001:1::/64 [0/0]
    via ::, 00:43:05, vlan2
L   2001:1::2/128 [0/0]
    via ::, 00:43:04, lo0
C   2001:2::/64 [0/0]
    via ::, 00:40:01, vlan3
L   2001:2::1/128 [0/0]
    via ::, 00:39:57, lo0
O   2001:3::/64 [110/2]
    via fe80::2212:1ff:fe01:101, 00:34:00, vlan3
O   2001:4::/64 [110/2]
    via fe80::201:7aff:fe61:7a24, 00:27:28, vlan2
O   2001:5::/64 [110/3]
    via fe80::2212:1ff:fe01:101, 00:12:41, vlan3
```

#View the OSPFv3 LSDB (Link State Database) on Device2.

```
Device2#show ipv6 ospf database

        OSPFv3 Router with ID (2.2.2.2) (Process 100)


            Link-LSA (Interface vlan2)
Link State ID   ADV Router      Age Seq#       CkSum  Prefix
0.0.0.1         1.1.1.1         81 0x80000001 0x8d18      1
0.0.0.1         2.2.2.2         78 0x80000001 0xf996      1


            Link-LSA (Interface vlan3)
Link State ID   ADV Router      Age Seq#       CkSum  Prefix
0.0.0.2         2.2.2.2         71 0x80000003 0x2467      1
0.0.0.1         3.3.3.3         35 0x80000003 0xcd12      1


            Router-LSA (Area 0.0.0.0)
Link State ID   ADV Router      Age Seq#       CkSum    Link
0.0.0.0         2.2.2.2         37 0x80000004 0x0dd6      1
0.0.0.0         3.3.3.3         25 0x80000007 0xda03      1


            Network-LSA (Area 0.0.0.0)
Link State ID   ADV Router      Age Seq#       CkSum
0.0.0.1         3.3.3.3         35 0x80000001 0x5790


            Inter-Area-Prefix-LSA (Area 0.0.0.0)
Link State ID   ADV Router      Age Seq#       CkSum  Prefix
0.0.0.2         2.2.2.2         42 0x80000007 0x9e25 2001:1::/64
0.0.0.3         2.2.2.2         23 0x80000002 0xcef4 2001:4::/64
0.0.0.1         3.3.3.3         35 0x80000005 0xaa16 2001:3::/64
0.0.0.3         3.3.3.3         55 0x80000001 0xc0fe 2001:5::/64


            Intra-Area-Prefix-LSA (Area 0.0.0.0)
Link State ID   ADV Router      Age Seq#       CkSum  Prefix  Reference
0.0.0.3         3.3.3.3         34 0x80000001 0xb2d3      1  Network-LSA
```

```
                Router-LSA (Area 0.0.0.1)
Link State ID   ADV Router      Age Seq#       CkSum    Link
0.0.0.0         1.1.1.1         41 0x80000004 0xc726     1
0.0.0.0         2.2.2.2         37 0x80000004 0xac3c     1


                Network-LSA (Area 0.0.0.1)
Link State ID   ADV Router      Age Seq#       CkSum
0.0.0.1         2.2.2.2         42 0x80000001 0x21d2


                Inter-Area-Prefix-LSA (Area 0.0.0.1)
Link State ID   ADV Router      Age Seq#       CkSum  Prefix
0.0.0.1         2.2.2.2         42 0x80000004 0xbc0a 2001:2::/64
0.0.0.4         2.2.2.2         19 0x80000001 0xb80c 2001:3::/64
0.0.0.5         2.2.2.2         19 0x80000001 0xd0ef 2001:5::/64


                Intra-Area-Prefix-LSA (Area 0.0.0.1)
Link State ID   ADV Router      Age Seq#       CkSum  Prefix  Reference
0.0.0.1         1.1.1.1         35 0x80000005 0xc4ce     1  Router-LSA
0.0.0.3         2.2.2.2         41 0x80000001 0x8807     1  Network-LSA
```

For Device2, both 2001:3::/642 and 2001:5::/64 are inter-area routes. Relevant routing LSA information can be seen from Inter-Area-Prefix-LSA (Area 0.0.0.0). For intra-area route, show ipv6 ospf database intra-prefix is required to see relevant routing LSA information.

Step 4: Configure the network type of OSPFv3 interface as point-to-point.

#On Device3, change the OSPFv3 network type of vlan3 to point-to-point.

```
Device3(config)#interface vlan3
Device3(config-if-vlan3)#ipv6 ospf network point-to-point
Device3(config-if-vlan3)#exit
```

#On Device4, change the OSPFv3 network type of vlan2 to point-to-point.

```
Device4(config)#interface vlan2
Device4(config-if-vlan2)#ipv6 ospf network point-to-point
Device4(config-if-vlan2)#exit
```

Step 5: Check the result.

#View the OSPFv3 neighbors and routing table on Device3.

```
Device3#show ipv6 ospf neighbor
OSPFv3 Process (100)
Neighbor ID     Pri   State           Dead Time   Interface                 Instance ID
2.2.2.2           1   Full/Backup     00:00:39    vlan2                     0
4.4.4.4           1   Full/ -         00:00:39    vlan3                     0

Device3#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management

L   ::1/128 [0/0]
     via ::, 1d:09:10:10, lo0
O   2001:1::/64 [110/2]
     via fe80::201:7aff:fe5e:6d46, 02:07:25, vlan2
C   2001:2::/64 [0/0]
     via ::, 03:07:51, vlan2
L   2001:2::2/128 [0/0]
     via ::, 03:07:48, lo0
C   2001:3::/64 [0/0]
     via ::, 03:07:41, vlan3
L   2001:3::1/128 [0/0]
     via ::, 03:07:39, lo0
O   2001:4::/64 [110/3]
     via fe80::201:7aff:fe5e:6d46, 02:07:25, vlan2
O   2001:5::/64 [110/2]
     via fe80::201:2ff:fe03:405, 00:00:22, vlan3
```

Note

- When OSPFv3 neighbor relations are established in point-to-point networks, there is no DR or BDR election.

#View the OSPFv3 neighbors and routing table on Device4.

```
Device4#show ipv6 ospf neighbor
OSPFv3 Process (100)
Neighbor ID     Pri   State           Dead Time   Interface                 Instance ID
```

```
3.3.3.3         1   Full/ -       00:00:38    vlan2             0

Device4#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management


L   ::1/128 [0/0]
     via ::, 00:05:34, lo0
O   2001:1::/64 [110/3]
     via fe80::2212:1ff:fe01:102, 00:03:12, vlan2
O   2001:2::/64 [110/2]
     via fe80::2212:1ff:fe01:102, 00:03:12, vlan2
C   2001:3::/64 [0/0]
     via ::, 00:04:34, vlan2
L   2001:3::2/128 [0/0]
     via ::, 00:04:31, lo0
O   2001:4::/64 [110/4]
     via fe80::2212:1ff:fe01:102, 00:03:12, vlan2
C   2001:5::/64 [0/0]
     via ::, 00:03:14, vlan3
L   2001:5::1/128 [0/0]
     via ::, 00:03:13, lo0
```

According to the result, after the network type of OSPFv3 interface is changed to point-to-point, neighbors can be normally established, and routes can be learned normally.

50.3.2 Configure OSPFv3 to Use IPSec Encryption & Authentication

Network Requirements

- All routers run OSPFv3, and the entire AS is divided into 2 areas.
- Device1, Device2, and Device3 use IPSec tunnels to encrypt and authenticate OSPFv3 protocol packets. Device1 and Device2 adopt ESP transmission and encapsulation, with the encryption algorithm being 3des and authentication algorithm sha1. Device2 and Device3 also use ESP transmission and encapsulation, but the encryption algorithm is aes128 and ESP authentication algorithm is sm3.
- Upon completion of the configuration, the device can normally establish neighbors and learn routes from each other.

Network Topology

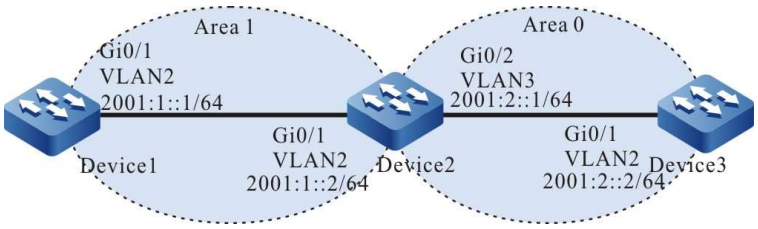


Figure 50 Network Topology for Configuring OSPFv3 to Use IPSec Encryption & Authentication

Configuration Steps

Step 1: Configure IPv6 addresses for the ports. (Omitted)

Step 2: Configure OSPFv3 process and enable OSPFv3 function on corresponding interface.

#On Device1, Device2 and Device3, configure OSPFv3 process and enable OSPFv3 on the interface.

```
Device1#configure terminal
Device1(config)#ipv6 router ospf 100
Device1(config-ospf6)#router-id 1.1.1.1
Device1(config-ospf6)#exit
Device1(config)#interface vlan2
Device1(config-if-vlan2)#ipv6 router ospf 100 area 1
Device1(config-if-vlan2)#exit

Device2#configure terminal
Device2(config)#ipv6 router ospf 100
Device2(config-ospf6)#router-id 2.2.2.2
Device2(config-ospf6)#exit
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ipv6 router ospf 100 area 1
Device2(config-if- vlan2)#exit
Device2(config)#interface vlan3
Device2(config-if- vlan3)#ipv6 router ospf 100 area 0
Device2(config-if- vlan3)#exit

Device3#configure terminal
Device3(config)#ipv6 router ospf 100
Device3(config-ospf6)#router-id 3.3.3.3
Device3(config-ospf6)#exit
Device3(config)#interface vlan2
Device3(config-if-vlan2)#ipv6 router ospf 100 area 0
Device3(config-if-vlan2)#exit
```

Step 3: Configure IPSec proposal and manual tunnel.

#On Device1, create IPSec proposal a, use ESP transmission & encapsulation mode (encryption algorithm 3des, authentication algorithm sha1), create IPSec manual tunnel a, and configure SPI and key.

```
Device1(config)#crypto ipsec proposal a
Device1(config-ipsec-prop)#mode transport
Device1(config-ipsec-prop)#esp 3des sha1
Device1(config-ipsec-prop)#exit
Device1(config)#crypto tunnel a manual
Device1(config-manual-tunnel)#set ipsec proposal a
```

```
Device1(config-manual-tunnel)#set inbound esp 1000 encryption 0 111111111111111111111111 authentication 0 aaaaaaaaaaaaa
aaaaaa
Device1(config-manual-tunnel)#set outbound esp 1001 encryption 0 aaaaaaaaaaaaaaaaaaaaaaa authentication 0 1111111111111
1111111
Device1(config-manual-tunnel)#exit
```

#On Device2, create IPSec proposal a, use ESP transmission & encapsulation mode (encryption algorithm 3des, authentication algorithm sha1), create IPSec manual tunnel a, and configure SPI and key; create IPSec proposal b, use ESP transmission & encapsulation mode (encryption algorithm aes128, authentication algorithm sm3), create IPSec manual tunnel b, and configure SPI and key.

```
Device2(config)#crypto ipsec proposal a
Device2(config-ipsec-prop)#mode transport
Device2(config-ipsec-prop)#esp 3des sha1
Device2(config-ipsec-prop)#exit
Device2(config)#crypto tunnel a manual
Device2(config-manual-tunnel)#set ipsec proposal a
Device2(config-manual-tunnel)#set inbound esp 1001 encryption 0 aaaaaaaaaaaaaaaaaaaaaaa authentication 0 11111111111111
111111
Device2(config-manual-tunnel)#set outbound esp 1000 encryption 0 111111111111111111111111 authentication 0 aaaaaaaaaaaa
aaaaaaaa
Device2(config-manual-tunnel)#exit
Device2(config)#crypto ipsec proposal b
Device2(config-ipsec-prop)#mode transport
Device2(config-ipsec-prop)#esp aes128 sm3
Device2(config-ipsec-prop)#exit
Device2(config)#crypto tunnel b manual
Device2(config-manual-tunnel)#set ipsec proposal b
Device2(config-manual-tunnel)#set inbound esp 2001 encryption 0 1111111111111111 authentication 0 aaaaaaaaaaaaaaaaaaaaa
aaaaaaaaaa
Device2(config-manual-tunnel)#set outbound esp 2000 encryption 0 1111111111111111 authentication 0 1111111111111111111
111111111111
Device2(config-manual-tunnel)#exit
```

#On Device3, create IPSec proposal b, use ESP transmission & encapsulation mode (encryption algorithm aes128, authentication algorithm sm3), create IPSec manual tunnel b, and configure SPI and key.

```
Device3(config)#crypto ipsec proposal b
Device3(config-ipsec-prop)#mode transport
Device3(config-ipsec-prop)#esp aes128 sm3
Device3(config-ipsec-prop)#exit
Device3(config)#crypto tunnel b manual
Device3(config-manual-tunnel)#set ipsec proposal b
Device3(config-manual-tunnel)#set inbound esp 2000 encryption 0 1111111111111111 authentication 0 1111111111111111111
11111111111
Device3(config-manual-tunnel)#set outbound esp 2001 encryption 0 1111111111111111 authentication 0 aaaaaaaaaaaaaaaaaaaa
aaaaaaaaaaa
Device3(config-manual-tunnel)#exit
```

Step 4: In the OSPFv3 process, bind corresponding IPSec tunnel to each area.

#In the OSPFv3 process of Device1, bind IPSec tunnel a to area 1.

```
Device1(config)#ipv6 router ospf 100
Device1(config-ospf6)#area 1 ipsec-tunnel a
Device1(config-ospf6)#exit
```

#In the OSPFv3 process of Device2, bind IPSec tunnel a to area 1 and IPSec tunnel b to area 0.

```
Device2(config)#ipv6 router ospf 100
Device2(config-ospf6)#area 1 ipsec-tunnel a
Device2(config-ospf6)#area 0 ipsec-tunnel b
Device1(config-ospf6)#exit
```

#In the OSPFv3 process of Device3, bind IPSec tunnel b to area 0.

```
Device3(config)#ipv6 router ospf 100
Device3(config-ospf6)#area 0 ipsec-tunnel b
Device3(config-ospf6)#exit
```

Step 5: Check the result.

#View OSPFv3 process information on Device1.

```
Device1#show ipv6 ospf 100
  Routing Process "OSPFv3 (100)" with ID 1.1.1.1
 Process bound to VRF default
 IETF graceful-restarter support disabled
 IETF gr helper support enabled
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Minimum LSA interval 5 secs, Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 0x0000
 Number of AS-Scoped Unknown LSA 0
 Number of LSA originated 5
 Number of LSA received 5
 Number of areas in this router is 1
 Not Support Demand Circuit lsa number is 0
 Autonomy system support flood DoNotAge Lsa
   Area 0.0.0.1
      Number of interfaces in this area is 1
       IPSec Tunnel Name:a , ID: 154
      Number of fully adjacent neighbors in this area is 1
      Number of fully adjacent sham-link neighbors in this area is 0
      Number of fully adjacent virtual neighbors through this area is 0
      SPF algorithm executed 4 times
      LSA walker due in 00:00:02
      Number of LSA 4.  Checksum Sum 0x2FC53
      Number of Unknown LSA 0
      Not Support Demand Circuit lsa number is 0
      Indication lsa (by other routers) number is: 0,
      area support flood DoNotAge Lsa
```

According to the result, IPSec tunnel a has been bound to the area, and ID is the random value in 0~1023.

#View IPSec tunnel information on Device1.

```
Device1#show crypto tunnel a
get the manual tunnel
Crypto tunnel a : MANUAL
      policy name : (null)
      peer address :
      local interface : (null) address :
      Ipsec proposal : a
      Inbound :
        esp : spi: 1000 encription key: ******** authentication key: ********
        ah spi: 0 authentication key: (null)
      Outbound :
        esp spi: 1001 encryption key: ******** authentication key: ********
        ah spi: 0 authentication key: (null)
      route ref : 1
      route asyn : 1
       route rt_id : 154
```

According to the result, the IDs in route rt_id and show ipv6 ospf 100 are equal.

#View IPSec tunnel encryption type on Device1.

```
Device1#show crypto ipsec sa tunnel a
route policy:
  the pairs of ESP ipsec sa : id :0 , algorithm : 3DES HMAC-SHA1-96
```

```
   inbound esp ipsec sa :  spi : 0x3e8(1000)  crypto m_context(s_context) : 0x4cd3ba78 / 0x4cd3bae0
      current input 26 packets, 2 kbytes
      encapsulation mode : Transport
      replay protection : OFF
      remaining lifetime (seconds/kbytes) : 0/0
      uptime is 0 hour 4 minute 45 second
   outbound esp ipsec sa :  spi : 0x3e9(1001)  crypto m_context(s_context) : 0x4cd3bb48 / 0x4cd3bbb0
      current output 39 packets, 3 kbytes
      encapsulation mode : Transport
      replay protection : OFF
      remaining lifetime (seconds/kbytes) : 0/0
      uptime is 0 hour 4 minute 45 second

total sa and sa group is 1
```

According to the result, IPSec tunnel a adopts ESP transmission & encryption mode, with the encryption algorithm being 3des and authentication algorithm sha1.

```
#View OSPFv3 interface information on Device1.
Device1#show ipv6 ospf interface vlan2
vlan2 is up, line protocol is up
  Interface ID 50331913
  IPv6 Prefixes
    fe80::201:7aff:fecf:fbec/10 (Link-Local Address)
     2001 :1::1/64
  Interface ID 13
  OSPFv3 Process (100), Area 0.0.0.1, Instance ID 0, Enabled 00:41:10, MTU 1500
    Router ID 1.1.1.1, Network Type BROADCAST, Cost: 1
    IPSec tunnel(Area):a, ID:154
    Transmit Delay is 1 sec, State Backup, 3 state change, Priority 1
    Designated Router (ID) 2.2.2.2
      Interface Address fe80::200:1ff:fe7a:adf0
    Backup Designated Router (ID) 1.1.1.1
      Interface Address fe80::201:7aff:fecf:fbec
    Timer interval configured, Hello 10, Dead 39, Wait 39, Retransmit 5
      Hello due in 00:00:06
    Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 2 sent 3, DD received 3 sent 4
  LS-Req received 1 sent 1, LS-Upd received 5 sent 3
  LS-Ack received 3 sent 2, Discarded 0
```

According to the result, IPSec tunnel a has been bound to the interface, and ID is the random value in 0~1023.

#View OSPFv3 neighbors' information and core routing table on Device1.

```
Device1#show ipv6 ospf neighbor
OSPFv3 Process (100)
Neighbor ID     Pri    State       Dead Time       Interface            Instance ID
2.2.2.2         1      Full/DR     00:00:39        vlan2     0

Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management


L   ::1/128 [0/0]
     via ::, 4d:04:06:36, lo0
C   2001:1::/64 [0/0]
     via ::, 03:00:53, vlan2
L   2001:1::1/128 [0/0]
     via ::, 03:00:49, lo0
O   2001:2::/64 [110/2]
     via fe80::201:7aff:fec9:1cdd, 2d:00:03:49, vlan2
```

On Device1, neighbors are normally established, and route learning is normal.

#View OSPFv3 process information on Device3.

```
Device3#show ipv6 ospf 100
 Routing Process "OSPFv3 (100)" with ID 3.3.3.3
 Process bound to VRF default
 IETF graceful-restarter support disabled
 IETF gr helper support enabled
 Initial SPF schedule delay 5000 msecs
 Minimum hold time between two consecutive SPFs 10000 msecs
 Maximum wait time between two consecutive SPFs 10000 msecs
 Minimum LSA interval 5 secs, Minimum LSA arrival 1 secs
 Number of external LSA 0. Checksum Sum 0x0000
 Number of AS-Scoped Unknown LSA 0
 Number of LSA originated 5
 Number of LSA received 6
 Number of areas in this router is 1
 Not Support Demand Circuit lsa number is 0
 Autonomy system support flood DoNotAge Lsa
   Area BACKBONE(0)
       Number of interfaces in this area is 1
        IPSec Tunnel Name:b , ID: 2
       Number of fully adjacent neighbors in this area is 1
       Number of fully adjacent sham-link neighbors in this area is 0
       SPF algorithm executed 4 times
       LSA walker due in 00:00:02
       Number of LSA 4.  Checksum Sum 0x24272
       Number of Unknown LSA 0
       Not Support Demand Circuit lsa number is 0
       Indication lsa (by other routers) number is: 0,
       area support flood DoNotAge Lsa
```

According to the result, IPSec tunnel b has been bound to the area, and ID is the random value in 0~1023.

#View information about IPSec tunnel of Device3.

```
Device3#show crypto tunnel b
get the manual tunnel
Crypto tunnel b : MANUAL
       policy name : (null)
       peer address :
       local interface : (null) address :
       Ipsec proposal : b
       Inbound :
         esp : spi: 2000 encription key: ******** authentication key: ********
         ah spi: 0 authentication key: (null)
       Outbound :
         esp spi: 2001 encryption key: ******** authentication key: ********
         ah spi: 0 authentication key: (null)
       route ref : 1
       route asyn : 1
        route rt_id : 2
```

According to the result, the IDs in route rt_id and show ipv6 ospf 100 are equal.

#View IPSec tunnel encryption type on Device3.

```
Device3#show crypto ipsec sa tunnel b
route policy:
  the pairs of ESP ipsec sa : id : 0, algorithm : AES128 HMAC-SM3
       inbound esp ipsec sa :  spi : 0x7d0(2000)  crypto m_context(s_context) : 0x6a0d9a98 /
        0x6a0d9a30
       current input 53 packets, 5 kbytes
       encapsulation mode : Transport
       replay protection : OFF
       remaining lifetime (seconds/kbytes) : 0/0
       uptime is 0 hour 6 minute 40 second
        outbound esp ipsec sa :  spi : 0x7d1(2001)  crypto m_context(s_context) : 0x6a0d99c8 /
        0x6a0d9960
       current output 52 packets, 5 kbytes
```

```
    encapsulation mode : Transport
    replay protection : OFF
    remaining lifetime (seconds/kbytes) : 0/0
    uptime is 0 hour 6 minute 40 second

total sa and sa group is 1
```

According to the result, IPSec tunnel adopts ESP transmission & encryption mode, with the encryption algorithm being aes128 and authentication algorithm sm3.

#View OSPFv3 interface information on Device3.

```
Device3#show ipv6 ospf interface vlan2
vlan2 is up, line protocol is up
  Interface ID 50331899
  IPv6 Prefixes
    fe80::200:1ff:fe7a:adf0/10 (Link-Local Address)
    2001 :2::1/64
  Interface ID 9
  OSPFv3 Process (100), Area 0.0.0.1, Instance ID 0, Enabled 00:50:39, MTU 1500
    Router ID 3.3.3.3, Network Type BROADCAST, Cost: 1
    IPSec tunnel(Area):b, ID:2
    Transmit Delay is 1 sec, State DR, 4 state change, Priority 1
    Designated Router (ID) 2.2.2.2
      Interface Address fe80::200:1ff:fe7a:adf0
    Backup Designated Router (ID) 1.1.1.1
      Interface Address fe80::201:7aff:fecf:fbec
    Timer interval configured, Hello 10, Dead 39, Wait 39, Retransmit 5
      Hello due in 00:00:02
    Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 272 sent 316, DD received 12 sent 9
  LS-Req received 3 sent 5, LS-Upd received 19 sent 18
  LS-Ack received 11 sent 13, Discarded 0
```

According to the result, IPSec tunnel b has been bound to the interface, and ID is the random value in 0~1023.

#View OSPFv3 neighbors' information and core routing table on Device3.

```
Device3#show ipv6 ospf neighbor
OSPFv3 Process (100)
Neighbor ID     Pri     State           Dead Time       Interface         Instance ID
2.2.2.2         1       Full/Backup     00:00:35        vlan2  0

Device3#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M – Management


L   ::1/128 [0/0]
     via ::, 09:53:53, lo0
O   2001:1::/64 [110/2]
     via fe80::ae9c:e4ff:fe77:889e, 00:23:36, vlan2
C   2001:2::/64 [0/0]
     via ::, 03:05:16, vlan2
L   2001:2::2/128 [0/0]
     via ::, 03:05:13, lo0
```

On Device3, neighbors are normally established, and route learning is normal.

Step 6: Bind corresponding IPSec tunnel to the OSPFv3 interface.

#On Device1, bind IPSec tunnel a to Vlan2.

```
Device1(config)#interface vlan2
```

```
Device1(config-if- vlan2)#ipv6 ospf ipsec-tunnel a
Device1(config-if- vlan2)#exit
```

#On Device2, bind IPSec tunnel a to vlan2 and IPSec tunnel b to vlan3.

```
Device2(config)#interface vlan2
Device2(config-if- vlan2)#ipv6 ospf ipsec-tunnel a
Device2(config-if- vlan2)#exit
Device2(config)#interface vlan3
Device2(config-if-vlan3)#ipv6 ospf ipsec-tunnel b
Device2(config-if-vlan3)#exit
```

#On Device3, bind IPSec tunnel b to vlan2.

```
Device3(config)#interface vlan2
                    Device3(config-if- vlan2)#ipv6 ospf ipsec-tunnel b
Device3(config-if- vlan2)#exit
```

Step 7: Check the result.

#View OSPFv3 interface information on Device1.

```
Device1#show ipv6 ospf interface vlan2
vlan2 is up, line protocol is up
  Interface ID 50331913
  IPv6 Prefixes
    fe80::201:7aff:fecf:fbec/10 (Link-Local Address)
     2001 :1::1/64
  Interface ID 13
  OSPFv3 Process (100), Area 0.0.0.1, Instance ID 0, Enabled 00:41:10, MTU 1500
    Router ID 1.1.1.1, Network Type BROADCAST, Cost: 1
     IPSec tunnel:a, ID:154
    Transmit Delay is 1 sec, State Backup, 3 state change, Priority 1
    Designated Router (ID) 2.2.2.2
      Interface Address fe80::200:1ff:fe7a:adf0
    Backup Designated Router (ID) 1.1.1.1
      Interface Address fe80::201:7aff:fecf:fbec
    Timer interval configured, Hello 10, Dead 39, Wait 39, Retransmit 5
      Hello due in 00:00:06
    Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 2 sent 3, DD received 3 sent 4
  LS-Req received 1 sent 1, LS-Upd received 5 sent 3
  LS-Ack received 3 sent 2, Discarded 0
```

According to the result, IPSec tunnel a has been bound to the interface, and ID is the random value in 0~1023.

#View the core routing table of OSPFv3 on Device1.

```
Device1#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management


L   ::1/128 [0/0]
     via ::, 4d:04:06:36, lo0
C   2001:1::/64 [0/0]
     via ::, 03:00:53, vlan2
L   2001:1::1/128 [0/0]
     via ::, 03:00:49, lo0
O   2001:2::/64 [110/2]
     via fe80::201:7aff:fec9:1cdd, 2d:00:03:49, vlan2
```

On Device1, route learning is normal.

#View OSPFv3 interface information on Device3.

```
Device3#show ipv6 ospf interface vlan2
vlan2 is up, line protocol is up
  Interface ID 50331899
  IPv6 Prefixes
    fe80::200:1ff:fe7a:adf0/10 (Link-Local Address)
    2001 :2::1/64
  Interface ID 9
  OSPFv3 Process (100), Area 0.0.0.1, Instance ID 0, Enabled 00:50:39, MTU 1500
    Router ID 3.3.3.3, Network Type BROADCAST, Cost: 1
     IPSec tunnel:b, ID:2
    Transmit Delay is 1 sec, State DR, 4 state change, Priority 1
    Designated Router (ID) 2.2.2.2
      Interface Address fe80::200:1ff:fe7a:adf0
    Backup Designated Router (ID) 1.1.1.1
      Interface Address fe80::201:7aff:fecf:fbec
    Timer interval configured, Hello 10, Dead 39, Wait 39, Retransmit 5
      Hello due in 00:00:02
    Neighbor Count is 1, Adjacent neighbor count is 1
  Hello received 272 sent 316, DD received 12 sent 9
  LS-Req received 3 sent 5, LS-Upd received 19 sent 18
  LS-Ack received 11 sent 13, Discarded 0
```

According to the result, IPSec tunnel b has been bound to the interface, and ID is the random value in 0~1023.

#View the core routing table of OSPFv3 on Device3.

```
Device3#show ipv6 route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
      O - OSPF, OE-OSPF External, M – Management


L   ::1/128 [0/0]
    via ::, 09:53:53, lo0
O   2001:1::/64 [110/2]
    via fe80::ae9c:e4ff:fe77:889e, 00:23:36, vlan2
C   2001:2::/64 [0/0]
    via ::, 03:05:16, vlan2
L   2001:2::2/128 [0/0]
    via ::, 03:05:13, lo0
```

On Device3, route learning is normal.

Note

- When configuring OSPFv3 to bind an IPSec tunnel, you can configure area binding or interface binding only, or configure both area and interface binding.
- When IPSec tunnel is configured for area binding and interface binding at the same time, the latter takes effect first.

51 Policy Route

51.1 Overview

Policy route is a routing mechanism which conducts packet forwarding according to users' customized policies. When forwarding routes, the packet can be matched according to ACL rules. The content to be matched includes IP protocol number, source IP address, destination IP address, source TCP/UDP port number, destination TCP/UDP port number, packet priority, and TCP flag. For the packets that meet the match rules, corresponding operations shall be conducted according to the specified policy (set next hop of the packet) to complete their forwarding control.

The traditional routing method forwards packets according to destination address. By contrast, policy route is more flexible. It effectively complements and reinforces the traditional routing mechanism.

51.2 Function Configuration of Policy Route

Table 51 Policy Route Configuration List

Configuration Task	
Configure Policy Route	Configure Next Hop IP Address for Packet Forwarding
	Configure Backup Next Hop IP Address for Packet Forwarding
	Configure Next Hop IPv6 Address for Packet Forwarding
	Configure Backup Next Hop IPv6 Address for Packet Forwarding

Configuration Task	
	Configure Binding of PBR Action Group to ACL
	Configure Binding of PBR Action Group to ACL Rules
Configuration Application of Policy Route	Configure Application of ACL with Policy Route to Layer-2/3 Ethernet Interface
	Configure Application of ACL with Policy Route to VLAN
	Configure Application of ACL with Policy Route to Interface VLAN
	Configure Application of ACL with Policy Route to VLAN RANGE
	Configure Application of ACL with Policy Route to Interface VLAN RANGE
	Configure Application of ACL with Policy Route to global

51.2.1 Configure Policy Route

The implementation of policy route depends on the filtration of packets by ACL rules. The ACL rules first filter out the packets that meet the conditions, and then execute policy route forwarding to the next hop for the packets.

Configuration Condition

Before configuring the functions of policy route, ensure that:

- Configure ACL and ACL rules.

Configure Next Hop IP Address for Packet Forwarding

Configure the next hop IP address for packet forwarding to specify the destination address of policy route.

Table 1 Configuring Next Hop IP Address for Packet Forwarding

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter PBR action group configuration mode	**pbr-action-group** *pbr-action-group-name*	-
Configure next hop IP address for packet forwarding	**redirect ipv4-nexthop** *ip-address* [vrf *vrf-name*]	Mandatory By default, the next hop IP address for packet forwarding is not configured.

Note

- If all the next hop IP addresses configured for forwarding are not reachable, the function of policy route will not take effect.
- The next hop IP address shall not be configured as multicast address or broadcast address.

Configure Backup Next Hop IP Address for Packet Forwarding

Configure the backup next hop IP address for packet forwarding to specify the destination address of policy route.

When the primary next hop is unreachable, if the backup next hop IP address is reachable, the packet is forwarded to the backup next hop IP address; if the primary next hop is reachable, the packet continues to be forwarded to such primary next hop IP address.

Table 2 Configuring Backup Next Hop IP Address for Packet Forwarding

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter PBR action group configuration mode	**pbr-action-group** *pbr-action-group-name*	-
Configure next hop IP address for packet forwarding	**redirect ipv4-nexthop backup** *ip-address* [vrf *vrf-name*]	Mandatory By default, the backup next hop IP address for packet

Step	Command	Description
		forwarding is not configured.

Note

- If the backup next hop IP address configured for forwarding is not reachable, the function of policy route will not take effect.
- The next hop IP address shall not be configured as multicast address or broadcast address.

Configure Next Hop IPv6 Address for Packet Forwarding

Configure the next hop IPv6 address for packet forwarding to specify the destination address of policy route.

Table 3 Configuring Next Hop IPv6 Address for Packet Forwarding

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter PBR action group configuration mode	**pbr-action-group** *pb-action-group-name*	-
Configure next hop IPv6 address for packet forwarding	**redirect ipv6-nexthop** *ipv6-address* [vrf *vrf-name*]	Mandatory By default, the next hop IPv6 address for packet forwarding is not configured.

Note

- If all the next hop IPv6 addresses configured for forwarding are not reachable, the function of policy route will not take effect.
- The next hop IPv6 address shall not be configured as multicast address or broadcast address.

Configure Backup Next Hop IPv6 Address for Packet Forwarding

Configure the backup next hop IPv6 address for packet forwarding to specify the destination address of policy route.

When the primary next hop is unreachable, if the backup next hop IPv6 address is reachable, the packet is forwarded to the backup next hop IPv6 address; if the primary next hop is reachable, the packet continues to be forwarded to such primary next hop IPv6 address.

Table 4 Configuring Backup Next Hop IPv6 Address for Packet Forwarding

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter PBR action group configuration mode	**pbr-action-group** *pbr-action-group-name*	-
Configure next hop IPv6 address for packet forwarding	**redirect ipv6-nexthop backup** *ipv6-address* [vrf *vrf-name*]	Mandatory By default, the backup next hop IPv6 address for packet forwarding is not configured.

Note

- If the backup next hop IPv6 address configured for forwarding is not reachable, the function of policy route will not take effect.
- The next hop IPv6 address shall not be configured as multicast address or broadcast address.

Configure Binding of PBR Action Group to ACL

Configure the binding of PBR action group to ACL so that all ACL rules are associated with actions of policy route.

After the PBR action group is bound to ACL, all ACL rules will associate with actions of policy route. Only if the packets received by the port match the ACL rules, they will be forwarded to the next hop.

Table 5 Configuring Binding of PBR Action Group to ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Binding of PBR Action Group to ACL	**ip pbr-action-group** *pbr-action-group-name* **access-list** { *access-list-number* | *access-list-name* }	Optional By default, PBR action group is not bound to IP ACL. PBR action group supports the binding of IP ACL which contains standard IP ACL and extended IP ACL.
	ipv6 pbr-action-group *pbr-action-group-name* **access-list** { *access-list-number* | *access-list-name* }	Optional By default, PBR action group is not bound to IPv6 ACL. PBR action group supports the binding of IPv6 ACL which contains standard IPv6 ACL and extended IPv6 ACL.

Note

- Only when the next hop IP address configured is reachable will the policy route take effect.
- The policy route only takes effect for the allowable rules in ACL.

Configure Binding of PBR Action Group to ACL Rules

Configure the binding of PBR action group to ACL rules so that ACL rules are associated with actions of policy route.

After the PBR action group is bound to ACL rules, ACL rules will associate with actions of policy route. If the packets received by the port match the ACL rules, they will be forwarded according to the next hop specified by the action group.

Table 51 Configuring Binding of PBR Action Group to ACL Rules

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Binding of PBR Action Group to ACL Rules	Please see "Configure Standard IP ACL" Please see "Configure Extended IP ACL" Please see "Configure Standard IPv6 ACL" Please see "Configure Extended IPv6 ACL"	When configuring the allowable rules of standard IP ACL and extended ACL, you must specify a PBR action group to make the policy route take effect. When configuring the allowable rules of standard IPv6 ACL and extended ACL, you must specify a PBR action group to make the policy route take effect.

Note

- Only when the next hop IP address configured is reachable will the policy route take effect.
- The policy route only takes effect for the allowable rules in ACL.

51.2.2 Configuration Application of Policy Route

The application of policy route is actually that of the ACL with policy route which takes effect depending on ACL rules. ACL can be applied to layer-2/3 Ethernet interface, VLAN, interface VLAN, VLAN RANGE, interface VLAN RANGE, and global.

When the ACL with policy route is applied to global, VLAN, Interface VLAN, VLAN RANGE, Interface VLAN RANGE, and Layer-2/3 Ethernet interface, conflict may appear. In this case, the policy route with a high priority takes effect. The following has the priority from high to low: port, VLAN/ Interface VLAN, VLAN RANGE/Interface VLAN RANGE, global.

Configuration Condition

None

Configure Application of ACL with Policy Route to Layer-2/3 Ethernet Interface

After applying the ACL with policy route to layer-2/3 Ethernet interface, corresponding layer-2/3 Ethernet interface will have the function of policy route.

Table 6 Configuring Application of Policy Route to Layer-2/3 Ethernet Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	
Configuration application of policy route to the port	**ip policy-based-route** { *access-list-number* | *access-list-name* }	Optional By default, no IP ACL with policy route is applied to the port.
	ipv6 policy-based-route { *access-list-number* | *access-list-name* }	Optional By default, no IPv6 ACL with policy route is applied to the port.

Configure Application of ACL with Policy Route to VLAN

After applying the ACL with policy route to VLAN, all ports within corresponding VLAN will have the function of policy route.

Table 7 Configuring Application of Policy Route to VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure application of policy route to VLAN	**ip policy-based-route**{ *access-list-number* | *access-list-name* }	Optional By default, no IP ACL with policy route is applied to VLAN.
	ipv6 policy-based-route{ *access-list-number* | *access-list-name* }	Optional By default, no IPv6 ACL with policy route is applied to VLAN.

Configure Application of ACL with Policy Route to Interface VLAN

After applying the ACL with policy route to Interface VLAN, corresponding Interface VLAN will have the function of policy route.

Table 8 Configuring Application of Policy Route to Interface VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Interface VLAN configuration mode	**Interface vlan** *vlan-id*	-
Configure application of policy route to Interface VLAN	**ip policy-based-route** { *access-list-number* | *access-list-name* }	Optional By default, no IP ACL with policy route is applied to Interface VLAN.

Step	Command	Description
	ipv6 policy-based-route { *access-list-number* | *access-list-name* }	Optional By default, no IPv6 ACL with policy route is applied to Interface VLAN.

Configure Application of ACL with Policy Route to VLAN RANGE

After applying the ACL with policy route to VLAN RANGE, corresponding VLAN RANGE will have the function of policy route.

Table 9 Configuring Application of Policy Route to Interface VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure application of policy route to VLAN RANGE	**ip policy-based-route** { *access-list-number* | *access-list-name* } **vlan range** <1-4094>	Optional By default, no IP ACL with policy route is applied to VLAN RANGE.
	ipv6 policy-based-route { *access-list-number* | *access-list-name* } **vlan range** <1-4094>	Optional By default, no IPv6 ACL with policy route is applied to VLAN RANGE.

Configure Application of ACL with Policy Route to Interface VLAN RANGE

After applying the ACL with policy route to Interface VLAN RANGE, corresponding Interface VLAN RANGE will have the function of policy route.

Table 10 Configuring Application of Policy Route to Interface VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
	ip policy-based-route { *access-list-number* |	Optional

Step	Command	Description
Configure application of policy route to Interface VLAN RANGE	*access-list-name* } **interface vlan range** <1-4094>	By default, no IP ACL with policy route is applied to Interface VLAN RANGE.
	ipv6 policy-based-route { *access-list-number* | *access-list-name* } **interface vlan range** <1-4094>	Optional By default, no IPv6 ACL with policy route is applied to Interface VLAN RANGE.

Configure Application of ACL with Policy Route as Global

After applying the ACL with policy route to global, all ports of the device will have the function of policy route.

Table 11 Configuring Application of Policy Route to Global

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure application of policy route to global	**global ip policy-based-route** { *access-list-number* | *access-list-name* }	Mandatory By default, no ACL with policy route is applied to global.

51.2.3 Policy Route Monitoring and Maintaining

Table 12 Policy Route Monitoring and Maintaining

Command	Description
show pbr-action-group [*pbr-action-group-name*]	Show the configuration information of policy route
show policy-based-route object [global | interface/ [vlan | switchport | vlan-range]| vlan | vlan-range]	Show policy route configuration and application information. If no parameter

Command	Description
	has been specified, then it means the application information of all PBRs.

51.3 Typical Configuration Example of Policy Route

51.3.1 Configure Policy Route

Network Requirements

- Device1 has default route. The gateway is Device2.
- By configuring policy route on Device1, the PC can access network 1.1.1.0/24 through Device3, and network 1.1.2.0/24 through Device2.

Network Topology

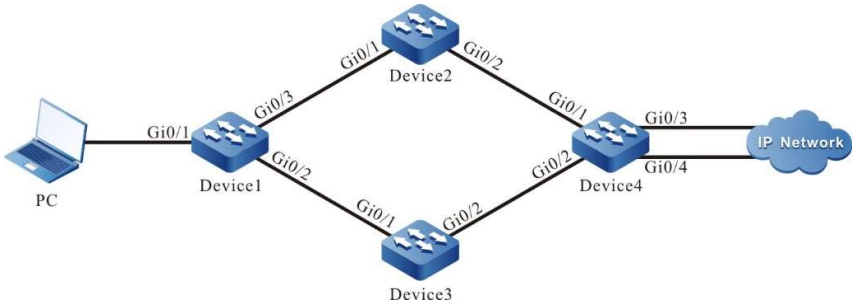


Figure 51 Network Topology for Configuring Policy Route

of equipment	port	VLAN	IP address
PC			10.1.1.1/24
Device1	Gi0/1	2	10.1.1.2/24
	Gi0/2	3	20.1.1.1/24
	Gi0/3	4	30.1.1.1/24
Device2	Gi0/1	2	30.1.1.2/24
	Gi0/2	3	50.1.1.1/24

of equipment	port	VLAN	IP address
Device3	Gi0/1	2	20.1.1.2/24
	Gi0/2	3	40.1.1.1/24
Device4	Gi0/1	2	50.1.1.2/24
	Gi0/2	3	40.1.1.2/24
	Gi0/3	4	1.1.1.1/24
	Gi0/4	5	1.1.2.1/24

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure static routes.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#ip route 0.0.0.0 0.0.0.0 30.1.1.2
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#ip route 10.1.1.0 255.255.255.0 30.1.1.1
Device2(config)#ip route 1.1.0.0 255.255.0.0 50.1.1.2
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#ip route 10.1.1.0 255.255.255.0 20.1.1.1
Device3(config)#ip route 1.1.0.0 255.255.0.0 40.1.1.2
```

#Configure Device4.

```
Device4#configure terminal
Device4(config)#ip route 30.1.1.0 255.255.255.0 50.1.1.1
Device4(config)#ip route 20.1.1.0 255.255.255.0 40.1.1.1
Device4(config)#ip route 10.1.1.0 255.255.255.0 50.1.1.1
Device4(config)#ip route 10.1.1.0 255.255.255.0 40.1.1.1
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
    D - Redirect, E - IRMP, Ex - IRMP external, o - SNSP, B - BGP, i-ISIS
```

```
Gateway of last resort is 30.1.1.2 to network 0.0.0.0

S   0.0.0.0/0 [1/100] via 30.1.1.2, 00:26:24, vlan4
C   10.1.1.0/24 is directly connected, 00:00:59, vlan2
C   20.1.1.0/24 is directly connected, 00:00:50, vlan3
C   30.1.1.0/24 is directly connected, 00:00:39, vlan4
C   127.0.0.0/8 is directly connected, 03:47:36, lo0
```

Step 4: Configure policy route on Device1.

#Configure PBR action group, and re-direct the packets to the next hop 20.1.1.2.

```
Device1(config)#pbr-action-group pbr
Device1(config-action-group)#redirect ipv4-nexthop 20.1.1.2
Device1(config-action-group)#exit
```

#View the information of PBR action group on Device1.

```
Device1#show pbr-action-group pbr
pbr-action-group pbr
redirect ipv4-nexthop 20.1.1.2(valid)
```

#Configure ACL, and bind the ACL rules matching the destination IP network segment 1.1.1.0/24 to the L3 PBR action group.

```
Device1(config)#ip access-list extended 1001
Device1(config-std-nacl)#permit ip any 1.1.1.0 0.0.0.255 pbr-action-group pbr
Device1(config-std-nacl)#permit ip any 1.1.2.0 0.0.0.255
Device1(config-std-nacl)#commit
Device1(config-std-nacl)#exit
```

#View the information of ACL on Device1.

```
Device1#show ip access-list 1001
ip access-list standard 1001
 10 permit ip any 1.1.1.0 0.0.0.255 pbr-action-group pbr (active)
 20 permit ip any 1.1.2.0 0.0.0.255
```

Step 6: Apply ACL.

#Apply ACL 1001 to the port vlan2 of Device1.

```
Device1(config)#interface vlan2
Device1(config-if-vlan2)#ip policy-based-route 1001
Device1(config-if-vlan2)#exit
```

Step 7: Check the result.

#On the PC, view through Traceroute the paths through which the destination network 1.1.1.0/24 can be reached.

```
C:\Documents and Settings\Administrator>tracert 1.1.1.1

Tracing route to 1.1.1.1 over a maximum of 30 hops

  1    1 ms    1 ms    1 ms  10.1.1.2
```

```
 2   <1 ms   <1 ms   <1 ms  20.1.1.2
 3   <1 ms   <1 ms   <1 ms  1.1.1.1
Trace complete.
```

It can be seen that PC reaches network 1.1.1.0/24 through Device1, Device3 and Device4.

#On the PC, view through Traceroute the paths through which the destination network 1.1.2.0/24 can be reached.

```
C:\Documents and Settings\Administrator>tracert 1.1.2.1

Tracing route to 1.1.2.1 over a maximum of 30 hops

 1    1 ms    1 ms    1 ms  10.1.1.2
 2   <1 ms   <1 ms   <1 ms  30.1.1.2
 3   <1 ms   <1 ms   <1 ms  1.1.2.1
Trace complete.
```

It can be seen that PC reaches network 1.1.2.0/24 through Device1, Device2 and Device4.

Note

- The packets can be flexibly matched according to ACL rules referenced. The content to be matched includes packets' source IP address, destination IP address, source port, destination port, protocol, and TCP flag.
- For ACL binding, except for binding to layer-2/3 Ethernet interface, it can be bound to VLAN, Interface VLAN and global.

52 Routing Policy Tool

52.1 Overview

Routing policy changes the paths through which routing information or data traffic passes by changing route attributes or route reachability. It is mainly applied in the following aspects:

- Set route attributes: Set corresponding attributes through the route matching the routing policy;
- Control route distribution: When distributing routes, the routing protocol distributes the routing information which satisfies the conditions only;
- Control route receiving: When receiving routes, the routing protocol receives the routing information which satisfies the conditions only so as to control the number of routing table entries and improve network security;
- Control route redistribution: When redistributing and importing external routes, the routing protocol imports routing information which satisfies the conditions, or uses routing policy tool to set certain attributes of importing external routes.

Key-chain is a password management tool. It provides authentication password when the routing protocol is authenticating protocol packets.

52.2 Function Configuration of Routing Policy Tool

Table 52 Routing Policy Tool Configuration List

Configuration Task	
Configure Prefix List	Configure Prefix List
Configure AS-PATH List	Configure AS-PATH List
Configure List of Community Attributes	Configure List of Community Attributes
Configure List of Extcommunity Attributes	Configure List of Extcommunity Attributes

Configuration Task	
Configure Routing Map	Create Routing Map
	Configure match Sub-statement of Routing Map
	Configure set Sub-statement of Routing Map
Configure Key-chain	Configure Key-chain

52.2.1 Configure Prefix List

Configuration Condition

None

Configure Prefix List

Prefix list can be used to filter prefixes and particularly routes. ACL is designed to filter data packet at first and routes later. However, prefix list is designed to filter routes. Although they overlap in route filtration, prefix list is more flexible than ACL.

A prefix list is identified with a name of prefix list. Each prefix list can contain multiple entries, each of which can separately specify a match scope. Each entry corresponding to a number is used to indicate the sequence in which the prefix list conducts match check.

The relationship between entries of the prefix list is "or". During the matching process, the device checks according to corresponding sequence number of the entries from small to large. Once a specific entry is matched, the filtration of this prefix list has been passed, and it will not continue to check the next entry.

Table 52 Configuring Prefix List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IPv4 prefix list	**ip prefix-list** *prefix-list-name* [**seq** *seq-value*] { **deny |** permit } *network / length* [**ge** *ge-value*] [**le** *le-value*]	Mandatory By default, no IPv4 prefix list is configured.

Note

- **ge** means greater than or equal to, and **le** means less than or equal to. The value range is 0<=length<ge-value<=le-value<=32. For example, if you configure **ip prefix-list** test **permit** 192.168.0.0/16 **ge** 18 **le** 24, it means that routing entries with an address of 192.168.0.0 and a mask length between 18 (inclusive) and 24 (inclusive) are permitted to pass.
- When the network/length is configured as 0.0.0.0/0, it means the default route is matched; when it is configured as 0.0.0.0/0 **le** 32, it means all routes are matched.
- At the end of the IPv4 prefix list, there is an entry which prohibits all: **deny** 0.0.0.0/0 **le** 32. When deny statement is configured to prohibit some routes, it is recommended to add **permit** 0.0.0.0/0 **le** 32 statement at the end to permit other IPv4 routes to pass.

52.2.2 Configure AS-PATH List

Configuration Condition

None

Configure AS-PATH List

AS-PATH list can be used to filter AS numbers and BGP routes. The AS path attributes of BGP route record all the AS through which this route passes. When advertising a route to the outside of this AS, BGP will add the AS number to the AS path attributes to record the information of the AS path through which this route passes.

An AS-PATH list may contain multiple entries, the relationship between which is "or". During the matching process, the device checks according to the sequential order. As long as the route passes a certain entry in this AS-PATH list, it is deemed that it passes this AS-PATH list.

Table 52 Configuring AS-PATH List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure AS-PATH List	**ip as-path access-list** *path-list-number* { **permit** | **deny** } *regular-expression*	Mandatory By default, no AS-PATH list is configured.

Regular expressions are used in the AS-PATH list to specify the set of AS attributes that meets the requirements. Regular expression is composed of some general characters and some metacharacters.

General characters include letters in upper and lower case and figures; metacharacters have special meanings, as shown in the table below.

Table 52 Meanings of Metacharacters in Regular Expression

SYMBOL	Meaning
.	Match any single character
*	Match the sequence which can follow 0 or more bits in the mode
+	Match the sequence which can follow 1 or more bits in the mode
?	Match the sequence which can follow 0 or 1 bit in the mode
^	Match the start of the input string
$	Match the end of the input string
_	Match comma, bracket, start and end of character string, and space
[]	Match the single characters in a certain scope
-	Separate the end points in a scope

52.2.3 Configure List of Community Attributes

Configuration Condition

None

Configure List of Community Attributes

Community-list is used to filter the community attributes of route. Generally, a route has two parts, i.e. prefix and route attributes. In particular, route attributes are different among various routing protocols. Generally, there are simple attributes in the IGP protocol, such as metric. BGP has many complicated attributes, including community attributes. Community-list is used to filter these attributes. The community-list filtering result is obtained for the entire route where this community attribute is located. That is to say, if the filtering result is deny, the entire route rather than just this community attribute will be denied.

Community-list has two types, i.e. standard and extended. The standard community-list filters according to local-AS, internet, no-advertise, and no-export of BGP routes; the extcommunity-list uses regular expressions to filter the BGP routes with these community attributes.

For the use of community-list, routing protocols with community attributes can be used directly. Generally, they are often used indirectly by binding the community-list to the routing map and then applying the routing map to the routing protocol.

A community-list may contain multiple entries, the relationship between which is "or". During the matching process, the device checks according to the sequential order. As long as the route passes a certain entry in this community-list, it is deemed that it passes this community-list. When configuring the extcommunity-list, the use of regular expression can refer to the part of configuring AS-PATH list.

Table 52 Configuring Community-list

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure standard community-list	**ip community-list** { *community-list-number* | **standard** *community-list-name* } { **permit** | **deny** } [*community-number* / *aa*：*nn* / **local-AS** / **internet** / **no-advertise** / **no-export**]	Mandatory By default, no standard community-list is configured.
Configure extcommunity-list	**ip community-list** { *community-list-number* | **expanded** *community-list-name* } { **permit** | **deny** } *regular-expression*	Mandatory By default, no extcommunity-list is configured.

52.2.4 Configure List of Extcommunity Attributes

Configuration Condition

None

Configure List of Extcommunity Attributes

Extcommunity-list can be used to filter extcommunity attributes and particularly routes. The nature and application method of extcommunity-list are almost the same as those of community-list. The difference is

that the extcommunity attributes are mainly used in MPLS L3VPN. Therefore, extcommunity-list is also mainly used in MPLS L3VPN.

Extcommunity-list has two types, i.e. standard and extended. The standard community-list filters according to Router Target and Site of Origin; the extended extcommunity-list uses regular expressions to filter the BGP routes with these community attributes.

An extcommunity-list may contain multiple entries, the relationship between which is "or". During the matching process, the device checks according to the sequential order. As long as the route passes a certain entry in this extcommunity-list, it is deemed that it passes this extcommunity-list. When configuring the extended extcommunity-list, the use of regular expression can refer to the part of configuring AS-PATH list.

Table 52 Configuring Extcommunity-list

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure standard extcommunity-list	**ip extcommunity-list** { *extcommunity-list-number* | **standard** *extcommunity-list-name*} { **permit** | **deny** } [**rt** *extcommunity-number* / **soo** *extcommunity-number*]	Mandatory By default, no standard extcommunity-list is configured.
Configure extended extcommunity-list	**ip extcommunity-list** { *extcommunity-list-number* **| expanded** *extcommunity-list-name* } { **permit** | **deny** } *regular-expression*	Mandatory By default, no extended extcommunity-list is configured.

52.2.5 Configure Routing Map

Routing map is a tool used to match routes and set route attributes. A routing map is composed of several statements, each of which contains some match sub-statements and set sub-statements. The former define the match rules of this statement, while the latter define the actions after passing the match of match sub-statements. The relationship between match sub-statements is "and", i.e. all match sub-statements of this statement must be satisfied.

The relationship between statements of the routing map is "or". During the matching process, the device checks according to corresponding sequence number of the statements from small to large. Once the check

of a specific statement is passed, it means this routing map has been matched, and it will not continue to check the next statement. If no statement check has been passed, this routing map is not matched.

Configuration Condition

Before configuring a routing map, ensure that:

- Configure the ACL, prefix list, AS-PATH, community-list or extcommunity list required for routing map.

Create Routing Map

When creating the routing map, the match mode of its statements can be specified, i.e. **permit** or **deny**:

permit specifies the match mode of the statement of the routing map created is permit. The routing entries are allowed to pass and execute the set sub-statements of this statement when they meet all the match sub-statements of this statement. If the routing entries cannot satisfy the match sub-statements of this statement, the next statement of this routing map will be checked;

The word **deny** specifies the match mode of the statements of the routing map created is deny. The routing entries will be denied and check of the next statement will not be conducted only when they meet all the match sub-statements of this statement. The set sub-statement is not performed in **deny** mode.

Table 52 Creating Routing Map

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create Routing Map	**route-map** *map-name* [{ **permit** | **deny** } [*seq-number*]]	Mandatory By default, no routing map is created.

Note

- Create a routing map through the command route-map. When only the name of routing map is configured, yet the match mode and statement number are ignored, a statement with the match mode of permit and number of 10 will be added automatically.
- When the routing protocol applies a routing map which is not configured, all the objects will be matched ineffectively.

Configure match Sub-statement of Routing Map

The relationship between the match sub-statements of the routing map's statements is "and". All the match sub-statements must be satisfied to pass.

Table 1 Creating Match Sub-statements of Routing Map

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enters the routing map configuration mode	**route-map** *map-name* [{ **permit** | **deny** } [*seq-number*]]	-
Specify the AS-PATH list which matches the routing map	**match as-path** *path-list-number*	Optional By default, no AS-PATH list which matches the routing map is specified.
Specify the BGP community-list which matches the routing map	**match community** *community-list-number* / *community-list-name* [**exact-match**]	Optional By default, no BGP community-list which matches the routing map is specified.
Specify the BGP extcommunity-list which matches the routing map	**match extcommunity** ext*community-list-number* / ext*community-list-name*	Optional By default, no BGP extcommunity-list which matches the routing map is specified.
Specify the interface which matches the routing map	**match interface** *interface-names*	Optional By default, no interface which matches the routing map is specified.
Specify the route prefix which matches the routing map	**match ip address** { *access-list-number* | *access-list-name* | **prefix-list** *prefix-list-name* }	Optional By default, no route prefix which matches the routing map is specified.
Specify the next hop address which matches the routing map	**match ip next-hop** { *access-list-name* | **prefix-list** *prefix-list-name* }	Optional

Step	Command	Description
		By default, no next hop address which matches the routing map is specified.
Specify the source address of route which matches the routing map	**match ip route-source** { *access-list-name* | **prefix-list** *prefix-list-name* }	Optional By default, no source address of route which matches the routing map is specified.
Specify the metric value which matches the routing map	**match metric** *metric-value* [**+-***offset*]	Optional By default, no metric value which matches the routing map is specified.
Specify the route type which matches the routing map	**match route-type** { **external** / **interarea** / **internal** / **level-1** / **level-2** / **nssa-external** / **type-1** / **type-2** }	Optional By default, no route type which matches the routing map is specified.
Specify the tag value which matches the routing map	**match tag** *tag-value*	Optional By default, no tag value which matches the routing map is specified.

Note

- When no match sub-statement is configured in routing map, all the objects can be successfully matched.
- When there is no ACL and prefix list associated with the match sub-statements, all the objects cannot be successfully matched.

Configure set Sub-statement of Routing Map

Only when the match mode of the routing map is permit and all the match sub-statements are successfully matched, the set operation can be executed. When the match mode is deny, no set operation will be performed.

Table 52 Configuring Set Sub-statements of Routing Map

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enters the routing map configuration mode	**route-map** *map-name* [{ **permit** | **deny** } [*seq-number*]]	-
Set the AS path attributes of BGP route	**set as-path prepend** *as-path-number*	Optional By default, no AS path attribute of BGP route is set.
Set the community attributes of BGP route	**set communtiy** { *community-number* | **additive** | **local-AS** | **internet** | **no-advertise** | **no-export** | **none** }	Optional By default, no community attribute of BGP route is set.
Delete the specified BGP community-list	**set comm-list** { *community-list-number* / *community-list-name* } **delete**	Optional By default, the BGP community-list is not deleted.
Set BGP route dampening parameters	**set dampening** *half-life start-reusing start-suppress max-duration*	Optional By default, no BGP route dampening parameter is set.
Set the extcommunity attributes of MPLS L3VPN route	**set extcommunity** { **rt** | **soo** } *extcommunity*	Optional By default, no extcommunity attribute of MPLS L3VPN route is set.
Set the next hop of route	**set ip default next-hop** *ip-address*	Optional By default, the next hop of route is not configured. Set the next hop of route in the redistribution of OSPF route
Set the next hop of route	**set ip next-hop** *ip-address*	Optional

Step	Command	Description
		By default, the next hop of route is not configured. Set the next hop of route for BGP's associated routing map
Set preference of BGP route	**set local-preference** *value*	Optional By default, no local preference of BGP route is set.
Set the metric value of route	**set metric** { *metric* | *+metric* | *-metric* | *bandwidth delay reliable loading mtu* }	Optional By default, no metric value of route is set.
Set the metric type of route	**set metric-type** { **external** | **internal** | **type-1** | **type-2** }	Optional By default, no metric type of route is set.
Set the Origin attributes of BGP route	**set origin** { **egp** *as-number* | **igp** | **incomplete** }	Optional By default, no Origin attribute of BGP route is set.
Set the field of external route's tag option	**set tag** *tag-value*	Optional By default, no field of external route's tag option is set.
Set the weight of BGP route	**set weight** *weight-value*	Optional By default, the weight of BGP route is not set.

52.2.6 Configure Key-chain

Configuration Condition

None

Configure Key-chain

Key-chain is a password management tool. It provides authentication password when the routing protocol is authenticating protocol packets. Key-chain can provide different passwords for the sending and receiving of packets as well as for different Key IDs. Besides, Key-chain can periodically and automatically switch password according to the effective time of the Key configured, i.e. use different passwords at different time periods, which greatly improves the security of password.

Multiple Key IDs can be configured for a Key-chain. When the protocol uses the Key-chain for authentication, the Key ID is selected according to the following rules:

- Obtain the minimum valid sending password of Key ID when necessary;
- Obtain the minimum valid receiving password of Key ID in the Key where the Key ID is greater than or equals to the given Key ID;
- When the protocol packets received contain Key ID, they will search corresponding valid receiving password in the local port according to this Key ID; otherwise, the minimum valid effective receiving password of the Key ID in the Key-chain of local port will be used.

Table 52 Configuring Key-chain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to generate a Key-chain	**key chain** *keychain-name*	Mandatory By default, Key-chain is not configured.
Configure Key ID	**key** *key-id*	Mandatory By default, Key ID is not configured.
Configure password	**key-string** [**0 | 7**] *password*	Mandatory By default, password is not configured. Please note that space is also considered as a password character
Set the valid time of Key as a receiving password	**accept-lifetime** *time-start* { *time-end* | **duration** *second* | **infinite** }	Mandatory By default, the receiving password is always valid.

Step	Command	Description
Set the valid time of Key as a sending password	**send-lifetime** *time-start* { *time-end* | **duration** *second* | **infinite** }	Mandatory By default, the sending password is always valid.

52.2.7 Routing Policy Tool Monitoring and Maintaining

Table 52 Routing Policy Tool Monitoring and Maintaining

Command	Description
clear ip prefix-list [*prefix-list-name network/length*]	Clears prefix list statistics.
show ip prefix-list [*prefix-list-name* [*network/lenghter* [**first-match** | **longer**] | **seq** *sep_value*] | **detail** [*prefix-list-name*] | **orf-prefix | summary** [*prefix-list-name*]	Show the information of prefix list
show ip as-path-access-list [*list-name*]	Show the information of AS-PATH list
show ip community-list [*community-list-number* | *community-list-name*]	Show the information of community-list
show ip extcommunity-list [*extcommunity-list-number* | *extcommunity-list-name*]	Show the information of extcommunity-list
show route-map [*route-map-name*]	Show the information of routing map
show key chain [*keychain-name*]	Show the information of Key-chain

52.3 Example of Typical Routing Policy Tool Configuration

52.3.1 Configure Route Redistribution and Associate Routing Policy

Network Requirements

- OSPF protocol is run between Device1 and Device2, and RIP protocol is run between Device2 and Device3.
- Configure OSPF to redistribute RIP routes on Device2, associate the routing policy, modify the Tag attribute of 100.1.1.0/24 as 5 and the metric value of 110.1.1.0/24 as 50, and keep the attributes of 120.1.1.0/24 unchanged.

Network Topology

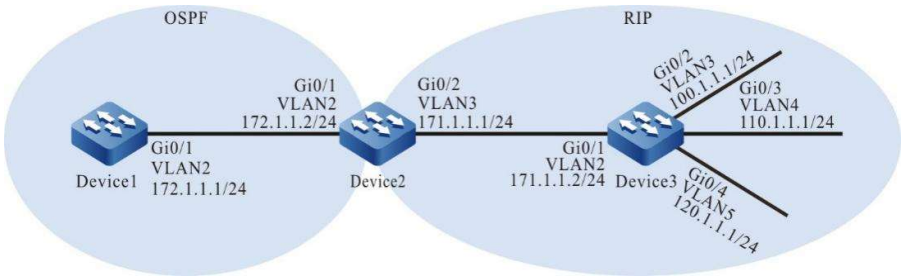


Figure 52-1 Network Topology for Configuring Route Redistribution and Association with Routing Policy

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure OSPF.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#network 172.1.1.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#network 172.1.1.0 0.0.0.255 area 0
Device2(config-ospf)#exit
```

Step 4: Configure RIP.

#Configure Device2.

```
Device2(config)#router rip
Device2(config-rip)#version 2
Device2(config-rip)#network 171.1.1.0
Device2(config-rip)#exit
```

#Configure Device3.

```
Device3(config)#configure terminal
Device3(config)#router rip
```

```
Device3(config-rip)#version 2
Device3(config-rip)#network 171.1.1.0
Device3(config-rip)#network 100.1.1.0
Device3(config-rip)#network 110.1.1.0
Device3(config-rip)#network 120.1.1.0
Device3(config-rip)#exit
```

Step 5: Configure OSPF to redistribute RIP routes.

#Configure Device2.

```
Device2(config)#router ospf 100
Device2(config-ospf)#redistribute rip
Device2(config-ospf)#exit
```

#View the routing table of Device1.

```
Device1#show ip route ospf
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

OE  100.1.1.0/24 [150/20] via 172.1.1.2, 02:22:08, vlan2
OE  110.1.1.0/24 [150/20] via 172.1.1.2, 00:49:57, vlan2
OE  120.1.1.0/24 [150/20] via 172.1.1.2, 02:22:08, vlan2
OE  171.1.1.0/24 [150/20] via 172.1.1.2, 02:22:41, vlan2
```

By checking the routing table of Device1, you will find that the RIP routes on Device2, i.e. 100.1.1.0/24, 110.1.1.0/24, and 120.1.1.0/24, have been redistributed to the OSPF process and successfully advertised to Device1.

Step 6: Configure access list and routing policy.

#Configure Device2.

Configure access list, and allow the routes 100.1.1.0/24, 110.1.1.0/24 and 120.1.1.0/24 to pass.

```
Device2(config)#ip access-list standard 1
Device2(config-std-nacl)#permit 100.1.1.0 0.0.0.255
Device2(config-std-nacl)#commit
Device2(config-std-nacl)#exit
Device2(config)#ip access-list standard 2
Device2(config-std-nacl)#permit 110.1.1.0 0.0.0.255
Device2(config-std-nacl)#commit
Device2(config-std-nacl)#exit
Device2(config)#ip access-list standard 3
Device2(config-std-nacl)#permit 120.1.1.0 0.0.0.255
Device2(config-std-nacl)#commit
Device2(config-std-nacl)#exit
```

Configure the routing policy rip_to_ospf. Set the tag attribute of the routes allowed by the access list with a match number of 1, set the metric attribute of the routes allowed by the access list with a match number of 2, and keep the attributes of the routes allowed by the access list with a match number of 3 unchanged.

```
Device2(config)#route-map rip_to_ospf 10
Device2(config-route-map)#match ip address 1
Device2(config-route-map)#set tag 5
Device2(config-route-map)#exit
Device2(config)#route-map rip_to_ospf 20
Device2(config-route-map)#match ip address 2
```

```
Device2(config-route-map)#set metric 50
Device2(config-route-map)#exit
Device2(config)#route-map rip_to_ospf 30
Device2(config-route-map)#match ip address 3
Device2(config-route-map)#exit
```

Note

- When configuring a routing policy, both the prefix list and ACL can create matching rules. The difference is that the prefix list can exactly match the routing mask.

Step 7: Configure OSPF to redistribute RIP routes and associate routing policy.

#Configure Device2.

```
Device2(config)#router ospf 100
Device2(config-ospf)#redistribute rip route-map rip_to_ospf
Device2(config-ospf)#exit
```

Step 8: Check the result.

#View the OSPF database of Device1.

```
Device1#show ip ospf database external
        OSPF Router with ID (172.1.1.1) (Process ID 100)

            AS External Link States


  LS age: 1183
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: AS-external-LSA
 Link State ID: 100.1.1.0 (External Network Number)
 Advertising Router: 172.1.1.2
 LS Seq Number: 80000006
 Checksum: 0xbcc0
 Length: 36
 Network Mask: /24
      Metric Type: 2 (Larger than any link state path)
      TOS: 0
      Metric: 20
      Forward Address: 0.0.0.0
       External Route Tag: 5


 LS age: 1233
 Options: 0x22 (-|-|DC|-|-|-|E|-)
 LS Type: AS-external-LSA
 Link State ID: 110.1.1.0 (External Network Number)
 Advertising Router: 172.1.1.2
 LS Seq Number: 80000006
 Checksum: 0x0d4d
 Length: 36
 Network Mask: /24
      Metric Type: 2 (Larger than any link state path)
```

```
    TOS: 0
     Metric: 50
    Forward Address: 0.0.0.0
    External Route Tag: 0


LS age: 1113
Options: 0x22 (-|-|DC|-|-|-|E|-)
LS Type: AS-external-LSA
Link State ID: 120.1.1.0 (External Network Number)
Advertising Router: 172.1.1.2
LS Seq Number: 80000005
Checksum: 0x5f10
Length: 36
Network Mask: /24
    Metric Type: 2 (Larger than any link state path)
    TOS: 0
    Metric: 20
    Forward Address: 0.0.0.0
    External Route Tag: 0
```

#View the routing table of Device1.

```
Device1#show ip route ospf
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
     U - Per-user Static route
     O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

OE  100.1.1.0/24 [150/20] via 172.1.1.2, 02:30:28, vlan2
OE  110.1.1.0/24 [150/50] via 172.1.1.2, 00:58:17, vlan2
OE  120.1.1.0/24 [150/20] via 172.1.1.2, 02:30:28, vlan2
```

By checking the OSPF database and routing table of Device1, you will find that the route tag of 100.1.1.0/24 is 5, the metric value of 110.1.1.0/24 is 50, and the route attributes of 120.1.1.0/24 remain the same.

Note

- When external routes are redistributed, the direct routes covered by the RIP process will also be redistributed into the target protocol.

52.3.2 Configure BGP to Associate with the Routing Policy

Network Requirements

- Device1 runs IGP protocol OSPF with Device2 and Device3 to establish IBGP neighbors, and Device4 establishes EBGP neighbors with Device2 and Device3.
- Routing policy is required to be configured on Device2 and Device3. In this case, some data of Device1 will reach the network segment 100.1.1.0/24 through Device2 and some reach the network segment 110.1.1.0/24 through Device3; some data of Device4 will reach the network segment 120.1.1.0/24 through Device2 and some reach the network segment 130.1.1.0/24 through Device3.

Network Topology

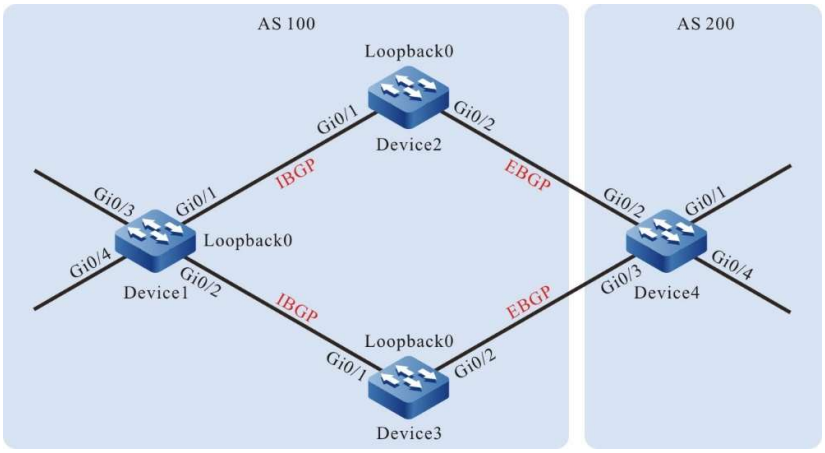


Figure 52-2 Network Topology for Configuring BGP Association with Routing Policy

of equipment	Interface	VLAN	IP address
Device1	Gi0/1	2	1.0.0.1/24
	Gi0/2	3	2.0.0.1/24
	Gi0/3	4	120.1.1.1/24
	Gi0/4	5	130.1.1.1/24
	Loopback0		38.1.1.1/32
Device2	Gi0/1	2	1.0.0.2/24
	Gi0/2	3	3.0.0.1/24
	Loopback0		39.1.1.1/32
Device3	Gi0/1	2	2.0.0.2/24
	Gi0/2	3	4.0.0.1/24
	Loopback0		40.1.1.1/32
Device4	Gi0/1	2	100.1.1.1/24
	Gi0/2	3	3.0.0.2/24
	Gi0/3	4	4.0.0.2/24

of equipment	Interface	VLAN	IP address
	Gi0/4	5	110.1.1.1/24

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure OSPF so that the routes of Loopback between devices are reachable from each other.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#network 1.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#network 2.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#network 38.1.1.1 0.0.0.0 area 0
Device1(config-ospf)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#network 1.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#network 39.1.1.1 0.0.0.0 area 0
Device2(config-ospf)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router ospf 100
Device3(config-ospf)#network 2.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#network 40.1.1.1 0.0.0.0 area 0
Device3(config-ospf)#exit
```

#View the routing table of Device1.

```
Device1#show ip route ospf
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

O   39.1.1.1/32 [110/2] via 1.0.0.2, 19:11:33, vlan2
O   40.1.1.1/32 [110/2] via 2.0.0.2, 18:56:32, vlan3
```

#View the routing table of Device 2.

```
Device2#show ip route ospf
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

O   2.0.0.0/24 [110/2] via 1.0.0.1, 19:19:10, vlan2
O   38.1.1.1/32 [110/2] via 1.0.0.1, 19:09:43, vlan2
O   40.1.1.1/32 [110/3] via 1.0.0.1, 18:56:49, vlan2
```

#Check the routing table of Device3.

```
Device3#show ip route ospf
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

O   1.0.0.0/24 [110/2] via 2.0.0.1, 19:17:33, vlan2
O   38.1.1.1/32 [110/2] via 2.0.0.1, 19:09:59, vlan2
O   39.1.1.1/32 [110/3] via 2.0.0.1, 19:12:06, vlan2
```

After the configuration, Device1 establishes OSPF neighbors with Device2 and Device3, and learn the Loopback route from each other.

Step 4: Configure BGP.

#Configure Device1.

Configure Device1 to establish IBGP neighbors with Device2 and Device3 using Loopback interface address, and advertise the routes 120.1.1.0/24 and 130.1.1.0/24 to the BGP routing table.

```
Device1(config)#router bgp 100
Device1(config-bgp)#neighbor 39.1.1.1 remote-as 100
Device1(config-bgp)#neighbor 39.1.1.1 update-source loopback0
Device1(config-bgp)#neighbor 40.1.1.1 remote-as 100
Device1(config-bgp)#neighbor 40.1.1.1 update-source loopback0
Device1(config-bgp)#network 120.1.1.0 255.255.255.0
Device1(config-bgp)#network 130.1.1.0 255.255.255.0
Device1(config-bgp)#exit
```

#Configure Device2.

```
Device2(config)#router bgp 100
Device2(config-bgp)#neighbor 38.1.1.1 remote-as 100
Device2(config-bgp)#neighbor 38.1.1.1 update-source loopback0
Device2(config-bgp)#neighbor 38.1.1.1 next-hop-self
Device2(config-bgp)#neighbor 3.0.0.2 remote-as 200
Device2(config-bgp)#exit
```

#Configure Device3.

```
Device3(config)#router bgp 100
Device3(config-bgp)#neighbor 38.1.1.1 remote-as 100
Device3(config-bgp)#neighbor 38.1.1.1 update-source loopback0
Device3(config-bgp)#neighbor 38.1.1.1 next-hop-self
Device3(config-bgp)#neighbor 4.0.0.2 remote-as 200
Device3(config-bgp)#exit
```

#Configure Device4.

Configure Device4 to establish EBGP neighbors with Device2 and Device3, and advertise the routes 100.1.1.0/24 and 110.1.1.0/24 to the BGP routing table.

```
Device4#configure terminal
Device4(config)#router bgp 200
Device4(config-bgp)#neighbor 3.0.0.1 remote-as 100
Device4(config-bgp)#neighbor 4.0.0.1 remote-as 100
Device4(config-bgp)#network 100.1.1.0 255.255.255.0
Device4(config-bgp)#network 110.1.1.0 255.255.255.0
Device4(config-bgp)#exit
```

#View the BGP routing information of Device1.

```
Device1#show ip bgp
```

```
BGP table version is 2, local router ID is 38.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network          Next Hop            Metric LocPrf Weight Path
[B]*>i100.1.1.0/24   39.1.1.1                 0    100      0 200 i
[B]* i               40.1.1.1                 0    100      0 200 i
[B]*>i110.1.1.0/24   39.1.1.1                 0    100      0 200 i
[B]* i               40.1.1.1                 0    100      0 200 i
[B]*> 120.1.1.0/24   0.0.0.0                  0         32768 i
[B]*> 130.1.1.0/24   0.0.0.0                  0         32768 i
```

#View the routing table of Device1.

```
Device1#show ip route bgp
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

B   100.1.1.0/24 [200/0] via 39.1.1.1, 19:03:19, vlan2
B   110.1.1.0/24 [200/0] via 39.1.1.1, 19:03:19, vlan2
```

It can be seen from the BGP routing table of Device1 that there are two valid routes for the data leading to the network segments 100.1.1.0/24 and 110.1.1.0/24. Since the router ID of Device2 is small, the data BGPs all reach the network segments 100.1.1.0/24 and 110.1.1.0/24 through Device2 by default.

#View the BGP routing information of Device 4.

```
Device4#show ip bgp
BGP table version is 3, local router ID is 110.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
   Network          Next Hop            Metric LocPrf Weight Path
[B]*> 100.1.1.0/24   0.0.0.0                  0         32768 i
[B]*> 110.1.1.0/24   0.0.0.0                  0         32768 i
[B]*  120.1.1.0/24   4.0.0.1                  0             0 100 i
[B]*>                3.0.0.1                  0             0 100 i
[B]*  130.1.1.0/24   4.0.0.1                  0             0 100 i
[B]*>                3.0.0.1                  0             0 100 i
```

#View the routing table of Device 4.

```
Device4#show ip route bgp
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

B   120.1.1.0/24 [20/0] via 3.0.0.1, 19:25:05, vlan3
B   130.1.1.0/24 [20/0] via 3.0.0.1, 19:25:05, vlan3
```

It can be seen from the BGP routing table of Device4 that there are two valid routes for the data leading to the network segments 120.1.1.0/24 and 130.1.1.0/24. Since Device4 first establishes neighbors with Device2 and it takes longer to learn these two routes from Device2, the data BGPs all reach the network segments 120.1.1.0/24 and 130.1.1.0/24 through Device2 by default.

Step 5: Configure prefix list and routing policy.

#Configure Device2.

Configure prefix list, and allow the routes 100.1.1.0/24 and 130.1.1.0/24 to pass.

```
Device2(config)#ip prefix-list 1 permit 100.1.1.0/24
Device2(config)#ip prefix-list 2 permit 130.1.1.0/24
```

Configure routing policy lp so that Device2 sets local-preference attribute for the routes allowed by the prefix list with the match number of 1.

```
Device2(config)#route-map lp 10
Device2(config-route-map)#match ip address prefix-list 1
Device2(config-route-map)#set local-preference 200
Device2(config-route-map)#exit
Device2(config)#route-map lp 20
Device2(config-route-map)#exit
```

Configure the routing policy med so that Device2 sets MED attribute for the routes allowed by the prefix list with the match number of 2.

```
Device2(config)#route-map med 10
Device2(config-route-map)#match ip address prefix-list 2
Device2(config-route-map)#set metric 10
Device2(config-route-map)#exit
Device2(config)#route-map med 20
Device2(config-route-map)#exit
```

#Configure Device3.

Configure prefix list, and allow the routes 110.1.1.0/24 and 120.1.1.0/24 to pass.

```
Device3(config)#ip prefix-list 1 permit 110.1.1.0/24
Device3(config)#ip prefix-list 2 permit 120.1.1.0/24
```

Configure routing policy lp so that Device3 sets local-preference attribute for the routes allowed by the prefix list with the match number of 1.

```
Device3(config)#route-map lp 10
Device3(config-route-map)#match ip address prefix-list 1
Device3(config-route-map)#set local-preference 200
Device3(config-route-map)#exit
Device3(config)#route-map lp 20
Device3(config-route-map)#exit
```

Configure the routing policy med so that Device3 sets MED attribute for the routes allowed by the prefix list with the match number of 2.

```
Device3(config)#route-map med 10
Device3(config-route-map)# match ip address prefix-list 2
Device3(config-route-map)#set metric 10
Device3(config-route-map)#exit
Device3(config)#route-map med 20
Device3(config-route-map)#exit
```

Note

- When configuring a routing policy, both the prefix list and ACL can create matching rules. The difference is that the prefix list can exactly match the routing mask.

Step 6: Configure BGP to associate with the routing policy.

#Configure Device2.

Apply the routing policy lp to the routes of neighbor 38.1.1.1 in the outgoing direction and med to those of neighbor 3.0.0.2 in the outgoing direction.

```
Device2(config)#router bgp 100
Device2(config-bgp)#neighbor 38.1.1.1 route-map lp out
Device2(config-bgp)#neighbor 3.0.0.2 route-map med out
Device2(config-bgp)#exit
```

#Configure Device3.

Apply the routing policy lp to the routes of neighbor 38.1.1.1 in the outgoing direction and med to those of neighbor 4.0.0.2 in the outgoing direction.

```
Device3(config)#router bgp 100
Device3(config-bgp)#neighbor 38.1.1.1 route-map lp out
Device3(config-bgp)#neighbor 4.0.0.2 route-map med out
Device3(config-bgp)#exit
```

Step 7: Check the result.

#View the BGP routing information of Device1.

```
Device1#show ip bgp
BGP table version is 9, local router ID is 38.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
     Network          Next Hop            Metric LocPrf Weight Path
[B]* i100.1.1.0/24    40.1.1.1                 0    100      0 200 i
[B]*>i                39.1.1.1                 0    200      0 200 i
[B]*>i110.1.1.0/24    40.1.1.1                 0    200      0 200 i
[B]* i                39.1.1.1                 0    100      0 200 i
[B]*> 120.1.1.0/24    0.0.0.0                  0         32768 i
[B]*> 130.1.1.0/24    0.0.0.0                  0         32768 i
```

#View the routing table of Device1.

```
Device1#show ip route bgp
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

B   100.1.1.0/24 [200/0] via 39.1.1.1, 02:58:12, vlan2
B   110.1.1.0/24 [200/0] via 40.1.1.1, 02:58:10, vlan3
```

It can be seen from the BGP routing table of Device1 that the route 100.1.1.0/24 has two next hops, i.e. 40.1.1.1 and 39.1.1.1. The local preference of the route with the next hop of 39.1.1.1 becomes 200, so the data prefer to reach the network segment 100.1.1.0/24 through Device2. There are also two next hops on the route 110.1.1.0/24, i.e. 40.1.1.1 and 39.1.1.1. The local preference of the route with the next hop of 40.1.1.1 becomes 200, so the data prefer to reach the network segment 110.1.1.0/24 through Device3.

#View the BGP routing information of Device 4.

```
Device4#show ip bgp
BGP table version is 9, local router ID is 110.1.1.1
Status codes: s suppressed, d damped, h history, * valid, > best, i - internal,
              S Stale
Origin codes: i - IGP, e - EGP, ? - incomplete
     Network          Next Hop            Metric LocPrf Weight Path
[B]*> 100.1.1.0/24    0.0.0.0                  0         32768 i
```

```
[B]*> 110.1.1.0/24       0.0.0.0              0       32768 i
[B]*  120.1.1.0/24       4.0.0.1             10           0 100 i
[B]*>                    3.0.0.1              0           0 100 i
[B]*> 130.1.1.0/24       4.0.0.1              0           0 100 i
[B]*                     3.0.0.1             10           0 100 i
```

#View the routing table of Device 4.

```
Device4#show ip route bgp
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

B   120.1.1.0/24 [20/0] via 3.0.0.1, 03:05:39, vlan3
B   130.1.1.0/24 [20/0] via 4.0.0.1, 03:05:37, vlan4
```

It can be seen from the BGP routing table of Device1 that the route 120.1.1.0/24 has two next hops, i.e. 4.0.0.1 and 3.0.0.1. The metric of the route with the next hop of 4.0.0.1 becomes 10, so the data prefer to reach the network segment 120.1.1.0/24 through Device2. There are also two next hops on the route 130.1.1.0/24, i.e. 4.0.0.1 and 3.0.0.1. The metric of the route with the next hop of 3.0.0.1 becomes 10, so the data prefer to reach the network segment 130.1.1.0/24 through Device3.

Note

- When BGP peer or peer group applies the routing policy, it can be used in the receiving and advertising direction of the peer or peer group. This takes effect after resetting BGP.

53 L2 Multicast Basics

53.1 Overview

The main task of L2 multicast basics is to maintain the L2 multicast forwarding table. The application modules of L2 multicast generates their L2 multicast tables by static configuration and dynamic learning, and then synchronize the information to the L2 multicast basis modules. L2 multicast basis modules integrate the information to form the L2 multicast forwarding table.

53.2 L2 Multicast Basics Function Configuration

Table 53-1 L2 Multicast Basics Configuration List

Configuration Task	
Configure Unknown Packet Forwarding Policy of L2 Multicast	Configure Unknown Packet MAC Forwarding Policy of L2 Multicast
	Configure Unknown Packet IP Forwarding Policy of L2 Multicast
	Configure Policy of Forwarding Unknown Multicast to Uplink Port
Configure L2 static multicast	Configure L2 static multicast

53.2.1 Configure Unknown Packet Forwarding Policy of L2 Multicast

Unknown multicast service packets have two kinds of forwarding policies: drop unknown multicast service packets, or make the unknown multicast service packets flood.

Configuration Condition

Before configuring the unknown packet forwarding policy of L2 multicast, first complete the following task:

- Configure corresponding VLAN

Configure Unknown Packet MAC Forwarding Policy of L2 Multicast

In the L2 multicast MAC forwarding mode, the multicast service packets are forwarded by matching VLAN and destination MAC address. When the multicast service packet does not match the forwarding table, it is unknown multicast service packet. The device has two kinds of forwarding policies for the unknown multicast service packets: drop unknown multicast service packets, or make unknown multicast service packets flood.

Table 53-2 Configuring Unknown Packet MAC Forwarding Policy of L2 Multicast

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure the MAC forwarding policy of L2 multicast	**l2-multicast drop-unknown**	Optional By default, the function of dropping unknown multicast service packets is disabled in the VLAN

Configure Unknown Packet IP Forwarding Policy of L2 Multicast

In the IPV4 L2 multicast IP forwarding mode, the multicast service packets are forwarded by matching VLAN, multicast source IP address and multicast destination IP address. When the multicast service packet does not match the forwarding table, it is unknown multicast service packet. The device has two kinds of forwarding policies for the unknown multicast service packets: drop unknown multicast service packets, or make unknown multicast service packets flood.

Table 53-3 Configuring Unknown Packet IP Forwarding Policy of L2 Multicast

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure the IP forwarding policy of L2 multicast	**l3-multicast drop-unknown**	Mandatory By default, the function of dropping unknown multicast service packets is disabled in the VLAN

Configure Unknown Packet Ipv6 Forwarding Policy of L2 Multicast

In the IPV6 L2 multicast IP forwarding mode, the multicast service packets are forwarded by matching VLAN, multicast source IP address and multicast destination IP address. When the multicast service packet does not match the forwarding table, it is unknown multicast service packet. The device has two kinds of forwarding policies for the unknown multicast service packets: drop unknown multicast service packets, or make unknown multicast service packets flood.

Table 53-4 Configuring Unknown Packet IPv6 Forwarding Policy of L2 Multicast

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure the IP forwarding policy of L2 multicast	**l3-multicast ipv6 drop-unknown**	Mandatory By default, the function of dropping unknown multicast service packets is disabled in the VLAN

Configure Policy of Forwarding Unknown Multicast to Uplink Port

In the L2 multicast forwarding, the multicast service packets are forwarded by the L2 multicast forwarding table. When the multicast service packet does not match the forwarding table, it is unknown multicast service packet. The function of dropping unknown multicast service packets is enabled in the VLAN, and the unknown multicast service packets will be dropped. In this case, after the function of forwarding unknown multicast to the uplink port is enabled in the VLAN, the effect of flooding the unknown multicast service packets to the uplink port can be realized.

Table 53-5 Configuring the Policy of Forwarding Unknown Multicast to Uplink Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure the IP forwarding policy of L2 multicast	**l3-multicast drop-unknown**	Mandatory By default, the function of dropping unknown multicast service packets is disabled in the VLAN

Step	Command	Description
Configure the MAC forwarding policy of L2 multicast	**l2-multicast drop-unknown**	Mandatory By default, the function of dropping unknown multicast service packets is disabled in the VLAN
Configure Policy of Forwarding Unknown Multicast to Uplink Port	**multicast mrouter-forwarding**	Optional By default, forwarding the unknown multicast to the uplink port is not enabled in the VLAN

53.2.2 Configure L2 static multicast

L2 static multicast generates L2 multicast forwarding table by static configuration. It is formed by the user specifying multicast MAC address, VLAN, and port list (including member port list and prohibited port list).

Configuration Condition

Before configuring L2 static multicast, first complete the following task:

- Configure corresponding VLAN

Configure L2 static multicast

Table 53-6 Configuring L2 Static Multicast

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create L2 static multicast	**l2-multicast mac-entry static** *mac-address* **vlan** *vlan-id*	Mandatory By default, no L2 static multicast entry is configured
Configure the member port for L2 static multicast entries	**interface** *interface-list-name* { **member** | **forbidden** }	Optional By default, the member port for L2 static multicast entries is not configured

Step	Command	Description
Configure the member aggregation group for L2 static multicast entries	**interface link-aggregation** *link-aggregation-id* { **member** | **forbidden** }	Optional The member aggregation group for L2 static multicast entries is not configured

53.2.3 Monitoring and Maintaining of L2 Multicast Basics

Table 53-7 Monitoring and Maintaining of L2 Multicast Basics

Command	Description
show l2-multicast ha { phase batch | phase flat | statistics }	Show the information about high reliability of the L2 multicast
show l2-multicast ip-entry	Show the information of the IP forwarding table of the L2 multicast
show l2-multicast l3-ip-entry	Show the information of the L3 IP forwarding table of the L2 multicast
show l2-multicast mac-entry { **all** | **forward** | **static** }	Show the L2 multicast table
show l2-multicast vlan-setting { all | *vlan-id* **}**	Show the VLAN information of the L2 multicast

53.3 Typical Configuration Examples of L2 Static Multicast

53.3.1 Configure L2 Static Multicast

Network Requirements

- On Device 1, configure the multicast routing protocol, on Device 2, configure the L2 static multicast in VLAN 2, PC1 is the receiver of multicast services, and PC2 and PC3 are not receivers of multicast services.
- Multicast Server sends the multicast service packets, PC 1 can correctly receive the multicast service packets, and PC 2 and PC 3 cannot receive the multicast service packets.

Network Topology

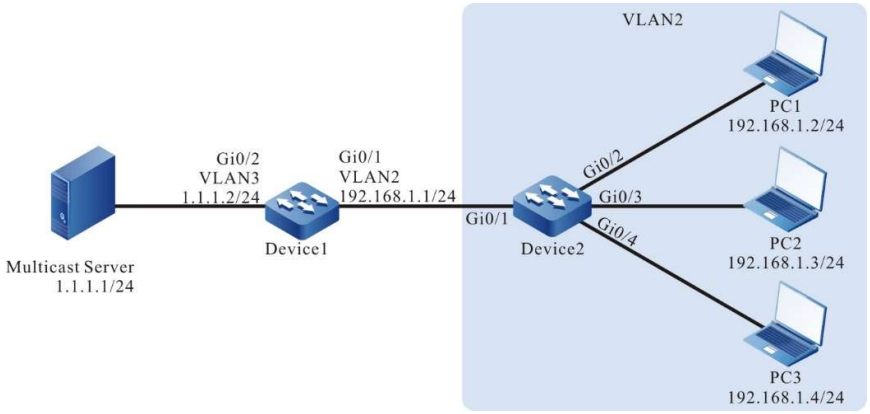


Figure 53-1 Network Topology for Configuring L2 Static Multicast

Configuration Steps

Step 1: On Device 1, configure the interface IP address and enable the multicast routing protocol. (Omitted)

Step 2: Configure Device2.

Create VLAN2 on #Device 2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#On Device 2, configure the link type of ports gigabitethernet0/2-gigabitethernet0/4 to Access to allow services of VLAN 2 to pass.

```
Device2(config)#interface gigabitethernet 0/2-0/4
Device2(config-if-range)#switchport access vlan 2
Device2(config-if-range)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#Enable unknown multicast drop in VLAN 2.

```
Device2(config)#vlan 2
Device2(config-vlan2)#l2-multicast drop-unknown
Device2(config-vlan2)#exit
```

#Configure L2 static multicast group members.

```
Device2(config)#l2-multicast mac-entry static 0100.5E01.0101 vlan 2
Device2(config-mcast)#interface gigabitethernet 0/2 member
Device2(config-mcast)#exit
Device2(config)#l2-multicast mac-entry static 0100.5E01.0101 vlan 2
Device2(config-mcast)#interface gigabitethernet 0/3 forbidden
Device2(config-mcast)#exit
```

Step 3: Check the result.

#View the L2 static multicast entries of Device 2.

```
Device2#show l2-multicast mac-entry static
Current L2 Static Multicast 2 entries

---- -------- ------------------ ------------------------------
NO.  VID      Group MAC address  Interface Name
---- -------- ------------------ ------------------------------
1    2        0100.5E01.0101     [M] gi0/2
2    2        0100.5E01.0101     [F] gi0/3
```

#Multicast Server sends the multicast service packet with the destination address of 224.1.1.1, PC1 can correctly receive the multicast service packet, and PC2 and PC3 cannot receive the multicast service packet.

53.3.2 Configure IPv6 L2 Static Multicast

Network Requirements

- On Device 1, configure the IPv6 multicast routing protocol, on Device 2, configure the IPv6 L2 static multicast in VLAN 2, PC1 is the receiver of multicast services, and PC2 and PC3 are receivers of non-multicast services;
- Multicast Server sends the IPv6 multicast service packets, PC1 can correctly receive the multicast service packets, and PC2 and PC3 cannot receive the multicast service packets.

Network Topology

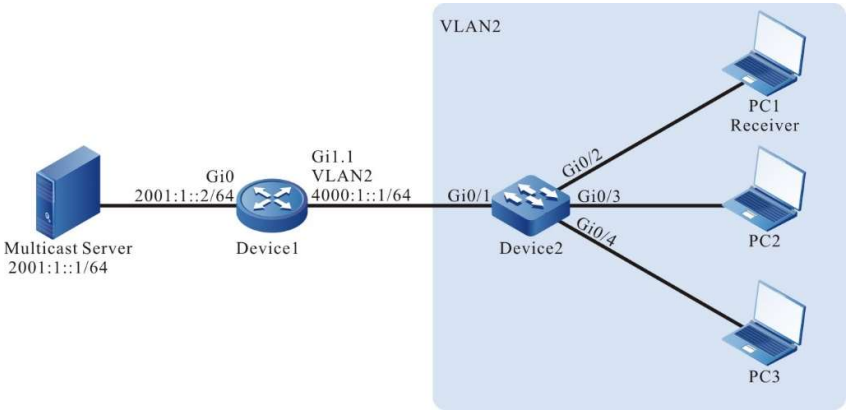


Figure 53-2 Network Topology for Configuring IPv6 L2 Static Multicast

Configuration Steps

Step 1: On Device 1, configure the interface IP address and enable the multicast routing protocol. (Omitted)

Step 2: Configure Device2.

Create VLAN2 on #Device 2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#On Device 2, configure the link type of ports gigabitethernet0/2-gigabitethernet0/4 to Access to allow services of VLAN 2 to pass.

```
Device2(config)#interface gigabitethernet 0/2-0/4
Device2(config-if-range)#switchport access vlan 2
Device2(config-if-range)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#Enable unknown multicast drop in VLAN 2.

```
Device2(config)#vlan 2
Device2(config-vlan2)#l2-multicast drop-unknown
Device2(config-vlan2)#exit
```

#Configure L2 static multicast group members.

```
Device2(config)# l2-multicast mac-entry static 3333.0000.0001 vlan 2
Device2(config-mcast)#interface gigabitethernet 0/2 member
Device2(config-mcast)#interface gigabitethernet 0/3 forbidden
Device2(config-mcast)#exit
```

Step 3: Check the result.

#View the IPv6 L2 static multicast entries of Device 2.

```
Device2# show l2-multicast mac-entry static
Current L2 Static Multicast 1 entries

---- -------- ------------------ ----------------------------------------------
NO.  VID      Group MAC address  Interface Name
---- -------- ------------------ ----------------------------------------------
1    2        3333.0000.0001     [M] gi0/2
                                 [F] gi0/3
```

#Multicast Server sends the multicast service packet with the destination address of ff10 ::1, PC 1 can correctly receive the multicast service packet, and PC 2 and PC 3 cannot receive the multicast service packet.

Note

- In the IPv6 L2 static multicast, the multicast service packets are only forwarded to the port whose role is member.
- For the forbidden port, even if you add the multicast groups corresponding to the static multicast groups by means of mld snooping, the multicast service packet whose destination address is the static multicast group will not be forwarded to the

forbidden port.

- For the non-member and non-forbidden port, the multicast groups corresponding to the static multicast groups can be added by means of mld snooping, the multicast service packet whose destination address is the static multicast group will be forwarded to such port.

---

54 IGMP Snooping

54.1 Overview

IGMP Snooping (Internet Group Management Protocol snooping) is the function designed for the device that does not support IGMP to reduce the spreading range of the multicast service packet and prevent the multicast packet from being spread to the network segments that do not need the multicast packet. It forms and maintains the downstream member port list of each multicast group at the local by listening to IGMP packets. In this way, when receiving multicast service packet, forward at the specified downstream member port. Meanwhile, IGMP Snooping can listen to the IGMP protocol packets and cooperate with the upstream multicast router to manage and control multicast services.

IGMP Snooping mainly realizes the following functions:

- Listen to the IGMP packets to set up multicast information. IGMP Snooping gets the downstream multicast receiver information by listening to IGMP packets, realizing the forwarding of multicast service packets at the specified member port.
- Listen to the IGMP protocol packets. In this way, the upstream multicast router can correctly maintain IGMP member relation table.

54.2 IGMP Snooping Function Configuration

Table 54-1 IGMP Snooping Function Configuration List

Configuration Task	
Configure the basic functions of IGMP snooping	Enable the IGMP snooping function
	Configure the IGMP snooping version
	Enable the IGMP snooping L2 forwarding function
Configure IGMP snooping Querier	Enable IGMP snooping Querier
	Configure the source IP address of the IGMP query packet

Configuration Task	
	Configure Query Interval of General Group
	Configure Max. Response Time
	Configure Query Interval of Specified Group
	Configure Fast Leave
Configure IGMP snooping Router Port	Configure IGMP snooping Router Port
	Configure age time for the IGMP snooping dynamic router port
Configure the IGMP snooping TCN event	Enable fast convergence
	Configure TCN event query interval
	Configure TCN event query count
Configure the IGMP snooping policy	Configure the port filtering rules
	Configure the maximum number of port multicast group entries
	Configure the upper limit policy of port multicast groups
Configure IGMP snooping Proxy	Configure IGMP snooping Proxy
Configure IGMP snooping Static Group	Configure IGMP snooping Static Group

54.2.1 Configure Basic Functions of IGMP Snooping

In the various configuration tasks for IGMP snooping, you must first enable the IGMP snooping function so that the configuration of the other function features can take effect.

Configuration Condition

Before configuring the basic functions of IGMP snooping, do the following:

- Configure VLAN.

Enable the IGMP Snooping Function

The IGMP snooping function will run on the device only after it is enabled.

Table 54-2 Enabling the IGMP Snooping Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the global IGMP snooping function	**ip igmp snooping**	Mandatory By default, the global IGMP snooping function is disabled
Enable the IGMP snooping function of the specified VLAN	**ip igmp snooping vlan** *vlan-id*	Mandatory By default, the IGMP snooping function is disabled in the VLAN

Note

- The IGMP snooping function of the specified VLAN can be enabled only after the global IGMP snooping function is enabled.

Configure the IGMP Snooping Version

The handling rules for the configured IGMP snooping version and IGMP protocol packets are as follows:

If the configured IGMP snooping version is V3, the device can handle IGMP protocol packets of versions V1, V2, and V3;

If the configured IGMP snooping version is V2, the device can handle IGMP protocol packets of versions V1 and V2, and does not handle the protocol packets of version V3 but floods them in the VLAN;

If the configured IGMP snooping version is V1, the device can handle IGMP protocol packets of version V1, and does not handle the protocol packets of versions V2 and V3 but floods them in the VLAN.

Table 54-3 Configuring IGMP Snooping Version

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the IGMP snooping version	**ip igmp snooping vlan** *vlan-id* **version** *version-number*	Optional By default, the IGMP snooping version is 2

Enable IGMP Snooping L2 Forwarding

Generally, IGMP snooping forwards the multicast service packets in the VLAN based on the multicast source IP address and the multicast destination IP address. After IGMP snooping L2 forwarding, IGMP snooping will forward the multicast service packets in the VLAN based on the multicast destination MAC address.

Table 54-4 IGMP Snooping L2 Forwarding

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the L2 multicast L2 forwarding function in the specified VLAN	**ip igmp snooping vlan** *vlan-id* **l2-forwarding**	Mandatory By default, the L2 multicast IP forwarding function of IGMP snooping is enabled for the VLAN

Caution

- As 32 multicast IP addresses correspond to one multicast MAC address, with L2 forwarding being unable to specify the multicast source forwarding, it is possible that multiple IP multicast source groups correspond to the same MAC group, and then forwarding conflicts may occur.

54.2.2 Configure IGMP Snooping Querier

If there is no L3 multicast device in the network, it cannot realize the related functions of the IGMP querier. To solve the problem, the IGMP snooping querier can be configured on the L2 multicast device to realize

the IGMP querier function. Therefore, the L2 multicast device can set up and maintain the multicast forwarding entry, so as to forward multicast service packets normally.

Configuration Condition

Before configuring the basic functions of IGMP snooping querier, first complete the following task:

- Enable global and VLAN IGMP snooping function

Enable IGMP Snooping Querier

You should first enable the IGMP snooping querier function so that the configuration of the other features of the querier can take effect.

Table 54-5 Enabling IGMP snooping Querier

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable IGMP snooping Querier	**ip igmp snooping vlan** *vlan-id* **querier**	Mandatory By default, the IGMP snooping querier of the specified VLAN is disabled

Configure Querier IP Address

The querier configured with IP address takes part in the election of the IGMP querier in VLAN and the querier fills the IP address in the source IP address field of the sent IGMP group query packet.

Table 54-6 Configuring Querier IP Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Querier IP Address	**ip igmp snooping vlan** *vlan-id* **querier address** *ip-address*	Mandatory By default, the querier IP address of the specified VLAN is not configured

Note

- When the querier IP address is not configured, the default source IP address of the querier is 0.0.0.0, but the querier does not send the IGMP group query packet with source IP address 0.0.0.0.

Configure Query Interval of General Group

IGMP querier periodically sends the query packets of the general group to maintain the group member relation. The interval of sending the IGMP general group query packets can be modified according to the actuality of the network. For example, if the configured general group query interval is long, it can reduce the number of the IGMP protocol packets in the network, avoiding the network congestion.

Table 54-7 Configuring Query Interval of General Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Query Interval of General Group	**ip igmp snooping vlan** *vlan-id* **querier query-interval** *interval-value*	Optional By default, the query interval of the general group is 125 seconds

Note

- In the same VLAN, the configured query interval of the general group should be larger than the maximum response time. Otherwise, the configuration cannot succeed.

Configure Max. Response Time

The general group query packet sent by IGMPv2 querier contains the maximum response time field. The multicast receiver sends the member report packets within the maximum response interval. If the multicast receiver does not send the member report packets within the maximum response time, the device regards that the subnet does not have the receiver of the multicast group and then deletes the multicast group information at once.

Table 54-8 Configuring Maximum Response Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Max. Response Time	**ip igmp snooping vlan** *vlan-id* **querier max-response-time** *time-value*	Optional By default, the maximum response time is 10 seconds

Note

- In the same VLAN, the configured maximum response time should be smaller than the query interval of the general group. Otherwise, the configuration cannot succeed.

Configure Query Interval of Specified Group

When the IGMP querier receives the leave packet of one multicast group, it sends the query packet of the specified group to query the segment for the multicast group, so as to know whether the subnet has the member of the multicast group. If not receiving the member report packet of the multicast group after waiting for “maximum response time”, delete the information of the multicast group.

Table 54-9 Configuring Query Interval of Specified Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Query Interval of Specified Group	**ip igmp snooping vlan** *vlan-id* **last-member-query-interval** *interval-value*	Optional By default, the query interval of the specified group is 1000 milliseconds

Configure Fast Leave

If the device receives the leave packet of one multicast group after configuring fast leave, the device does not send the query packet of the specified group to the port any more and the information of the multicast group is deleted at once.

Table 54-10 Configuring Immediate Leave

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Fast Leave	**ip igmp snooping vlan** *vlan-id* **immediate-leave**	Mandatory By default, the fast leave function of the specified VLAN is disabled

Note

- There are multiple receivers of the same multicast group in the device port at the same time. When the port receives the IGMP leave packet of the multicast group sent by one receiver and if fast leave is configured in the VLAN of the device port, the multicast services of the other receivers are interrupted.

54.2.3 Configure IGMP Snooping Router Port

IGMP snooping router port is the port receiving IGMP group query packets or multicast routing protocol packets. When the device receives the IGMP member report or leave packet, forward the packet via IGMP snooping router port. In this way, the upper-connected router can maintain the IGMP member relation table correctly.

IGMP snooping router port can be dynamically learned or configured manually. IGMP snooping dynamic router port refreshes the age time by regularly receiving the IGMP group query packets or multicast routing protocol packets. IGMP snooping static router port does not age.

Configuration Condition

Before configuring the IGMP snooping router port functions, first complete the following tasks:

- Enable global and VLAN IGMP snooping function
- Add port member in VLAN

Configure IGMP Snooping Static Router Port

After configuring IGMP snooping static router port, the device can forward the IGMP protocol packet via the port even the port does not receive the IGMP group query packet or multicast routing protocol packet. It can prevent the problem that the router port ages because the services of the upper-connected L3 multicast device are interrupted.

Table 54-11 Configuring IGMP snooping Static Router Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IGMP snooping Static Router Port	**ip igmp snooping vlan** *vlan-id* **mrouter** { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Mandatory By default, the IGMP snooping static router port is not configured

Configure Age Time for the IGMP Snooping Dynamic Router port

As long as the configured age time for the IGMP snooping dynamic router port is longer, the problem can be effectively prevented that the router port ages fast because the services of the uplink L3 multicast device are interrupted.

Table 54-12 Configuring Age Time for IGMP Snooping Dynamic Router Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure age time for the IGMP snooping dynamic router port	**ip igmp snooping vlan** *vlan-id* **timer router-port expiry** *expiry-value*	Optional By default, the age time of the IGMP snooping dynamic router port is 255 seconds

54.2.4 Configure the IGMP Snooping TCN Event

Configuration Condition

Before configuring the IGMP snooping TCN event function, do the following:

- Enable global and VLAN IGMP snooping function

Enable Fast Convergence

When the network topology varies, a TCN event will be generated. The root port of the spanning tree will actively send a global IGMP leave packet (group address: 0.0.0.0) to request the IGMP querier in order to send a general group query packet, achieving fast convergence.

After you enable the fast convergence of the IGMP snooping TCN event, the root port of the non-spanning tree can also actively send a global IGMP leave packet (group address: 0.0.0.0), achieving the fast convergence.

Table 54-13 Enabling Fast Convergence

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable fast convergence	**ip igmp snooping tcn query solicit**	Mandatory By default, fast convergence is disabled in the TCN event

Configure TCN Event Query Interval

When the TCN event occurs, the IGMP snooping querier will send a general group query at the TCN event query interval.

Table 54-14 Configuring TCN Event Query Interval

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TCN event query interval	**ip igmp snooping vlan** *vlan-id* **querier tcn query interval** *interval-value*	Optional By default, the TCN event query interval is 31 seconds

Configure TCN Event Query Count

When the TCN event occurs, the IGMP snooping querier will send a general group query at the TCN event query interval, and will restore to the general group query interval after the number of sending times reaches the configured TCN event query count.

Table 54-15 Configuring TCN Event Query Count

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TCN event query count	**ip igmp snooping vlan** *vlan-id* **querier tcn query count** *count-number*	Optional By default, the TCN event query count is 2

54.2.5 Configure the IGMP Snooping Policy

The IGMP snooping policy is mainly used to control the receiver on the port, thereby controlling the multicast flow and restricting the receiver's behavior. The IGMP snooping policy can also be applied in the established L2 multicast flow forwarding environment.

Configuration Condition

Before configuring the IGMP snooping policy, do the following:

- Enable global and VLAN IGMP snooping function

Configure the Port Filtering Rules

When expecting to obtain multicast services, the receiver may actively initiate an IGMP member report packet, and the device will make a judgment according to the port filtering rules applied under the port: deny the user to join the destination multicast group; allow the user to join the destination multicast group; and limit the number of times and duration that the user joins the destination multicast group.

Table 54-16 Configuring Port Filtering Rules

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the IGMP profile configuration mode	**ip igmp profile** *profile-id*	-
Configure the range of denying multicast groups	**deny** { **all** | *low-ip-address* [*high-ip-address*] }	Optional By default, the range of denying multicast groups is not configured

Step	Command	Description
Configure the range of permitting multicast groups	**permit** { **all** | *low-ip-address* [*high-ip-address*] }	Optional By default, the range of permitting multicast groups is not configured
Configure preview rules for multicast groups	**preview** { **all** | *low-ip-address* [*high-ip-address*] | **count** *count-number* | **interval** *interval-time* | **time** *time-duration* }	Optional By default, the preview rules for multicast groups are not configured
Return to the global configuration mode	**exit**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Apply the IGMP port filtering rules under the port	**ip igmp filter** *profile-number*	Mandatory By default, the IGMP port filtering rules are not applied under the port

Note

- The multicast group address can only be in one of the IGMP profile filtering rules: deny, permit, and preview. The new rule overrides the old rule.
- Reset cycle of preview count > preview duration × preview count + preview interval × (preview count - 1).

Configure the Maximum Number of Port Multicast Group Entries

The maximum number of port multicast group entries can limit the number of receivers joining the multicast groups.

Table 54-17 Maximum Number of Port Multicast Group Entries

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the maximum number of the port multicast group entries under the port	**ip igmp max-groups** *number*	Optional By default, the maximum number of the multicast group entries that can dynamically join the port is 6144

Configure the Upper Limit Policy of Port Multicast Groups

In the case that the number of the multicast groups the receiver joins exceeds the configured maximum number of multicast group entries, if the upper limit policy of port multicast groups is replace, the newly joined multicast group on the device automatically replaces the existing multicast group, and if the upper limit policy of port multicast groups is deny, the newly joined multicast group is denied.

Table 54-18 Configuring Upper Limit Policy of Port Multicast Groups

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the upper limit policy of port multicast groups	**ip igmp max-groups action** { **deny | replace** }	Optional By default, when the number of the multicast group entries that dynamically join the port reaches the maximum, the handling action is reject new entries

Configure Interface Control for PIM JOIN Packet

After Configure Interface for Control PIM JOIN Packet is enabled, the JOIN packet runs through not hardware but software.

Table 54-19 Configuring Interface Control for PIM JOIN Packet

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Interface Control for PIM JOIN Packet	**ip igmp snooping vlan** *vlan-id* **ctrl-pim**	Mandatory

Step	Command	Description
		By default, the PIM JOIN packet of the specified VLAN is not controlled

Note

- The VLAN will be flooded with the JOIN packets before enabling, and after enabling, the CPU will be captured and the VLAN will not be flooded.

54.2.6 Configure IGMP Snooping Proxy

When there are many multicast group receivers in the network, you can configure IGMP snooping Proxy on the device in order to reduce the quantity of IGMP member reports and leave packets received by the upstream multicast device and effectively reduce the system overhead.

IGMP snooping Proxy can act as proxy of downstream receivers to send IGMP member report packets and leave packets to upstream devices; it can also respond to the IGMP group query packets sent by the upstream multicast devices, and then send the IGMP group query packets to the downstream devices.

Configuration Condition

Before configuring the IGMP snooping function, do the following:

- Enable global and VLAN IGMP snooping function

Configure IGMP Snooping Proxy

Table 54-20 Configuring IGMP snooping Proxy

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IGMP snooping Proxy	**ip igmp snooping proxy vlan** *vlan-id* **upstream** { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Mandatory By default, no IGMP proxy port in the VLAN is configured

54.2.7 Configure IGMP Snooping Static Group

IGMP snooping static groups are static IGMP snooping group entries generated by means of static configuration. By configuring the IGMP snooping static groups, the aging problem of the multicast groups dynamically learned by IGMP snooping can be effectively solved.

When the device is configured with the IGMP snooping static group in the VLAN, the IGMP snooping querier and querier address in the VLAN, and the IGMP snooping proxy port in the VLAN, the device will generate static IGMP snooping groups entries and send the IGMP member report packet to the IGMP snooping proxy port in the VLAN. The source IP address of this IGMP member report packet is the configured querier address. In this way, the uplink router can correctly maintain the IGMP membership table. When you delete the IGMP snooping static group configuration in the VLAN, the device will delete the corresponding IGMP snooping static group entries and send an IGMP member leave packet to the IGMP snooping proxy port in the VLAN.

Configuration Condition

Before configuring the IGMP snooping static group function, do the following:

- Enable global and VLAN IGMP snooping function
- Add port member in VLAN

Configure IGMP Snooping Static Group

Table 54-21 Configuring IGMP snooping Static Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IGMP snooping Static Group	**ip igmp snooping vlan** *vlan-id* **static-group** *group-ip-address* **{ interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Mandatory By default, the IGMP snooping static group in the VLAN is not configured

54.2.8 Monitoring and Maintaining of IGMP Snooping

Table 54-22 Monitoring and Maintaining of IGMP Snooping

Command	Description
clear ip igmp snooping groups [**grp-addr** *ip-address* | **vlan** *vlan-id* [**grp-addr** *ip-address-in-vlan*]]	Clear IGMP snooping group information
clear ip igmp snooping statistics vlan *vlan-id* [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Clear statistics of IGMP protocol packets
show ip igmp snooping proxy member database [**vlan** *vlan-id*]	Show IGMP snooping proxy member database information
show ip igmp snooping proxy special query source-list [**vlan** *vlan-id*]	Show the source list of the specified source queries received by IGMP snooping proxy
show ip igmp snooping proxy upstream [**vlan** *vlan-id*]	Show the running information of IGMP snooping proxy
show ip igmp snooping debugging	Show IGMP snooping debugging status information
show ip igmp snooping egress_table	Show the IGMP snooping L2 forwarding table
show ip igmp snooping groups [**vlan** *vlan-id*] [**grp-addr** *ip-address*]	Show IGMP snooping multicast groups information
show ip igmp snooping groups [**vlan** *vlan-id*] **count**	Show the count of the IGMP snooping multicast groups information
show ip igmp snooping groups detail [**vlan** *vlan-id*] [**grp-addr** *ip-address*]	Show the detail of IGMP snooping multicast groups
show ip igmp snooping interface statistics	Show statistics about the count of multicast groups joining the IGMP snooping port
show ip igmp snooping l3_ip_table	Show the IGMP snooping L3 forwarding table
show ip igmp snooping mcast_table	Show the IGMP snooping forwarding table
show ip igmp snooping mrouter [**vlan** *vlan-id*]	Show IGMP snooping router port information

Command	Description
show ip igmp snooping querier [**vlan** *vlan-id*]	Show IGMP snooping querier information
show ip igmp snooping statistics vlan *vlan-id* [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Show statistics about IGMP packets of the IGMP snooping port
show ip igmp snooping [**vlan** *vlan-id* [**info**]]	Show IGMP snooping information
show multicast control [**all-info | interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Show L2 multicast control information

54.3 Typical Configuration Examples of IGMP Snooping

54.3.1 Configure IGMP Snooping

Network Requirements

- On Device 1, configure the multicast routing protocol, on Device 2, enable IGMP snooping, PC 1 and PC 2 are the receivers of multicast services, and PC 3 is a receiver of non-multicast services.
- Multicast Server sends the multicast service packets, PC 1 and PC 2 can correctly receive the multicast service packets, and PC 3 cannot receive the multicast service packets.

Network Topology

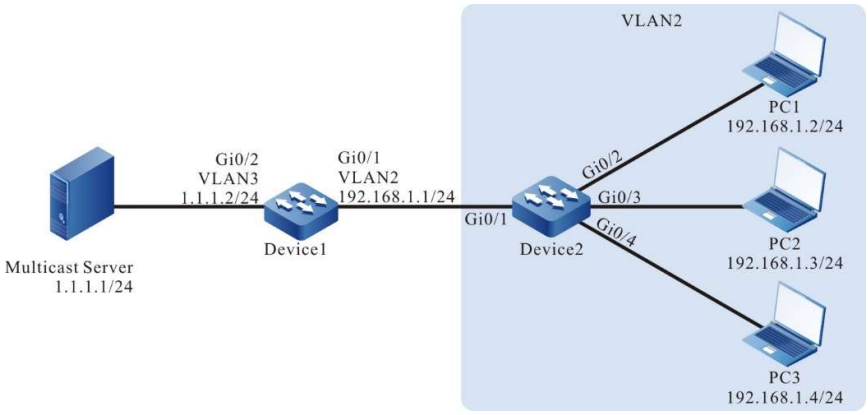


Figure 54-1 Network Topology for Configuring IGMP Snooping

Configuration Steps

Step 1: On Device 1, configure the interface IP address and enable the multicast routing protocol. (Omitted)

Step 2: Configure Device2.

Create VLAN2 on #Device 2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#On Device 2, configure the link type of ports gigabitethernet0/2-gigabitethernet0/4 to Access to allow services of VLAN 2 to pass.

```
Device2(config)#interface gigabitethernet 0/2-0/4
Device2(config-if-range)#switchport access vlan 2
Device2(config-if-range)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#Enable unknown multicast drop in VLAN 2.

```
Device2(config)#vlan 2
Device2(config-vlan2)#l2-multicast drop-unknown
Device2(config-vlan2)#l3-multicast drop-unknown
Device2(config-vlan2)#exit
```

#Enable IGMP Snooping.

```
Device2(config)#ip igmp snooping
Device2(config)#ip igmp snooping vlan 2
```

Step 3: Check the result.

#PC 1 and PC 2 send IGMPv2 member report packets to join the multicast group 224.1.1.1.

#View the multicast membership table of Device 2.

```
Device2#show ip igmp snooping groups
VLAN ID  Interface Name Group Address Expires Last Reporter V1 Expires V2 Expires Uptime
```

2	gi0/2	224.1.1.1	00:03:26	192.168.1.2	stopped	00:00:55	
2	gi0/3	224.1.1.1	00:03:44	192.168.1.3	stopped	00:00:40	

#Multicast Server sends the multicast service packet with the destination address of 224.1.1.1, PC 1 and PC 2 can correctly receive the multicast service packet, and PC 3 cannot receive the multicast service packet.

54.3.2 Configure Multicast Receiving Control

Network Requirements

- On Device 1, configure the multicast routing protocol.
- Device 2 enables IGMP snooping, configures multicast receiving control and applies it to the corresponding port.
- Multicast Server sends the multicast service packets, and PC 1 and PC 2 can correctly receive the multicast service packets.

Network Topology

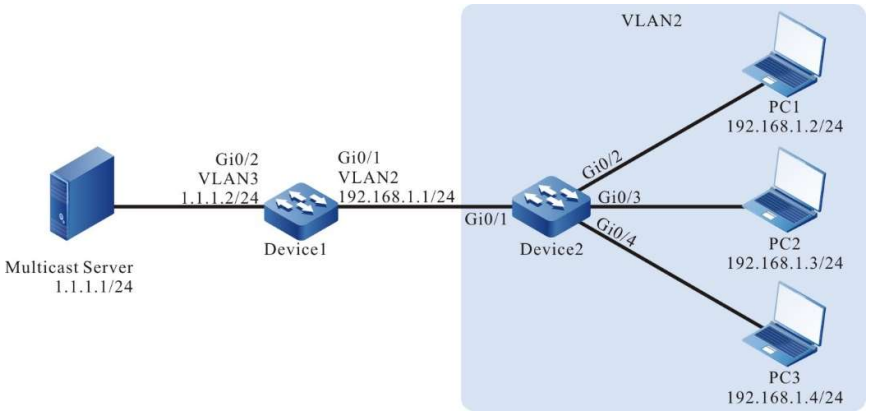


Figure 54-2 Network Topology for Configuring Multicast Receiving Control

Configuration Steps

Step 1: On Device 1, configure the interface IP address and enable the multicast routing protocol. (Omitted)

Step 2: Configure Device2.

#Create VLAN2 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#On Device 2, configure the link type of ports gigabitethernet0/2-gigabitethernet0/4 to Access to allow services of VLAN 2 to pass.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
Device2(config)#interface gigabitethernet 0/2-0/4
Device2(config-if-range)#switchport access vlan 2
Device2(config-if-range)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#Enable IGMP Snooping.

```
Device2(config)#ip igmp snooping
Device2(config)#ip igmp snooping vlan 2
```

#Configure multicast receiving control policy profile1 to allow joining the multicast group 224.1.1.1 and apply it to port gigabitethernet0/2.

```
Device2(config)#ip igmp profile 1
Device2(config-igmp-profile)#permit 224.1.1.1
Device2(config-igmp-profile)#exit
Device2(config)#interface gigabitethernet 0/2
Device2(config-if-gigabitethernet0/2)#ip igmp filter 1
Device2(config-if-gigabitethernet0/2)#exit
```

#Configure multicast receiving control policy profile2 to allow previewing the multicast group 224.1.1.1 and apply it to port gigabitethernet0/3.

```
Device2(config)#ip igmp profile 2
Device2(config-igmp-profile)#preview 224.1.1.1
Device2(config-igmp-profile)#exit
Device2(config)#interface gigabitethernet 0/3
Device2(config-if-gigabitethernet0/3)#ip igmp filter 2
Device2(config-if-gigabitethernet0/3)#exit
```

#Configure multicast receiving control policy profile3 to deny joining the multicast group 224.1.1.1 and apply it to port gigabitethernet0/4.

```
Device2(config)#ip igmp profile 3
Device2(config-igmp-profile)#permit all
```

```
Device2(config-igmp-profile)#deny 224.1.1.1
Device2(config-igmp-profile)#exit
Device2(config)#interface gigabitethernet 0/4
Device2(config-if-gigabitethernet0/4)#ip igmp filter 3
Device2(config-if-gigabitethernet0/4)#exit
```

Step 3: Check the result.

#PC 1, PC 2, and PC 3 send IGMPv2 member report packets to join the multicast group 224.1.1.1.

#View the multicast membership table of Device 2.

```
Device2#show ip igmp snooping groups
IGMP Snooping Group Membership
Total 2 groups

VLAN ID Interface Name Group Address Expires Last Reporter V1 Expires V2 Expires Uptime
_____
2    gi0/2      224.1.1.1   00:04:19  192.168.1.2 stopped        00:00:01
2    gi0/3      224.1.1.1   00:04:19  192.168.1.3 stopped        00:00:01
```

PC 1 and PC 2 can join the multicast group 224.1.1.1, and PC3 does not join the multicast group 224.1.1.1.

#Multicast Server sends the multicast service packet with the destination address of 224.1.1.1.

PC 1 and PC 2 can correctly receive the multicast service packet, and PC 3 cannot receive the multicast service packet.

#After 10 seconds, view the multicast membership table of Device 2 and gigabitethernet0/3 multicast receiving control information.

```
Device2#show ip igmp snooping groups
IGMP Snooping Group Membership
Total1 group

VLAN ID Interface Name Group Address Expires Last Reporter V1 Expires V2 Expires Uptime
_____
2    gi0/2      224.1.1.1   00:04:10  192.168.1.2 stopped        00:00:10
Device2#show multicast control interface gigabitethernet 0/3
ip multicast control gigabitethernet0/3 vlan 2 information
----------------------------------------------
profile: 2
group right information:
 preview: 224.1.1.1
```

```
preview information:
  preview count: 3
  preview count remain: 2
  preview time: 10 (s)
  preview interval: 60 (s)
group information:
  group: 224.1.1.1
    uptime: 00:00:10
    next preview time remain: 00:00:60
```

When the preview time of gigabitethernet0/3 port expires (10 s later), the group membership table entry is deleted, PC1 can correctly receive multicast service packets, and PC 2 and PC 3 cannot receive multicast service packets.

54.3.3 Configure IGMP Snooping Proxy

Network Requirements

- On Device 1, configure the multicast routing protocol.
- Enable IGMP snooping and IGMP Snooping Proxy and configure IGMP snooping static group on Device 2.
- Multicast Server sends the multicast service packets, and PC 1, PC 2 and PC 3 can correctly receive the multicast service packets.

Network Topology

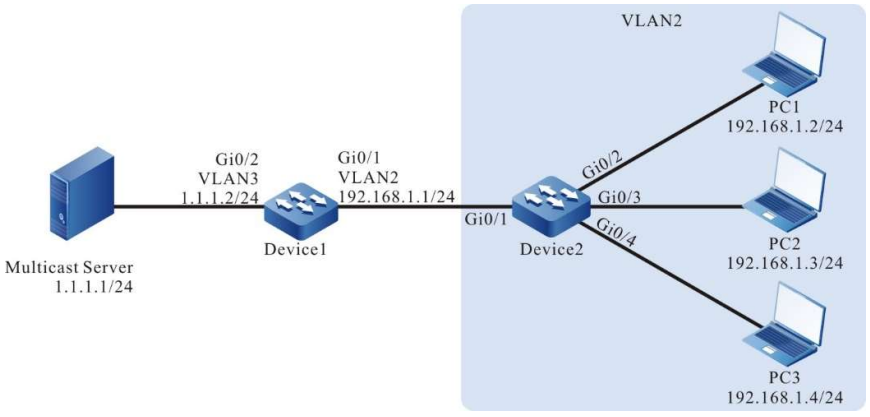


Figure 54-3 Network Topology for Configuring IGMP Snooping Proxy

Configuration Steps

Step 1: On Device 1, configure the interface IP address and enable the multicast routing protocol.

```
Device1#configure terminal
```

```
Device1(config)#ip multicast-routing
Device1(config)#interface gigabitethernet0/1
Device1(config-if-gigabitethernet0/1)# switchport mode trunk
Device1(config-if-gigabitethernet0/1)# witchport trunk allowed vlan add 2
Device1(config-if-gigabitethernet0/1)# switchport trunk pvid vlan 1
Device1(config-if-gigabitethernet0/1)# exit
Device1(config)#interface gigabitethernet0/2
Device1(config-if-gigabitethernet0/2)# switchport mode trunk
Device1(config-if-gigabitethernet0/2)# witchport trunk allowed vlan add 3
Device1(config-if-gigabitethernet0/2)# switchport trunk pvid vlan 1
Device1(config-if-gigabitethernet0/2)# exit
Device1(config)#interface vlan 2
Device1(config-if-vlan2)# ip address 192.168.1.1 255.255.255.0
Device1(config-if-vlan2)# ip pim sparse-mode
Device1(config-if-vlan2)# exit
Device1(config)#interface vlan 3
Device1(config-if-vlan3)# ip address 1.1.1.2 255.255.255.0
Device1(config-if-vlan3)# ip pim sparse-mode
Device1(config-if-vlan3)# exit
```

Step 2: Configure Device2.

#Create VLAN2 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#On Device 2, configure the link type of ports gigabitethernet0/2-gigabitethernet0/4 to Access to allow services of VLAN 2 to pass.

```
Device2(config)#interface gigabitethernet 0/2-0/4
Device2(config-if-range)#switchport access vlan 2
Device2(config-if-range)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#Enable in VLAN2, IGMP snooping and configure the IGMP snooping querier address as 192.168.1.254.

```
Device2(config)#ip igmp snooping
Device2(config)#ip igmp snooping vlan 2
Device2(config)#ip igmp snooping vlan 2 querier
Device2(config)#ip igmp snooping vlan 2 querier address 192.168.1.254
```

#Configure IGMP snooping Proxy.

```
Device2(config)#ip igmp snooping proxy vlan 2 upstream interface gigabitethernet 0/1
```

#Configure IGMP snooping Static Group.

```
Device2(config)#ip igmp snooping vlan 2 static-group 224.1.1.1 interface gigabitethernet 0/4
Device2(config)#exit
```

Step 3: Check the result.

#IGMP snooping dynamic group joining: PC1 and PC2 send IGMPv2 member report packets to join the multicast group 224.1.1.1 successively.

#View the IGMP Snooping Proxy information of Device 2.

```
Device2#show ip igmp snooping proxy upstream vlan 2
vlan 2 proxy upstream information:
------------------------------
upstream interface                  : gi0/1
upstream querier compatmode version     : 2
upstream querier address                : 192.168.1.1
upstream report source address          : 192.168.1.4
upstream querier query interval         : 125s
upstream querier query response interval: 10s
upstream querier LMQI                   : 1s
upstream querier LMQC                   : 2
upstream querier robustness variable    : 2
upstream querier present timer          : 00:02:50
upstream V1 querier present timer       : stopped
upstream V2 querier present timer       : 00:02:55
```

#View the Device 2 multicast membership table and the IGMP Snooping Proxy member database.

```
Device2#show ip igmp snooping groups
IGMP Snooping Group Membership
Total 2 groups

VLAN ID Interface Name Group Address Expires Last Reporter V1 Expires V2 Expires Uptime
_____ _____ _____ _____ _____ _____ _____
```

```
2      gi0/2        224.1.1.1     00:04:09  192.168.1.2 stopped          00:00:14
2      gi0/3        224.1.1.1     00:04:09  192.168.1.3 stopped          00:00:11

IGMP Snooping Static Group Membership
Total 1 group

VLAN ID  Port Name          Group Address    Uptime
_______  _________________  _______________  _________
2        gi0/4              224.1.1.1        00:00:48
```

It is indicated that PC 1, PC 2, and PC 3 join the multicast group 224.1.1.1.

```
Device2#show ip igmp snooping proxy member database vlan 2
IGMP Snooping Proxy Member Database Table
Total 1 group

VLAN ID  Group Address    Mode     Source Address
-------  ---------------  -------  ---------------
2        224.1.1.1        EXCLUDE  *
```

#View the multicast membership table of Device 1.

```
Device1#show ip igmp groups
IGMP Connected Group Membership
Total 1 groups
Group Address    Interface          Uptime   Expires  Last Reporter   V1 Expires    V2 Expires
224.1.1.1        vlan 2             00:00:15 00:04:11 192.168.1.254     stopped
```

You can see that when PC joins the multicast group 224.1.1.1, Device 2 only forwards the first IGMPv2 member report packet to Device 1, and drops all other packets. The source IP address of the member report packet is the querier address configured by Device 2.

#Multicast Server sends the multicast service packet with the destination address of 224.1.1.1, PC 1, PC 2 and PC 3 can correctly receive the multicast service packet.

#PC 1 sends an IGMPv2 leave packet to leave the multicast group 224.1.1.1.

```
Device2#show ip igmp snooping groups
IGMP Snooping Group Membership
Total 1 group

VLAN ID Interface Name Group Address Expires Last Reporter V1 Expires V2 Expires Uptime
_____________________________________________________________________________________
2      gi0/3        224.1.1.1     00:03:54 192.168.1.3  stopped          00:06:37

IGMP Snooping Static Group Membership
```

```
Total 1 group

VLAN ID  Port Name          Group Address    Uptime
_______ ____________________ _______________ _________
2        gi0/4              224.1.1.1        00:00:48

Device1#show ip igmp groups
IGMP Connected Group Membership
Total 1 groups
Group Address    Interface          Uptime   Expires  Last Reporter   V1 Expires    V2 Expires
224.1.1.1        vlan 2             00:06:48 00:03:48 192.168.1.254    stopped
```

After PC 1 leaves the multicast group 224.1.1.1, because PC 2 has not left this multicast group with PC 3 direct port being the member port of the IGMP snooping static group 224.1.1.1 and PC 2 and PC 3 still being in the multicast membership table, Device 2 will not send a leave packet of this multicast group to Device 1.

#PC 1 cannot receive multicast service packets, but PC2 and PC3 can correctly receive multicast service packets.

#PC 2 sends an IGMPv2 leave packet to leave the multicast group 224.1.1.1. View the multicast membership tables of Device 2 and Device 1.

```
Device2#show ip igmp snooping groups
IGMP Snooping Static Group Membership
Total 1 group

VLAN ID  Port Name          Group Address    Uptime
_______ ____________________ _______________ _________
2        gi0/4              224.1.1.1        00:00:48

Device1#show ip igmp groups
IGMP Connected Group Membership
Total 1 groups
Group Address    Interface          Uptime   Expires  Last Reporter   V1 Expires    V2 Expires
224.1.1.1        vlan 2             00:07:08 00:03:28 192.168.1.254    stopped
```

After PC2 leaves the multicast group 224.1.1.1, because PC3 direct port is a member port of the IGMP snooping static group 224.1.1.1 and PC3 is still in the multicast membership table, Device2 will not send a leave packet of this multicast group to Device1.

#PC 1 and PC 2 cannot receive multicast service packets, but PC3 can correctly receive multicast service packets.

#Delete the configured IGMP snooping static group and view the Device 2 and Device 1 multicast member table.

```
Device2#show ip igmp snooping groups
```

It is indicated that there is no multicast membership table on Device 2.

```
Device1#show ip igmp groups
```

There are no multicast members on Device 1. When PC 3, the last group member, leaves the multicast group, Device 2 will send a leave packet of this multicast group to Device 1.

#PC 1, PC 2 and PC 3 cannot receive the multicast service packet.

54.3.4 Configure Unknown Multicast Redirection

Network Requirements

- On Device 2, configure the multicast routing protocol.
- Enable IGMP snooping, unknown multicast drop and unknown multicast redirection on Device 1.
- Multicast Server sends the multicast service packets, and PC 1 can correctly receive the multicast service packets.

Network Topology

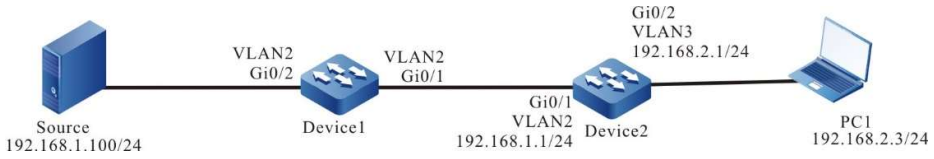


Figure 54-4 Network Topology for Configuring Unknown Multicast Group Redirect

Configuration Steps

Step 1: Configure Device 2 interface IP addresses. (Omitted)

Step 2: Configure each interface of Device 2 to enable multicast routing protocol PIM-SM, and Device 1 to enable IGMP snooping and unknown multicast redirect.

#On Device 2, configure the link type of port gigabitethernet0/2 to Access to allow services of VLAN 3 to pass, and configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass. Configure PVID to 1.

```
Device2(config)#vlan2-3
Device2(config)#interface gigabitethernet 0/2
Device2(config-if-gigabitethernet0/2)#switchport access vlan 3
Device2(config-if-gigabitethernet0/2)#exit
Device2(config)#interface gigabitethernet 0/1
```

```
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#Configure Device 2 to enable multicast forwarding globally, and enable the multicast protocol PIM-SM on related interfaces.

```
Device2(config)#ip multicast-routing
Device2(config)#interface vlan2
Device2(config-if-vlan2)#ip pim sparse-mode
Device2(config-if-vlan2)#exit
Device2(config)#interface vlan3
Device2(config-if-vlan2)#ip pim sparse-mode
Device2(config-if-vlan3)#exit
```

#On Device 1, configure the link type of port gigabitethernet0/2 to Access to allow services of VLAN 2 to pass, and configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass. Configure PVID to 1.

```
Device1(config)#interface gigabitethernet 0/2
Device1(config-if-gigabitethernet0/2)# switchport access vlan 2
Device1(config-if-gigabitethernet0/2)#exit
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#switchport mode trunk
Device1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device1(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device1(config-if-gigabitethernet0/1)#exit
```

#Enable unknown multicast drop in VLAN 2.

```
Device1(config)#vlan 2
Device1(config-vlan2)#l2-multicast drop-unknown
Device1(config-vlan2)#l3-multicast drop-unknown
Device1(config-vlan2)#exit
```

#Enable IGMP Snooping.

```
Device1(config)#ip igmp snooping
Device1(config)#ip igmp snooping vlan 2
```

#Enable unknown multicast redirect in VLAN 2.

```
Device1(config)#vlan 2
Device1(config-vlan2)#multicast mrouter-forwarding
Device1(config-vlan2)#exit
```

Step 3: Check the result.

#View the learned IGMP snooping router port on Device 1.

```
Device1#show ip igmp snooping mrouter
 Vlan        SourceAddr          Expires       Interface
 ----        ----------          -------       ---------
 2           192.168.1.1         00:04:04      gigabitethernet0/1(dynamic)
```

#PC 1 sends IGMPv2 member report packets to join the multicast group 224.1.1.1.

#View the multicast membership table of Device 2.

```
Device2#show ip igmp groups
IGMP Connected Group Membership
Total 1 groups
Group Address   Interface          Uptime     Expires    Last Reporter   V1 Expires  V2 Expires
224.1.1.1       vlan3              00:21:02   00:03:47   192.168.2.3     stopped
```

#Multicast Server sends the multicast service packet with the destination address of 224.1.1.1. View the multicast routing table entries on Device 2.

```
Device2#show ip pim mroute
IP Multicast Routing Table:
PIM VRF Name: Default
Total 0 (*,*,RP) entry
Total 1 (*,G) entry
Total 1 (S,G) entry
Total 1 (S,G,rpt) entry
Total 0 FCR entry
Up timer/Expiry timer


(*, 224.1.1.1)
Up time: 00:08:12
RP: 0.0.0.0
RPF nbr: 0.0.0.0
RPF idx: None
Flags:
 JOIN DESIRED
Upstream State: JOINED
 Local interface list:
   vlan3
 Joined interface list:
 Asserted interface list:
```

(192.168.1.100, 224.1.1.1)

Up time: 00:07:24

KAT time: 00:02:22

RPF nbr: 0.0.0.0

RPF idx: None

SPT bit: TRUE

Flags:

JOIN DESIRED

COULD REGISTER

Upstream State: JOINED

Local interface list:

Joined interface list:

register_vif0

Asserted interface list:

Outgoing interface list:

register_vif0

vlan3

Packet count 8646421

(192.168.1.100, 224.1.1.1, rpt)

Up time: 00:07:24

RP: 0.0.0.0

Flags:

RPT JOIN DESIRED

RPF SGRPT XG EQUAL

Upstream State: NOT PRUNED

Local interface list:

Pruned interface list:

Outgoing interface list:

vlan3

#PC1 can correctly receive the multicast service packet sent by Multicast Server.

54.3.5 Configure IGMP Snooping Static Group

Network Requirements

- On Device 1, configure the multicast routing protocol, on Device 2, enable IGMP

snooping in VLAN 2, PC 1 and PC 2 are the receivers of IGMP snooping static group services, and PC 3 is not a receiver of multicast services.

- Multicast Server sends the multicast service packets, PC 1 and PC 2 can correctly receive the multicast service packets, and PC 3 cannot receive the multicast service packets.

Network Topology

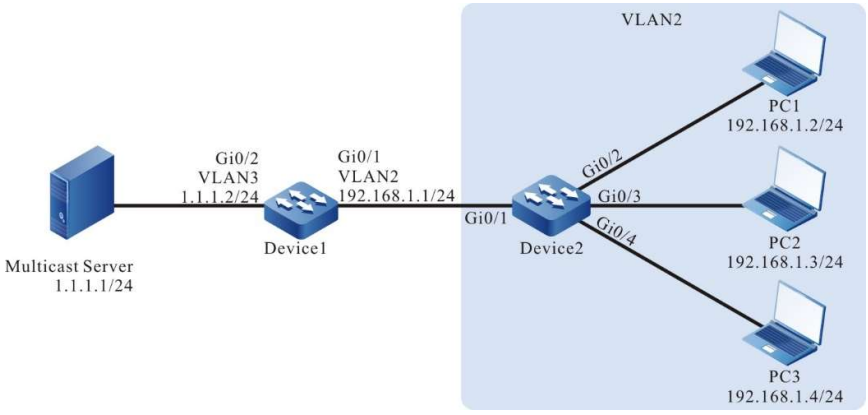


Figure 54-5 Network Topology for Configuring IGMP Snooping Static Group

Configuration Steps

Step 1: On Device 1, configure the interface IP address and enable the multicast routing protocol. (Omitted)

Step 2: Configure Device2.

Create VLAN2 on #Device 2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#On Device 2, configure the link type of ports gigabitethernet0/2-gigabitethernet0/4 to Access to allow services of VLAN 2 to pass.

```
Device2(config)#interface gigabitethernet 0/2-0/4
Device2(config-if-range)#switchport access vlan 2
Device2(config-if-range)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#Enable unknown multicast drop in VLAN 2.

```
Device2(config)#vlan 2
Device2(config-vlan2)#l2-multicast drop-unknown
Device2(config-vlan2)#l3-multicast drop-unknown
Device2(config-vlan2)#exit
```

#Enable IGMP snooping and configure IGMP snooping static group.

```
Device2(config)#ip igmp snooping
Device2(config)#ip igmp snooping vlan 2
Device2(config)#ip igmp snooping vlan 2 static-group 224.1.1.1 interface gigabitethernet 0/2
Device2(config)#ip igmp snooping vlan 2 static-group 224.1.1.1 interface gigabitethernet 0/3
Device2(config)#exit
```

Step 3: Check the result.

#View the multicast membership table of Device 2.

```
Device2#show ip igmp snooping groups
IGMP Snooping Static Group Membership
Total 2 group

VLAN ID  Port Name          Group Address    Uptime
_______  _____________________  _______________  _________
2        gi0/2              224.1.1.1        00:00:48
2        gi0/3              224.1.1.1        00:00:45
```

#Multicast Server sends the multicast service packet with the destination address of 224.1.1.1, PC 1 and PC 2 can correctly receive the multicast service packet, and PC 3 cannot receive the multicast service packet.

55 Multicast VLAN

55.1 Overview

In the traditional L2 multicast on-demand mode, when users in different VLANs request on-demand, each VLAN will replicate a multicast stream in the same VLAN. This multicast on-demand mode wastes a lot of bandwidth.

To solve this problem, you can configure a multicast VLAN so that users in different VLANs share one multicast VLAN. After the multicast VLAN function is enabled, the multicast stream is transmitted only in the multicast VLAN, and the multicast VLAN is completely isolated from the user VLAN. This not only saves bandwidth but also ensures security.

There are two types of multicast VLAN: MVR (Multicast VLAN Registration) and MVP (Multicast VLAN Plus).

55.2 Multicast VLAN Configuration

Table 55-1 Multicast VLAN Configuration List

Configuration Task	
Configure MVP	Configure MVP Multicast VLAN
	Enable MVP function
Configure MVR	Configure MVR multicast VLAN
	Enable MVR function

55.2.1 Configure MVP

MVP is used in edge networks, and the sub-VLAN member ports can be connected to multicast devices or directly to users. When connected to a multicast device, a sub-VLAN member port can send multicast

packets with a VLAN tag; when connected to a user, the sub-VLAN member port can send multicast packets without VLAN tag.

Configuration Condition

Before configuring MVP multicast VLAN, do the following:

- Configure the VLAN;
- Enable global and VLAN IGMP snooping function

Configure MVP Multicast VLAN

You can configure MVP to implement cross-VLAN forwarding of multicast packets between the MVP multicast VLAN and member sub-VLANs. The member port of the MVP multicast VLAN needs to be consistent with the VLAN tag of the upstream device connected to it, and the member ports of the MVP sub-VLANs must be consistent with that the VLAN tag of the downstream device connected to it.

Table 55-2 Configuring MVP Multicast VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure MVP Multicast VLAN	**multicast-vlan** *mvlan-id* **subvlan** *subvlan-id*	Mandatory By default, no MVP multicast VLAN or member sub-VLANs are configured

Enable MVP Function

Only after the MVP function is enabled in the MVP multicast VLAN, can packets be forwarded across VLANs between the MVP multicast VLAN and the member sub-VLANs.

Table 55-3 Enabling MVP Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Enable the MVP function in the VLAN	**multicast-vlan enable**	Mandatory

Step	Command	Description
		By default, the MVP function is disabled in the VLAN

55.2.2 Configure MVR

MVR is used in edge networks. MVR multicast VLAN member port can only connect to users, and multicast packets sent from the VLAN member port cannot bear the VLAN tag.

Configuration Condition

Before configuring MVR multicast VLAN, do the following:

- Configure the corresponding VLAN;
- Enable global and corresponding intra-VLAN IGMP snooping functions.

Configure MVR Multicast VLAN

When multiple user ports belong to different VLANs, these ports can be added to the MVR multicast VLAN, so that users in different VLANs can share one multicast VLAN.

Table 55-4 Configuring MVR Multicast VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure MVR multicast VLAN	**mvr vlan** *vlan-id*	Mandatory By default, the MVP multicast VLAN is not configured

Enable MVR Function

Only after the MVR function is enabled, can the MVR multicast VLAN configuration take effect.

Table 55-5 Enabling MVR Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable MVR function	**mvr enable**	Mandatory By default, the MVR function is not enabled

55.2.3 Monitoring and Maintaining of Multicast VLAN

Table 55-6 Monitoring and Maintaining of Multicast VLAN

Command	Description
show multicast-vlan *vlan-id*	Show information of MVP multicast VLAN
show mvr	Show MVR information

55.3 Typical Example of Configuration of Multicast VLAN

55.3.1 Configure MVP

Network Requirements

- On Device 1, configure the multicast routing protocol.
- Device 2 enables IGMP snooping and configures MVP.
- Multicast Server sends multicast service packets, and multicast VLAN 2 can copy the multicast service packets to sub-VLAN 4 to sub-VLAN 5. PC 1, PC 2 and PC 3 can correctly receive the multicast service packets.

Network Topology

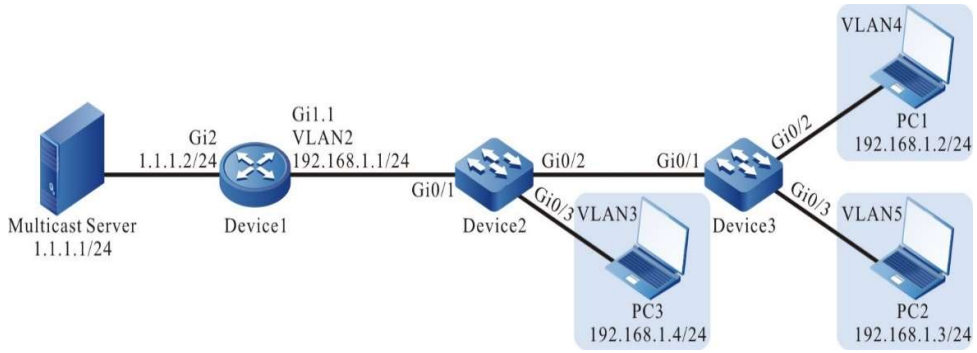


Figure 55-1 MVP Typical Configuration Network Topology

Configuration Steps

Step 1: On Device 1, configure the interface IP address and enable the multicast routing protocol. (Omitted)

Step 2: Configure Device2.

#Create VLAN 2 to VLAN 5 on Device 2.

```
Device2#configure terminal
Device2(config)#vlan 2-5
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)# switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 4 to VLAN 5 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/2
Device2(config-if-gigabitethernet0/2)#switchport mode trunk
Device2(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 4-5
Device2(config-if-gigabitethernet0/2)# switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/2)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/3 to Access to allow services of VLAN 3 to pass.

```
Device2(config)#interface gigabitethernet 0/3
Device2(config-if-gigabitethernet0/3)#switchport access vlan 3
Device2(config-if-gigabitethernet0/3)#exit
```

#Configure IGMP Snooping.

```
Device2(config)#ip igmp snooping
Device2(config)#ip igmp snooping vlan 2
Device2(config)#ip igmp snooping vlan 3
Device2(config)#ip igmp snooping vlan 4
Device2(config)#ip igmp snooping vlan 5
```

#Configure MVP.

```
Device2(config)#multicast-vlan 2 subvlan 3-5
Device2(config)#vlan 2
Device2(config-vlan2)#multicast-vlan enable
Device2(config-vlan2)#exit
```

Step 3: Configure Device 3.

#Create VLAN 4 to VLAN 5 on Device 3.

```
Device3#configure terminal
Device3(config)#vlan 4-5
```

#On Device 3, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 4 to VLAN 5 to pass, and configure PVID to 1.

```
Device3(config)#interface gigabitethernet 0/1
Device3(config-if-gigabitethernet0/1)#switchport mode trunk
Device3(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 4-5
Device3(config-if-gigabitethernet0/1)# switchport trunk pvid vlan 1
Device3(config-if-gigabitethernet0/1)#exit
```

#On Device 3, configure the link type of port gigabitethernet0/2 to Access to allow services of VLAN 4 to pass.

```
Device3(config)#interface gigabitethernet 0/2
Device3(config-if-gigabitethernet0/2)#switchport access vlan 4
Device3(config-if-gigabitethernet0/2)#exit
```

#On Device 3, configure the link type of port gigabitethernet0/3 to Access to allow services of VLAN 5 to pass.

```
Device3(config)#interface gigabitethernet 0/3
Device3(config-if-gigabitethernet0/3)#switchport access vlan 5
Device3(config-if-gigabitethernet0/3)#exit
```

Step 4: Check the result.

#View MVP information.

```
Device2#show multicast-vlan
Multicast Vlan Table
---------------------------------
VLAN ID: 2
status: enable
subvlan count: 3
subvlan: 3-5
```

#PC 1, PC 2 and PC 3 send IGMPv2 membership reports to join the multicast group 224.1.1.1.

#View the multicast membership table of Device 2.

```
Device2#show ip igmp snooping groups
IGMP Snooping Group Membership
Total 3 groups

VLAN ID Interface Name Group Address Expires Last Reporter V1 Expires V2 Expires Uptime
_____ _____ _____ _____ _____ _____ _____ _____
3       gi0/3       224.1.1.1     00:03:54  192.168.1.4  stopped       00:01:18
4       gi0/2       224.1.1.1     00:04:17  192.168.1.2  stopped       00:00:07
5       gi0/2       224.1.1.1     00:03:54  192.168.1.3  stopped       00:01:21
```

#View the multicast forwarding table of Device 2.

```
Device2#show ip igmp snooping l3_ip_table
Total 1 entry

Flags: M - L2 multicast, S - short of resources

(*, 224.1.1.1)
 Ingress Vlan: 2
 Flags      : M
 L2 Interface List: gigabitethernet0/1
  Egress Vlan  Flags  L3 Interface List
  3          M     gigabitethernet0/3
    4          M     gigabitethernet0/2
    5          M     gigabitethernet0/2
```

#Multicast Server sends the multicast service packet with the destination address of 224.1.1.1. PC 1, PC 2 and PC 3 can correctly receive the multicast service packets.

55.3.2 Configure MVR

Network Requirements

- On Device 1, configure the multicast routing protocol.

- There are 3 VLANs in the whole network, VLAN 2 to VLAN 4, and the port connected to the PC joins the corresponding VLAN in Hybrid mode.
- On Device 2, enable IGMP snooping and configure MVP.
- Multicast Server sends the multicast service packets, and PC 1, PC 2 and PC 3 can correctly receive the multicast service packets.

Network Topology

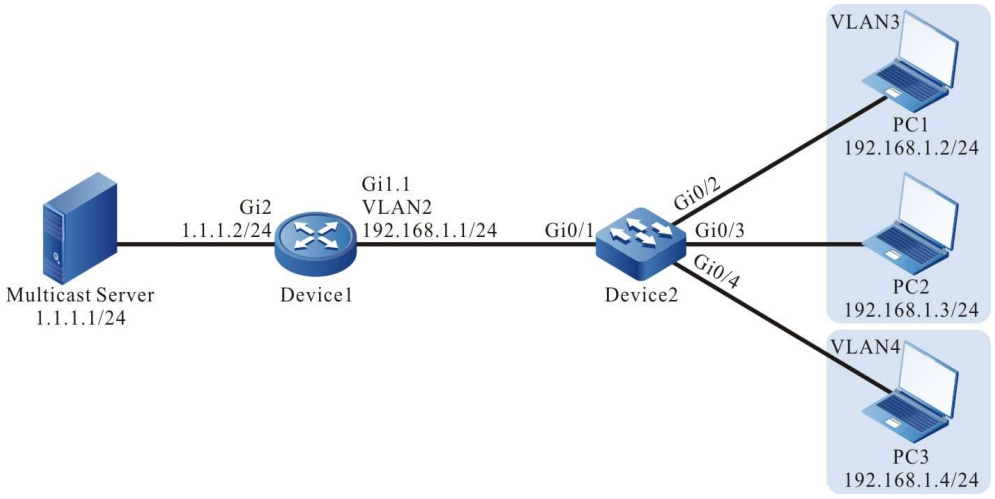


Figure 55-2 Network Topology for Configuring MVR

Configuration Steps

Step 1: On Device 1, configure the interface IP address and enable the multicast routing protocol. (Omitted)

Step 2: Configure Device2.

#Create VLAN 2 to VLAN 4 on Device 2.

```
Device2#configure terminal
Device2(config)#vlan 2-4
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode hybrid
Device2(config-if-gigabitethernet0/1)#switchport hybrid tagged vlan 2
Device2(config-if-gigabitethernet0/1)# switchport hybrid  pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#On Device 2, configure the link types of port gigabitethernet0/2-0/3 to Hybrid to allow services of VLAN 2 to VLAN 3 to pass, and configure PVID to 3.

```
Device2(config)#interface gigabitethernet 0/2-0/3
```

```
Device2(config-if-range)#switchport mode hybrid
Device2(config-if-range)#switchport hybrid untagged vlan 2-3
Device2(config-if-range)#switchport hybrid pvid vlan 3
Device2(config-if-range)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/4 to Hybrid to allow services of VLAN 2 and VLAN 4 to pass, and configure PVID to 4.

```
Device2(config)#interface gigabitethernet 0/4
Device2(config-if-gigabitethernet0/4)#switchport mode hybrid
Device2(config-if-gigabitethernet0/4)#switchport hybrid untagged vlan 4
Device2(config-if-gigabitethernet0/4)#switchport hybrid untagged vlan 2
Device2(config-if-gigabitethernet0/4)#switchport hybrid pvid vlan 4
Device2(config-if-gigabitethernet0/4)#exit
```

#Configure IGMP Snooping.

```
Device2(config)#ip igmp snooping
Device2(config)#ip igmp snooping vlan 2
Device2(config)#ip igmp snooping vlan 3
Device2(config)#ip igmp snooping vlan 4
```

#Configure MVR.

```
Device2(config)#mvr vlan 2
Device2(config)#mvr enable
Device2(config)#exit
```

Step 3: Check the result.

#View MVR information.

```
Device2#show mvr
 MVR status:enable
 multicast-vlan: 2
```

#PC 1, PC 2 and PC 3 send IGMPv2 membership reports to join the multicast group 224.1.1.1.

#View the multicast membership table of Device 2.

```
Device2#show ip igmp snooping groups
IGMP Snooping Group Membership
Total 3 groups

VLAN ID Interface Name Group Address Expires Last Reporter V1 Expires V2 Expires Uptime
_____
2    gi0/2    224.1.1.1    00:04:14  192.168.1.2  stopped    00:00:07
2    gi0/3    224.1.1.1    00:04:14  192.168.1.3  stopped    00:00:07
```

```
2      gi0/4        224.1.1.1     00:04:14  192.168.1.4  stopped          00:00:07
```

It is indicated that all ports and groups are present in VLAN 2.

#Multicast Server sends the multicast service packet with the destination address of 224.1.1.1, and PC 1, PC 2 and PC 3 can correctly receive the multicast service packet.

56 MLD snooping

56.1 Overview

MLD Snooping is short for Multicast Listener Discovery Snooping. It is IPv6 multicast constraint mechanism that runs on L2 devices and is used to manage and control IPv6 multicast groups.

IGMP Snooping mainly provides the following functions:

- Listen to the MLD packets to set up multicast information. IGMP Snooping gets the downstream multicast receiver information by listening to MLD packets, realizing the forwarding of multicast service packets at the specified member port;
- Listening to MLD protocol packets. In this way, the upstream multicast router can correctly maintain the MLD membership table.

56.2 MLD Snooping Function Configuration

Table 56 MLD Snooping Function Configuration List

Configuration Task	
Configure basic functions of MLD snooping	Enable MLD snooping function
	Configure MLD snooping version
	Enable MLD snooping MAC forwarding function
Configure MLD snooping querier	Enable MLD snooping querier
	Configure source IPv6 address of MLD query packet
	Configure Query Interval of General Group
	Configure Max. Response Time
	Configure Query Interval of Specified Group

Configuration Task	
	Configure Fast Leave
Configure MLD snooping router port	Configure MLD snooping router port
	Configure age time for MLD snooping dynamic router port
Configure MLD snooping TCN event	Enable fast convergence
	Configure TCN event query interval
	Configure TCN event query count

56.2.1 Configure Basic Functions of MLD Snooping

In the various configuration tasks for MLD snooping, you must first enable the MLD snooping function so that the configuration of the other function features can take effect.

Configuration Condition

Before configuring the basic functions of MLD snooping, do the following:

- Configure VLAN.

Enable MLD snooping function

The MLD snooping function will run on the device only after it is enabled.

Table 56 Enabling MLD Snooping Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the global MLD snooping function	**ipv6 mld snooping**	Mandatory By default, the global MLD snooping function is not enabled
Enable the MLD snooping function of the specified VLAN	**ipv6 mld snooping vlan** *vlan-id*	Mandatory

Step	Command	Description
		By default, the MLD snooping function is not enabled in the VLAN

Note

- The MLD snooping function of the specified VLAN can be enabled only after the global MLD snooping function is enabled.

Configure MLD Snooping Version

The handling rules for the configured MLD snooping version and MLD protocol packets are as follows:

If the configured MLD snooping version is V2, the device can handle IGMP protocol packets of versions V1 and V2.

If the configured MLD snooping version is V1, the device can handle MLD protocol packets of version V1, and does not handle the protocol packets of versions V2 but floods them in the VLAN.

Table 1 Configuring MLD Snooping Version

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure MLD snooping version	**ipv6 mld snooping vlan** *vlan-id* **version** *version-number*	Optional By default, the MLD snooping version is 2

Enable MLD Snooping MAC Forwarding

Generally, MLD snooping forwards the multicast service packets in the VLAN based on the multicast source IP address and the multicast destination IP address. After MLD snooping MAC forwarding is configured, MLD snooping will forward the multicast service packets in the VLAN based on the multicast destination MAC address.

Table 2 MLD Snooping MAC Forwarding

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the L2 multicast MAC forwarding function in the specified VLAN	**ipv6 mld snooping vlan** *vlan-id* **l2-forwarding**	Mandatory By default, the L2 multicast IP forwarding function of MLD snooping is enabled for the VLAN

56.2.2 Configure MLD Snooping Querier

If there is no L3 multicast device in the network, it cannot realize the related functions of the MLD querier. To solve the problem, you can configure the MLD snooping querier on the L2 multicast device to realize the MLD querier function. Therefore, the L2 multicast device can set up and maintain the multicast forwarding entry, so as to forward multicast service packets normally.

Configuration Condition

Before configuring the basic functions of MLD snooping querier, do the following:

- Enable global and intra-VLAN MLD snooping functions.

Enable MLD Snooping Querier

You should first enable the MLD snooping querier function so that the configuration of the other features of the querier can take effect.

Table 56 Enabling IGMP Snooping Querier

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable MLD snooping querier	**ipv6 mld snooping vlan** *vlan-id* **querier**	Mandatory By default, the MLD snooping querier of the specified VLAN is not enabled

Configure IPv6 Address of the Querier

The querier with IPv6 address configured takes part in the election of the MLD querier in VLAN and the querier fills the IPv6 address in the source IPv6 address field of the sent MLD group query packet.

Table 3 Configuring IPv6 Address of the Querier

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IPv6 Address of the Querier	**ipv6 mld snooping vlan** *vlan-id* **querier address** *ipv6-address*	Mandatory By default, the querier IPv6 address of the specified VLAN is not configured

Note

- When the querier IPv6 address is not configured, the default source IPv6 address of the querier is 0.::.0, but the querier does not send the IGMP group query packet with source IP address 0.0.0.0.

Configure Query Interval of General Group

MLD querier periodically sends the query packets of the general group to maintain the group membership. You can modify the interval of sending the MLD general group query packets according to the actuality of the network. For example, if the configured general group query interval is long, it can reduce the number of the MLD protocol packets in the network, avoiding the network congestion.

Table 56 Configuring Query Interval of General Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Query Interval of General Group	**ipv6 mld snooping vlan** *vlan-id* **querier query-interval** *interval-value*	Optional By default, the query interval of the general group is 125 seconds

Note

- In the same VLAN, the configured query interval of the general group should be larger than the maximum response time. Otherwise, the configuration cannot succeed.

Configure Max. Response Time

The general group query packet sent by the MLD querier contains the maximum response time field. The multicast receiver sends the membership report packet within the maximum response interval. If the multicast receiver does not send the group member report packet within the maximum response time interval, the device considers that this subnet does not have a receiver for this multicast group and immediately deletes the multicast group information.

Table 4 Configuring Maximum Response Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Max. Response Time	**ipv6 mld snooping vlan** *vlan-id* **querier max-response-time** *time-value*	Optional By default, the maximum response time is 10 seconds

Note

- In the same VLAN, the configured maximum response time should be smaller than the query interval of the general group. Otherwise, the configuration cannot succeed.

Configure Query Interval of Specified Group

When the MLD querier receives the leave packet of the certain multicast group, it sends the specified group query packet to query this segment for the multicast group, so as to learn whether the subnet has the members of the multicast group. If not receiving the member report packet of the multicast group after waiting for “max response time”, delete the information of the multicast group.

Table 5 Configuring Query Interval of Specified Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Query Interval of Specified Group	**ipv6 mld snooping vlan** *vlan-id* **last-member-query-interval** *interval-value*	Optional By default, the query interval of the specified group is 1000 milliseconds

Configure Fast Leave

If the device receives the leave packet of one multicast group after configuring fast leave, the device does not send the query packet of the specified group to the port any more and the information of the multicast group is deleted at once.

Table 6 Configuring Fast Leave

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	
Configure Fast Leave	**ipv6 mld snooping vlan** *vlan-id* **immediate-leave**	Mandatory By default, the fast leave function of the specified VLAN is disabled

Note

- There are multiple receivers of the same multicast group in the device port at the same time. When the port receives the MLD leave packet of the multicast group sent by one receiver and if fast leave is configured in the VLAN that the device port is within, the multicast services of the other receivers are interrupted.

56.2.3 Configure MLD Snooping Router Port

MLD snooping router port is the port receiving MLD group query packets or multicast routing protocol packets. When the device receives the MLD member report or leave packet, it forwards the packet via MLD snooping router port. In this way, the uplink router can maintain the MLD membership table correctly.

MLD snooping router port can be dynamically learned or configured manually. MLD snooping dynamic router port refreshes the age time by regularly receiving the MLD group query packets or multicast routing protocol packets. MLD snooping static router port does not age.

Configuration Condition

Before configuring the MLD snooping router port function, do the following:

- Enable global and intra-VLAN MLD snooping functions;
- Add port member in VLAN

Configure IGMP Snooping Static Router Port

After configuring MLD snooping static router port, the device can forward the MLD protocol packet via the port even the port does not receive the MLD group query packet or multicast routing protocol packet. It can prevent the problem that the router port ages because the services of the uplink L3 multicast device are interrupted.

Table 7 Configuring MLD Snooping Static Router Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IGMP snooping Static Router Port	**ipv6 mld snooping vlan** *vlan-id* **mrouter interface** { *interface-name* | **link-aggregation** *link-aggregation-id* }	Mandatory By default, the MLD snooping static router port is not configured

Configure Age time for MLD Snooping Dynamic Router Port

As long as the configured age time for the MLD snooping dynamic router port is longer, the problem can be effectively prevented that the router port ages fast because the services of the uplink L3 multicast device are interrupted.

Table 8 Configuring Aging Time for MLD Snooping Dynamic Router Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure age time for MLD snooping dynamic router port	**ipv6 mld snooping vlan** *vlan-id* **timer router-port expiry** *expiry-value*	Optional

Step	Command	Description
		By default, the age time of the MLD snooping dynamic router port is 255 seconds

56.2.4 Configure MLD Snooping TCN Event

Configuration Condition

Before configuring the MLD snooping TCN event function, do the following:

- Enable global and intra-VLAN MLD snooping functions.

Enable Fast Convergence

When the network topology varies, a TCN event will be generated. The root port of the spanning tree will actively send a global MLD leave packet to request the MLD querier in order to send a general group query packet, achieving fast convergence.

After you enable the fast convergence of the MLD snooping TCN event, the root port of the non-spanning tree can also actively send a global MLD leave packet, achieving the fast convergence.

Table 9 Enabling Fast Convergence

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable fast convergence	**ipv6 mld snooping tcn query solicit**	Mandatory By default, fast convergence is disabled in the TCN event

Configure TCN Event Query Interval

When the TCN event occurs, the MLD snooping querier will send a general group query at the TCN event query interval.

Table 56-10 Configuring TCN Event Query Interval

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TCN event query interval	**ipv6 mld snooping vlan** *vlan-id* **querier tcn query interval** *interval-value*	Optional By default, the TCN event query interval is 31 seconds

Configure TCN Event Query Count

When the TCN event occurs, the MLD snooping querier will send a general group query at the TCN event query interval. The interval will restore to the general group query interval after the number of sending times reaches the configured TCN event query count.

Table 11 Configuring TCN Event Query Count

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure TCN event query count	**ipv6 mld snooping vlan** *vlan-id* **querier tcn query count** *count-number*	Optional By default, the TCN event query count is 2

56.3 Typical Configuration Example of MLD Snooping

56.3.1 Configure MLD Snooping

Network Requirements

- Device 1 configures the IPv6 multicast routing protocol, Device 2 enables MLD snooping, PC 1 and PC 2 are the receivers of multicast services, and PC 3 is the receiver of non-multicast services;
- Multicast Server sends the IPv6 multicast service packets, PC 1 and PC 2 can correctly receive the multicast service packets, and PC 3 cannot receive the multicast service packets.

Network Topology

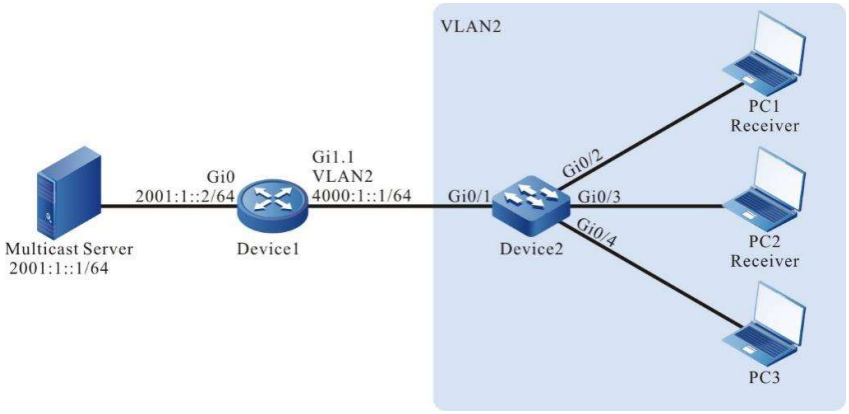


Figure 56 Network Topology for Configuring MLD Snooping

Configuration Steps

Step 1: On Device 1, configure the interface IPv6 address and enable the IPv6 multicast routing protocol (omitted).

Step 2: Configure Device2.

Create VLAN2 on #Device 2.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
```

#On Device 2, configure the link type of ports gigabitethernet0/2-gigabitethernet0/4 to Access to allow services of VLAN 2 to pass.

```
Device2(config)#interface gigabitethernet 0/2-0/4
Device2(config-if-range)#switchport access vlan 2
Device2(config-if-range)#exit
```

#On Device 2, configure the link type of port gigabitethernet0/1 to Trunk to allow services of VLAN 2 to pass, and configure PVID to 1.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2
Device2(config-if-gigabitethernet0/1)#switchport trunk pvid vlan 1
Device2(config-if-gigabitethernet0/1)#exit
```

#Enable unknown multicast drop in VLAN 2.

```
Device2(config)#vlan 2
Device2(config-vlan2)#l2-multicast drop-unknown
Device2(config-vlan2)#l3-multicast ipv6 drop-unknown
Device2(config-vlan2)#exit
```

#Enable MLD snooping and enable the routing port dynamic learning function of VLAN 2.

```
Device2(config)#ipv6 mld snooping
Device2(config)#ipv6 mld snooping vlan 2
Device2(config)#ipv6 mld snooping vlan 2 mrouter-learning
```

Step 3: Check the result.

#PC 1 and PC 2 send MLDv1 member report packets to join the IPv6 multicast group FF10::1.

#View the multicast membership table of Device 2.

```
Device2#show ipv6 mld snooping groups
MLD Snooping Group Membership
Total 2 groups

VLAN ID  Port Name  Group Address  Expires    Last Reporter   V1 Expires  Uptime
_______ __________ _____________ ________  ________     __________ _________
2       gi0/2      ff10::1       00:03:59   fe80::b         stopped    00:00:16
2       gi0/3      ff10::1       00:03:59   fe80::c         stopped    00:00:16
```

#Multicast Server sends the IPv6 multicast service packet with the destination address of FF10::1, PC 1 and PC 2 can correctly receive the multicast service packet, and PC 3 cannot receive the multicast service packet.

57 Hardware QoS

57.1 Overview

57.1.1 Background

In the traditional IP network, the forwarding device treats all packets equally, adopts “First in, first out” (FIFO) to process all packets and tries best effort to transmit the packet to the destination, so it cannot provide any guarantee for the reliability and delay of the packet transmission.

However, with the development of the IP network, the new applications based on the IP network emerge in endlessly, which put forward new requirements for the service quality of the IP network, especially the demand for the service packets with high real-time requirement is more obvious. For example, the network flow media, VoIP and other real-time services put forward high requirement for the transmission delay of the packets. If the packet transmission delay is long, the user cannot accept (relatively, E-mail and FTP

services are not sensitive to the transmission delay). To support the communication services with different service quality requirements, it is required that the network can intelligently distinguish different communication types, so as to provide the corresponding service. The capability of distinguishing the communication types is the basic premise of providing different service qualities for different communications, so the best-effort service mode of the traditional IP network cannot meet the requirements of the present IP network application. The QoS (Quality of Service) technology is to solve the problem, so as to meet the different service quality requirements of the users for the network.

57.1.2 Service Model

QoS provides the following three kinds of service models, that is, Best-Effort service, Integrated service, and Differentiated service (DiffServ for short).

Best-Effort is a single service model and also the simplest service model. The application program can send out any quantity of packets at any time without getting the permission or informing the network in advance. For the best-effort service, the network tries best to send the packets, but does not provide ant guarantee for the transmission delay and reliability of the packets. Best-Effort is the default service model of Internet and is applicable to most of network applications, such as FTP and E-Mail. It is realized via the FITO queue mechanism.

IntServ is one service model that can provide various service types. It can meet various QoS requirements. Before sending packets, the service model needs to apply for the specified service resources from the network. The request is completed via the RSVP signaling. RSVP applies for the network resources for the application before the application program starts to send packets, so it belongs to the out-band signaling. Before sending data, the application program first informs the network of its own traffic parameters and the needed specified service quality request, including bandwidth, delay and so on. After receiving the resource request of the application program, the network executes the resource distributing check, that is, judge whether to distribute resources for the application program based on the resource application of the application program and the present resources of the network. Once the network confirms to distribute resources for the application program, the network maintains one state for the specified flow (Flow, confirmed by the IP addresses, port numbers and protocol numbers of the two sides) and executes the packet classification, traffic monitoring, queuing and scheduling based on the state. After receiving the confirming information of the network (that is, confirm that the network already reserves resources for the packets of the application program), the application program can send packets. As long as the packets of the application program are controlled within the range described by the traffic parameters, the network will undertake to meet the QoS requirements of the application program.

DiffServ classifies the communications according to the service requirements, and then processes the ingress and egress packets according to the classification result, so as to ensure that the network is always in the good communication connection status. It is one multi-channel service model and can meet the QoS requirements of different flows. The largest difference with IntServ is that DiffServ can reserve resources in the network without signaling exchange. It just functions on one port of one transmission device in the network, processing the ingress and egress packets of the port. DiffServ does not need to maintain the status information for each kind of communication. It distinguishes the QoS level of each packet according

to the configured QoS mechanism and provides the service for the packet according to the level. Therefore, the mechanism providing the QoS scheme is also called CoS. There are many classification methods and the common modes are to classify according to the priority of the IP packet, to classify according to the source, destination address and port of the packet, to classify according to the packet protocol, to classify according to the packet ingress port, and so on.

Priority mapping, flow classification, traffic monitoring, traffic shaping, congestion management and congestion avoidance are the main components of DiffServ. The flow classification identifies the packets according to some matching rules and is the basis and premise of DiffServ; traffic monitoring, traffic shaping, congestion management and congestion avoidance distribute and schedule the resources for the network traffic from different aspects and they are the embodiment of the DiffServ idea.

57.1.3 Introduction to QoS Functions

Priority Mapping

Priority mapping includes the ingress mapping and egress mapping. Ingress mapping maps to the local priority (LP) according to the 802.1p priority and DSCP value in the packet; egress mapping maps to the 802.1p priority and DSCP value according to the local priority (LP) of the packet. Priority mapping serves for the queue scheduling and congestion control.

The device supports four kinds of priority mapping: mapping the packet DSCP to the local priority (LP); mapping the 802.1p priority of the packet to the local priority (LP); mapping the local priority (LP) of the packet to the egress 802.1p priority of the packet; mapping the local priority (LP) of the packet to the egress DSCP value of the packet. The diagram of the priority mapping relation is as follows:

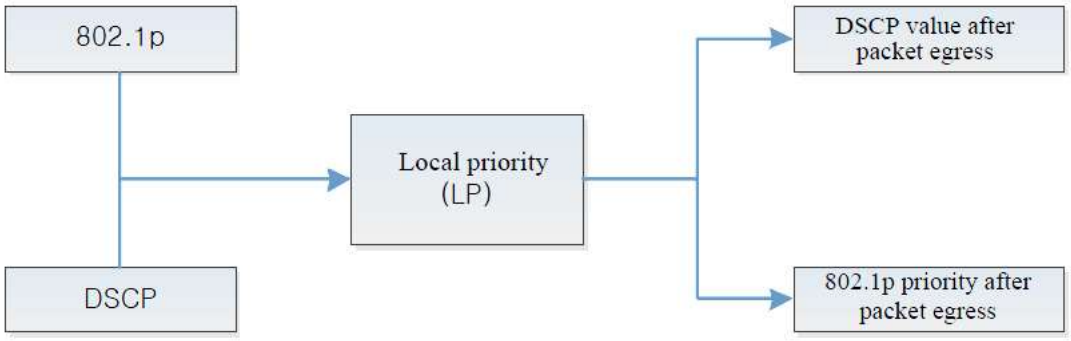


Figure 1 Diagram of Priority Mapping Relation

Flow Classification

Flow classification adopts some rule to identify the packets that comply with one feature, divides the packets of different features to multiple classes, and then uses the corresponding QoS mechanism to provide different services for different classes. Therefore, the flow classification is the premise and basis of providing different services.

Flow classification includes counter, meter, flow mirror, redirection and re-remarking.

Counter and meter perform the counting and metering actions according to the result of the flow classification.

Flow mirror means to mirror the matched packets to the specified ports.

Redirection means to redirect the matched packets to the specified ports.

Remarking means to set or modify the attributes of one kind of packets. After dividing the packets to different kinds via the flow classification, remarking can modify the attributes of the packet. Prepare for the subsequent processing of the packet.

Traffic Monitoring

Traffic monitoring limits the speed of the ingress packets via the token bucket. To ensure that the overload does not happen to the traffic passing the network and causes the congestion, the device provides the rate limitation based on the port receiving direction, limiting the total rate at the receiving direction of the port. The speeding traffic is dropped.

Traffic Shaping

The typical function of the traffic shaping means to limit the traffic of flowing out from one network, making the packets sent with an average rate. Usually, it is divided to the port traffic shaping and queue traffic shaping. When the sending rate of the packets exceeds the shaping rate, the speeding packets are buffered in the queue and then are sent out with an average rate. The difference between the traffic shaping and traffic monitoring: When using the traffic monitoring to control the packet traffic, the speeding packets are not buffered, but are directly dropped, while the traffic shaping buffers the speeding packets, reducing the dropped packets caused by the burst traffic. However, the traffic shaping may increase the delay, while the traffic monitoring nearly does not increase the delay.

Congestion Management

When the device traffic load is light, do not generate the congestion and the packets are forwarded out when reaching the port. When the arriving rate of the packets is larger than the sending rate of the port and exceeds the processing limit of the port or the device resources are not enough, congestion happens to the device. The congestion may make the communication of the whole network become unreliable. The end-to-end delay, jitter and packet loss rate used to measure the network service quality all increase. If enabling the congestion management and when the congestion happens, the packets queue at the port and waits for the port to forward. The congestion management usually adopts the queue technology and the port determines which queue the packet should be placed according to the packet priority and queue mechanism and how to schedule and forward packets.

The common scheduling includes SP (Strict Priority), RR (Round Robin), WRR (Weighted Round Robin), and WDRR (Weighted Deficit Round Robin).

SP (Strict Priority): There are eight queues on the port, queue 0-7. Queue 7 has the highest priority and queue 0 has the lowest priority.

RR (Round Robin): After one queue schedules one packet, turn to the next queue; WRR (Weighted Round Robin): you can configure the number of the packets scheduled by each queue before proceeding to the next queue;

WDRR (Weighted Deficit Round Robin): It is the improvement for the WRR algorithm. The algorithm is based on two variables, that is, quantum and credit counter. The quantum means the weight in the unit of byte and it is a configurable parameter. The credit counter means the accumulation and consumption of the quantum, which is a status parameter and cannot be configured. In the initial state, the credit counter of each queue is equal to the quantum. Every time the queue sends a packet, subtract the byte number of the packet from the credit counter. When the credit counter is lower than 0, stop the scheduling of the queue. When all queues stop scheduling, supplement quantum for all queues.

Congestion Avoidance

The congestion avoidance technology monitors the communication load of the network, so as to avoid the congestion before the network congestion happens. The common used technology is WRED (Weighted Random Early Detection). The difference with the tail drop method is that WRED selects the dropped packet according to the DSCP or IP priority and can provide different performance features for different service types of data. It also can avoid the TCP global synchronization.

In the WRED algorithm, the start point of the queue drop packet is marked as DropStartPoint and the end point of the drop is marked as DropEndPoint. When the average length of the queue is between DropStartPoint and DropEndPoint, WRED drops the packet at random by the corresponding drop rate, while when the queue length exceeds DropEndPoint, drop the packet by 100%. When the queue length is smaller than DropStartPoint, WRED does not drop the packet.

The following figure is a schematic diagram on How WRED Works:

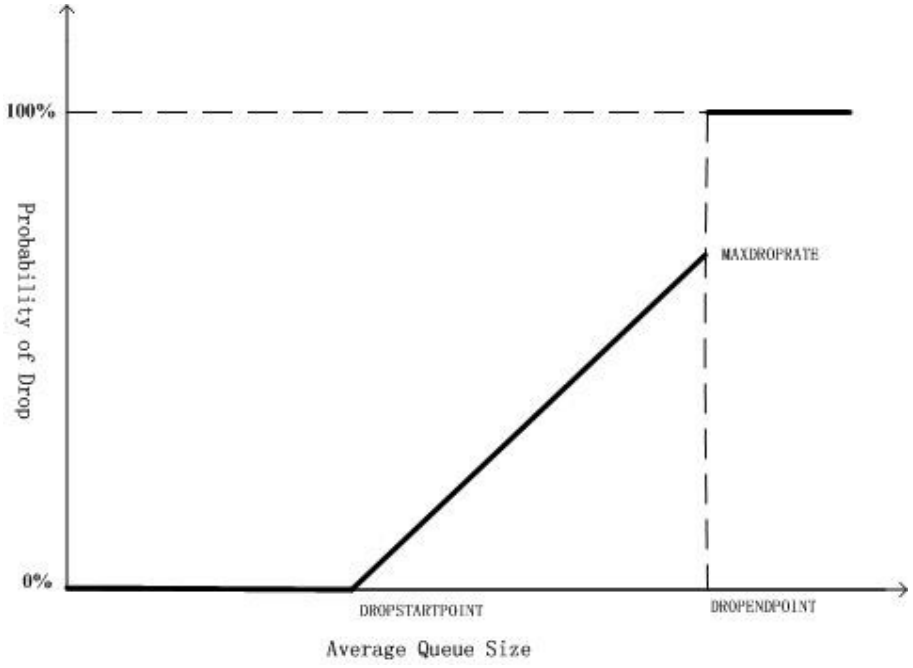


Figure 2 Schematic Diagram for Principle of WRED

Action Group Function

To support the flow classification and traffic control, the device extends the traditional ACL so that ACL and ACL rule can be bound with one action group respectively, adopting the corresponding action for the matched packet. The action group contains the configurations of the counter, meter, flow mirror, redirection and remarking.

For various ACLs and ACL rules being used in different function domains, the configurations of the action groups are different. For the ingress ACL, the used action group of IP ACL is L3 action group and the used action group of MAC ACL is L2 action group. The egress action group is used at the egress direction of ACL. The VFP action group is used to realize the flow-based QinQ. Each ACL can be bound with various action groups, but the effective one depends on the function domain bound with the ACL. For example, one rule of IP ACL is configured with L3 action group, egress action group and VFP action group at the same time. When the IP ACL is applied at the ingress direction, the action in the L3 action group take effect and the actions in the other two action groups do not take effect.

The policy route in the action group is one packet forwarding mechanism for flexible routing based on the destination network. The policy route classifies the packets via Content Aware Processor and forwards the data flow that complies with the classification rule according to the specified next hop. When some packet is routed by other path, but not the shortest path, we can enable the policy route. The policy route can be enabled when some packets need to be routed by other paths instead of the clear shortest path. The priority of the policy route is higher than any other route. Therefore, once the user configures enabling the policy route, the packet sending is processed according to the policy route. Only when the access list matching fails, we can continue to forward according to the searching result of the forwarding table. Otherwise, forward the packet according to the specified next-hop information of the route policy. The specified next hop of the policy route should be the direct-connected next hop. For the non-direct-connected next-hop address, the system permits to configure, but in fact, it is invalid.

57.2 Hardware QoS Function Configuration

Table 1 Hardware QoS Function Configuration List

Configuration Task	
Configure Priority Mapping	Configure Priority Mapping
	Configure Default Priority Mapping
Configure Flow Classification	Configure Counter
	Configure Meter
	Configure Flow Mirror

Configuration Task	
	Configure Redirection
	Configure Remarking l2-Priority
	Configure Remarking l3-Priority
Configure Traffic Monitoring	Configure Port-based Rate Limitation
Configure Traffic Shaping	Configure Queue-based Traffic Shaping
	Configure Port-based Traffic Shaping
Configure Congestion Management	Configure Scheduling Policy of Port Queue
Configure Congestion Avoidance	Configure Drop Mode
Configure VFP Action Group	Configure Processing of Single VLAN Tag Packets
	Configure Processing of Double VLAN Tag Packets
	Configure Processing of Packets without VLAN Tags
	Configure Binding of VRF in VFP Action Group

57.2.1 Configure Priority Mapping

Priority mapping is the mapping among the 802.1p priority, DSCP value and local priority (LP) in the packet. Modify or distribute the priority field of the packet to serve for the congestion avoidance and congestion management.

Configuration Condition

None

Configure Priority Mapping

Priority mapping includes the ingress mapping and egress mapping. The ingress mapping maps to the local priority (LP) according to the 802.1p priority and DSCP value in the packet; the egress mapping maps to the 802.1p priority and DSCP value according to the local priority (LP).

Table 2 Configuring Priority Mapping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure priority mapping template	**qos map-table {ingress | egress }** *template-name*	Mandatory Configure egress and ingress priority templates
Enter the template view	{ **dot1p-lp** | **dscp-lp** | **lp-dot1p** | **lp-dscp** } *index* **to** *value*	Optional By default, priority mapping under the template is default mapping relation
Binding the priority mapping template to the port	**map-table** *template- name* **{ ingress | egress }**	Mandatory By default, no priority mapping template is bound

Note

- For the packet with the specified priority entering the queue, you'd better not let the packet enter queue 7, because the packets sent out from CPU all enter queue 7. If queue 7 has too many packets, the packets from CPU may be dropped.
- The dscp-lp mapping and dotlp-lp are configured on the port at the same time. The dscp-lp has higher priority and it takes effect first.
- After enabling the ingress dot1p-lp mapping, the 802.1p priority of the forwarded packet is modified according to the local priority (LP) by default. For example, the dot1p-lp mapping relation is 1 to 5; after matching the 802.1p of the VLAN Tag in the ingress packet to 1, the 802.1p priority of the forwarded packet with VLAN Tag is modified to 5.
- The priority mapping does not take effect for the packet remarked by the action group. First, remark the local priority (LP) at the ingress action group, and then mapping to the 802.1p priority and DSCP value of the packet via the local priority (LP) at the egress takes effect. Remark the 802.1p priority at the ingress and then mapping the local priority and DSCP value via the 802.1p priority does not take effect, but remarking the 802.1p priority itself takes effect. Mapping according to the 802.1p priority of the original packet also takes effect. That is to say, remarking takes effect separately, the priority mapping takes effect separately, and the priority mapping according to the remarked value does not take effect.
- If the QINQ function is enabled on the port, and the template bound to the port

includes dot1p-lp and dscp-lp mappings, maybe you cannot get the desired mapping result. Therefore, it is recommended not to enable QinQ and bind the priority mapping function on one port at the same time.

- After configuring the lp-dscp mapping, the default mapping of lp-dscp is 0 to 7, 1 to 8, 2 to 16, 3 to 24, 4 to 32, 5 to 40, 6 to 48, and 7 to 56.

Configure Default Priority Mapping

The default priority mapping, the same as the priority mapping, has the ingress and egress mapping. The difference lies in that the default priority mapping maps the entries not configured with priority mapping to the default value.

Table 3 Configuring Default Priority Mapping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure priority mapping template	**qos map-table {ingress | egress }** *template-name*	Mandatory Configure egress and ingress priority templates
Configure Default Priority Mapping	**{ dot1p-lp | dscp-lp | lp-dot1p | lp-dscp } default** *value*	Mandatory By default, no default priority mapping is configured

57.2.2 Configure Flow Classification

Flow classification adopts some rule to identify the packets that comply with one feature, divides the packets of different features to multiple classes, and then uses the corresponding QoS mechanism to provide different services for different classes. Therefore, the flow classification is the premise and basis of providing different services.

Configuration Condition

Before configuring the flow classification, first complete the following task:

- Configure the ACL.

Configure Counter

Configuring counting action in the action group aims to count the number of the matched packets.

Table 4 Configuring the Counter

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure L3 action group and enter L3 action group configuration mode	**l3-action-group** *l3-action-group-name*	At least one option must be selected. The subsequent configuration takes effect only on the current L3 action group after you enter the L3 action group configuration mode, only on the current L2 action group after you enter the L2 action group configuration mode, only on the current egress action group after you enter the egress action group configuration mode
Configure L2 action group and enter L2 action group configuration mode	**l2-action-group** *l2-action-group-name*	
Configure egress action group and enter egress action group configuration mode	**egr-action-group** *egr-action-group-name*	
Configure Counter	**count** { **all-colors** }	Mandatory By default, packets are not counted in the action group

Configure Meter

Configure the meter in the action group to limit the rate or mark the matched packets. When configuring a nonexistent meter, the meter takes effect immediately when the specified meter is configured. When no meter is configured in the action group, all matched packets are considered as green packets. When a meter is configured in the action group for coloring the packets, the packets will be marked in green, yellow, and red according to the packet traffic, and then the counter will count the number of the packets of different colors.

Table 5 Configuring Meter

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure the meter and enter the meter mode	**traffic-meter** *traffic-meter-name*	Mandatory By default, the action for yellow packets in the meter is drop, and the meter mode is not configured After entering the meter configuration, one complete meter configuration contains the meter action for yellow packets and meter mode configuration, and the incomplete configuration will not take effect
Configure meter action	**meter action yellow** { **drop** | **transmit** }	Optional By default, the action for yellow packets in the meter is drop
Configure meter mode	**meter mode** { **srtcm** *cir cbs ebs* | **trtcm** *cir cbs pir pbs* }	Mandatory By default, the meter mode is not configured
Enter the global configuration mode.	**exit**	-
Configure L3 action group and enter L3 action group configuration mode	**l3-action-group** *l3-action-group-name*	At least one option must be selected. The subsequent configuration takes effect only on the current L3 action group after you enter the L3 action group configuration mode, only on the current L2 action group after you enter the L2 action group configuration mode, only on the current egress action group after you enter the egress action group configuration mode
Configure L2 action group and enter L2 action group configuration mode	**l2-action-group** *l2-action-group-name*	
Configure egress action group and enter egress action group configuration mode	**egr-action-group** *egr-action-group-name*	

Step	Command	Description
Configure to bind the meter	**meter** *traffic-meter-name*	Mandatory By default, no meter is bound

Note

- If the ACL bound to the objects is configured with the action group and the action group is configured with a meter for limiting the rate, conflicted rate limitation actions may exist. When the rate limitation is applied, the packets in red and yellow are dropped. For example, port 0/1 belongs to VLAN 1, ACL on port 0/1 permits the packets with the source IP address 1.1.1.1 to pass, and the action to limit its traffic to 5Mbps is configured. Whereas, ACL on VLAN 1 permits the packets with the IP address 1.1.1.1 to pass, and the action to limit its traffic to 1Mbps is configured. In this situation, the minimum rate in the packet channel will take effect and the traffic is configured within 1 Mbps. Specially, due to the hardware limitation, the actual traffic for multi-level rate limitation will be less than the minimum rate in the packet channel. Therefore, multi-level rate limitation is not recommended when an accurate rate limitation is needed.
- The meter in the egress action group does not support the remark lp or remark dotlp-lp action.
- Remarking of yellow packets is not supported.
- The meter is based on the chips. That is, the meter on each chip limits the traffic rate over the port. If the meter exists in two different chips under the link aggregation port, a meter exists in each chip and thus the rate limitation has the effect twice of the expected rate limitation effect.
- If a meter is applied to the VLAN, the meter takes effect for each chip on each line card. VLAN objects are limited within 10 Mbps. If five single-core line cards exist on the device, the 10 Mbps traffic takes effect for a pair of line cards. That is, the traffic on each line card complying with the VLAN rate limitation is 10 Mbps. If two chips exist on a line card, the traffic for each chip on the line card is 10 Mbps.

Configure Flow Mirror

Configuring the flow mirror in the action group aims to specify the matched packet to the port.

Table 6 Configuring Flow Mirror

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure L3 action group and enter L3 action group configuration mode	**l3-action-group** *l3-action-group-name*	At least one option must be selected. The subsequent configuration takes effect only on the current L3 action group after you enter the L3 action group configuration mode, and only on the current L2 action group after you enter the L2 action group configuration mode
Configure L2 action group and enter L2 action group configuration mode	**l2-action-group** *l2-action-group-name*	
Configure Flow Mirror	**mirror interface** *interface-name*	Mandatory By default, no flow mirror is configured

Configure Redirection

Configuring the packet redirect in the action group aims to redirect the matched packets to the specified port.

Table 7 Configuring Redirection

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure L3 action group and enter L3 action group configuration mode	**l3-action-group** *l3-action-group-name*	At least one option must be selected. The subsequent configuration takes effect only on the current L3 action group after you enter the L3 action group configuration mode, and only on the current L2 action group after you enter the L2 action group configuration mode
Configure L2 action group and enter L2 action group configuration mode	**l2-action-group** *l2-action-group-name*	

Step	Command	Description
Configure Redirection	**redirect** { **interface** *interface-name* |interface **link-aggregation** *link-aggregation-id*}	Mandatory By default, no packet redirection is configured

Configure Remarking l2-Priority

Configuring packet remarking in the action group aims to classify the matched packets. So users are allowed to adopt different QoS policies in the subsequent data communications.

Table 8 Configuring Remarking I2-Priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure L3 action group and enter L3 action group configuration mode	**l3-action-group** *l3-action-group-name*	At least one option must be selected. The subsequent configuration takes effect only on the current L3 action group after you enter the L3 action group configuration mode, only on the current L2 action group after you enter the L2 action group configuration mode, only on the current egress action group after you enter the egress action group configuration mode
Configure L2 action group and enter L2 action group configuration mode	**l2-action-group** *l2-action-group-name*	
Configure egress action group and enter egress action group configuration mode	**egr-action-group** *egr-action-group-name*	
Configure Remarking l2-Priority	**remark l2-priority** { **dscp** *dscp-value* |{{ **dot1p** | **dot1p-lp** | **lp** } { *priority-value* | **precedence** }}}	Mandatory By default, remarking l2-priority is not configured

Note

- The action group does not support using the priority field in the IP packet TOS to

Step	Command	Description
		remark the 802.1p priority in the VLAN Tag. ● The egress action group does not support the remark action.

Configure Remarking l3-Priority

Configuring packet remarking in the action group aims to classify the matched packets. So users are allowed to adopt different QoS policies in the subsequent data communications.

Table 9 Configuring Remarking l3-priority

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure L3 action group and enter L3 action group configuration mode	**l3-action-group** *l3-action-group-name*	At least one option must be selected. The subsequent configuration takes effect only on the current L3 action group after you enter the L3 action group configuration mode, and only on the current egress group after you enter the egress action group configuration mode
Configure egress action group and enter egress action group configuration mode	**egr-action-group** *egr-action-group-name*	
Configure Remarking l3-priority	**remark l3-priority** { **dscp** *dscp-value* | **precedence** { *priority-value* | **dot1p** }}	Mandatory By default, remarking l3-priority is not configured

Note

● If the ACL bound to the objects is configured with the action group, remarking confliction may exist. For example, port 0/1 belongs to VLAN1, the ACL on port 0/1 permits the packets of the source IP address 1.1.1.1 to pass, and the action for remarking the DSCP field as 5 is configured. The ACL of VLAN 1 permits the packets of the IP address 1.1.1.1 to pass and the action for remarking the DSCP field as 4 is configured. In this situation, this situation is handled based on port > VLAN > global and MAC ACL > IP ACL by priority and the final remarking value is 5.

- If the ACL bound to the objects is configured with the action group, conflict-free remarking action may exist. For example, port 0/1 belongs to VLAN1, the ACL on port 0/1 permits the packets of the source IP address 1.1.1.1 to pass, and the action for remarking the DSCP field as 5 is configured. The ACL of VLAN 1 permits the packets of the IP address 1.1.1.1 to pass and the 802.1p priority is remarked as 4. For the conflict-free remarking action, the packet DSCP will be marked as 5 and the 802.1p priority will be marked as 4.
- The action group does not support using the 802.1p priority in the VLAN Tag to remark the priority field in the IP packet TOS.
- The egress action group does not support the remark action.

57.2.3 Configure Traffic Monitoring

To ensure that the overload does not happen to the traffic passing the network and causes the congestion, the device provides the rate limitation based on the port receiving direction, limiting the total rate at the receiving direction of the port. The speeding traffic is dropped.

Configuration Condition

None

Configure Port-based Rate Limitation

To provide different rate limitations for ports at different time periods, each port is configured with eight rate limitations of different priorities. Each rate is limited and then bound to a time domain. For the entries taking effect at the same time, determine which entry takes effect by priority. The number 0 indicates the highest priority and the number 7 indicates the lowest priority. The rate limitation over the port can be configured directly without the time domain.

Table 10 Configuring Port-based Rate Limitation

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure port-based rate limiting	**rate-limit** { **default** *rate burst-size* | *priority rate burst-size* [**time-range** *time-range-name*] }	Mandatory By default, no flow limit is configured on the port

57.2.4 Configure Traffic Shaping

The traffic shaping enables the packets to be sent out at an average rate. The difference between the traffic shaping and traffic monitoring: the traffic monitoring takes effect in the ingress direction and the traffic shaping takes effect in the egress direction. The excessive traffic at the ingress direction will be dropped, but the excessive traffic at the egress direction will be cached.

Configuration Condition

None

Configure Queue-based Traffic Shaping

Queue-based traffic shaping enables the traffic in the queue to be sent out at an average rate. Different traffic shaping can be performed for different queues as required.

Table 11 Configuring Queue-based Traffic Shaping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Queue-based Traffic Shaping	**traffic-shape queue** *queue-id* **{ cir** *cir* **cbs** *cbs* **pir** *pir* **pbs** *pbs* }	Mandatory By default, queue-based traffic shaping is not configured

Configure Port-based Traffic Shaping

The port-based traffic shaping allows the time domain binding to achieve different bandwidths in different time periods. Each port is configured with eight traffic shaping of different priorities and each traffic shaping is bound to a time domain. For the entries taking effect at the same time, determine which entry takes effect by priority. The number 0 indicates the highest priority and the number 7 indicates the lowest priority.

Table 12 Configuring Port-based Traffic Shaping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Port-based Traffic Shaping	**traffic-shape**{ {**pir** *rate* **pbs** *burst-size* } | { *priority* **pir** *rate* **pbs** *burst-size*[**time-range** *range-name*] } }	Mandatory By default, queue-based traffic shaping is not configured on the port

57.2.5 Configure Congestion Management

In a complex network, congestion is common because the current bandwidth cannot satisfy the normal forwarding. Congestion may cause a series of negative problems as follows: the system breaks down because of abundant network resources, the network resource utility is low because of decreased network throughput, and packet transmission delay and jitter increase. Scheduling policy for the port queue is a method for managing the congestion.

Configuration Condition

None

Configure Scheduling Policy of Port Queue

The queue-based scheduling policy sends out the classified traffic by a certain priority-level algorithm. Each queue algorithm solves a certain network traffic problem and has great influence on bandwidth resource allocation, delay, and jitter. Queue scheduling processes the packets of different priorities in levels. A packet with high priority will be sent preferentially.

The common scheduling includes SP (Strict Priority), RR (Round Robin), WRR (Weighted Round Robin), and WDRR (Weighted Deficit Round Robin).

SP (Strict Priority): There are eight queues on the port, queue 0-7. Queue 7 has the highest priority and queue 0 has the lowest priority.

RR (Round Robin): After one queue schedules one packet, turn to the next queue; WRR (Weighted Round Robin): you can configure the number of the packets scheduled by each queue before proceeding to the next queue;

WDRR (Weighted Deficit Round Robin): It is the improvement for the WRR algorithm. The algorithm is based on two variables, that is, quantum and credit counter. The quantum means the weight in the unit of byte and it is a configurable parameter. The credit counter means the accumulation and consumption of the quantum, which is a status parameter and cannot be configured. In the initial state, the credit counter of each queue is equal to the quantum. Every time the queue sends a packet, subtract the byte number of the packet from the credit counter. When the credit counter is lower than 0, stop the scheduling of the queue. When all queues stop scheduling, supplement quantum for all queues.

Table 13 Configuring Scheduling Policy of Port Queue

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Scheduling Policy of Port Queue	**queue-schedule** { **sp** | **rr** | { { **wrr** | **wdrr** } *weight0 weight1 weight2 weight3 weight4 weight5 weight6 weight7*} }	Mandatory By default, strict priority (SP) scheduling is used as the scheduling policy of port queue

57.2.6 Configure Congestion Avoidance

The congestion avoidance technology monitors the network resource utility and communication load of the network, so as to avoid the congestion by actively dropping packets before the network congestion happens or worsens. Excessive congestion exerts great harm on network resources and therefore, a certain measure must be adopted to relieve the congestion. The common measure is to configure the packet drop mode.

Configuration Condition

None

Configure Drop Mode

Tail drop and WRED (Weighted Random Early Detection) are two common packet drop modes.

Tail drop: It is a traditional packet drop policy. When the queue length reaches the maximum value, all new packets will be dropped. This packet drop policy may cause TCP global synchronization. When the packets connected by multiple TCPs are dropped in a queue, multiple TCP connections will enter the congestion

avoidance and slow-start status to decrease and adjust the traffic, and then the traffic peak may occur simultaneously at a time. Repeatedly, the traffic and network are unstable.

WRED: When the queue length exceeds its own length, the packets are dropped by 100%. When the queue length is less than the start-value, do not drop any packet. When the queue length is greater than the start-value, drop packets at random according to the configured value. The random number generated by the WRED is based on the priority. The WRED introduces the IP priority to distinguish from the packet drop policy. The packet with high priority is considered for its benefit and this packet will be dropped in a relatively low probability.

Table 14 Configuring Drop Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure Drop Mode	**drop-mode** *cos-value* { **tail-drop** | **wred drop-start** start-value **drop-rate** drop-rate-value [**only-tcp** | **all**] }	Mandatory By default, the drop mode of port queue is tail-drop

57.2.7 Configure VFP Action Group

The VFP (VLAN Filter Processor) action group involves actions used to classify packets and re-specify single VLAN Tag packets, double VLAN Tag packets, and packets without VLAN tags.

Configuration Condition

Before configuring the VFP action group, do the following:

- Configure the ACL.

Configure Processing of Single VLAN Tag Packets

Configuring processing of single VLAN Tag packets in the VFP action group is mainly concerned with matching and processing of the 802.1P priories and VLAN numbers in the VLAN Tags.

Table 15 Configuring Processing of Single-layer VLAN Tag Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the VFP action group and enter the VFP action group configuration mode	**vfp-action-group** *vfp-action-group-name*	Mandatory By default, no VFP action group is configured
Configure Processing of Single VLAN Tag Packets	**one-tag** { **match-vlan** { **any** | *vlan-id* } | **ovlan-act** { **add-ovlan** *vlan-id* [**priority** *priority-value*] } | **replace-vlan** *vlan-id* }	Mandatory By default, processing of single VLAN Tag packets is not configured

Configure Processing of Double VLAN Tag Packets

Configuring processing of double VLAN Tag packets in the VFP action group is mainly concerned with matching and processing of the 802.1P priories and VLAN numbers in the inner and outer VLAN Tags.

Table 16 Configuring Processing of Double-layer VLAN Tag Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the VFP action group and enter the VFP action group configuration mode	**vfp-action-group** *vfp-action-group-name*	Mandatory By default, no VFP action group is configured
Configure Processing of Double VLAN Tag Packets	**double-tag** { **invlan-act** { **delete-invlan** | **replace-invlan** *vlan-id* } | **match-invlan** { **any** | *vlan-id* } | **match-ovlan** { **any** | *vlan-id* } | **ovlan-act replace-ovlan** *vlan-id* }	Mandatory By default, processing of double VLAN Tag packets is not configured

Configure Processing of Packets Without VLAN Tags

Configuring processing of packets without VLAN tags in the VFP action group is mainly concerned with configuring the addition of actions into the inner and outer VLAN Tags.

Table 17 Configuring Processing of Packets without VLAN Tags

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the VFP action group and enter the VFP action group configuration mode	**vfp-action-group** *vfp-action-group-name*	Mandatory By default, no VFP action group is configured
Configure Processing of Packets without VLAN Tags	**untag** { **invlan-act add-invlan** *vlan-id* } | **ovlan-act add-ovlan** *vlan-id*	Mandatory By default, processing of packets without VLAN Tags is not configured

Configure Binding of VRF in VFP Action Group

Table 18 Configuring Binding of VRF in VFP Action Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the VFP action group and enter the VFP action group configuration mode	**vfp-action-group** *vfp-action-group-name*	Mandatory By default, no VFP action group is configured
Configure Binding of VRF in VFP Action Group	**vrfset** *vrf-name*	Mandatory By default, binding VRF is not performed in the VFP action group

57.2.8 Hardware QoS Monitoring and Maintaining

Table 19 Hardware QoS Monitoring and Maintaining

Command	Description
show drop-mode [**interface** *interface-name*]	Show the drop mode of the port queue
show egr-action-group [*egr-action-group-name*]	Show related configuration information of the egress action group
show l2-action-group [*l2-action-group-name*]	Show related configuration information of the L2 action group
show l3-action-group [*l3-action-group-name*]	Show related configuration information of the L3 action group
show map-table user-name [*template name* **{ingress | egress}**]	Show priority mapping template information
show queue-schedule [**interface** *interface-name*]	Show the scheduling policy of the port queue
show rate-limit [**interface** *interface-name*]	Show rate limit information on the port
show traffic-count { **inst-all** | **inst-global** | { **inst-interface** *interface-name* / |**inst-vlan-range** *vlan-id* **|inst-interface-vlan-range** *vlan-id* **|inst-interface-vlan** *vlan-id* / **inst-link-aggregation** *link-aggregation-id* | **inst-vlan** *vlan-id* } { **ip-in** | **ip-out** | **ipv6-in** | **ipv6-out** | **mac-in** | **mac-out |hybrid-in|hybrid-out**}}	Show counter information of the ACL applied to the specified object
show traffic-meter [*traffic-meter-name*]	Show all information of the traffic meter
show traffic-shape [**interface** *interface-name*]	Show traffic shaping information on the port and queue
show vfp-action-group [*vfp-action-group-name*]	Show related configuration information of the VFP action group

57.3 Typical Configuration Example of Hardware QoS

57.3.1 Configure Priority Mapping

Network Requirements

- There are two servers on the network, namely Video Server and Data Server;
- the DSCP value in the video traffic packet is 34, and the DSCP value in the data traffic packet is 38;
- You can configure the priority mapping function so that the 802.1p priority of video traffic packets is 5 and that of data traffic packets is 1.

Network Topology

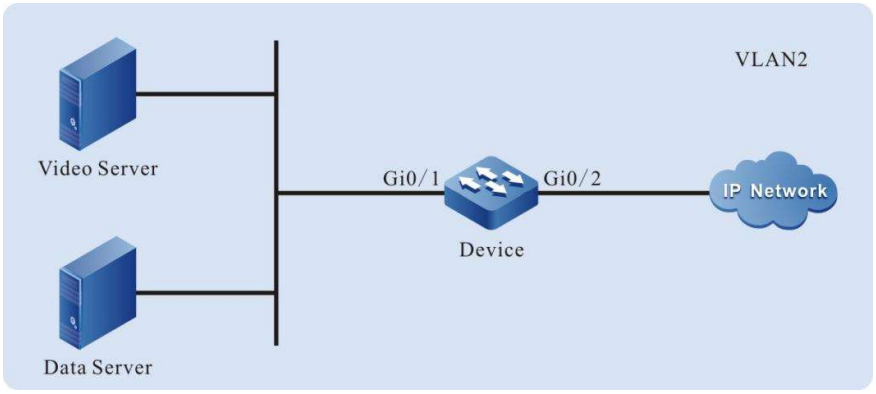


Figure 3 Network Topology for Configuring Priority Mapping

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
```

#Configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 2 to pass.

```
Device(config-if-gigabitethernet0/1)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
```

```
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the priority mapping function.

#Configure the priority mapping function globally to map packets with DSCP value 34 to queue 2 and packets with DSCP value 38 to queue 3.

```
Device(config)#qos map-table ingress a
Device(config-maptable-ingress)#dscp-lp 34 to 2
Device(config-maptable-ingress)# dscp-lp 38 to 3
```

#Configure the priority mapping function globally to map 802.1p priority of packets in the queue 2 as 5 and that of packets in the queue 3 as 1.

```
Device(config)#qos map-table egress b
Device(config-maptable-egress)#lp-dot1p 2 to 5
Device(config- maptable-egress)# lp-dot1p 3 to 1
```

#Bind the template globally and configure trust on the port

```
Device(config)#map-table a ingress
Device(config)#map-table b egress
Device(config)#interface gigabitethernet 0/1
-
Device(config-if-gigabitethernet0/1)#qos map-table trust dscp ingress
Device(config)#interface gigabitethernet 0/2
-
Device(config-if-gigabitethernet0/2)#qos map-table trust dot1p egress
```

Step 3: Check the result.

#After video traffic and data traffic are processed by Device, the 802.1p priority of the video traffic packets sent from port gigabitethernet0/2 are 5 and the 802.1p priority of the data traffic packets are 1.

57.3.2 Configure Remarking

Network Requirements

- There are two servers on the network, namely Video Server and Data Server;
- You can configure the remarking function so that the 802.1p priority of video traffic packets can be marked as 5 and that of data traffic packets remains unchanged.

Network Topology

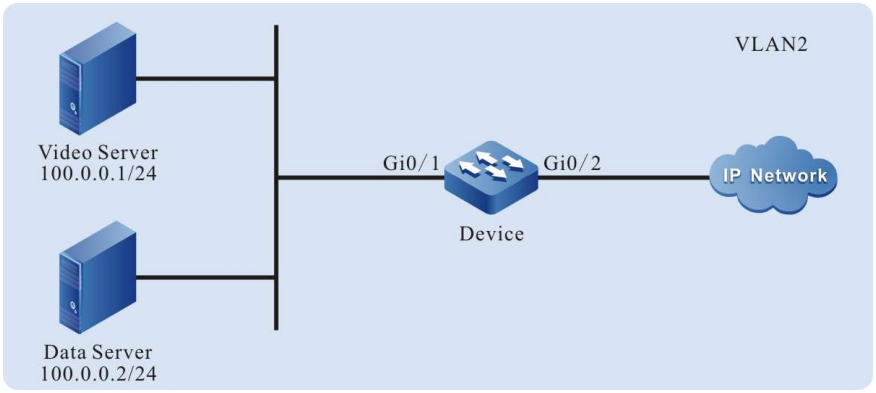


Figure 4 Network Topology for Configuring Remarking

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
```

#Configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 2 to pass.

```
Device(config-if-gigabitethernet0/1)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the L3 action group.

#Configure the L3 action group named remark. The action is to remark the 802.1p priority of the packets to 5.

```
Device(config)#l3-action-group remark
Device(config-action-group)#remark l2-priority dot1p 5
Device(config-action-group)#exit
```

Step 3: Configure the standard IP ACL.

#Configure the standard IP ACL numbered 1 on Device.

```
Device(config)#ip access-list standard 1
```

#Configure binding of rules to the L3 action group named remark so that the 802.1p priority of the video traffic packets can be remarked as 5.

```
Device(config-std-nacl)#permit host 100.0.0.1 l3-action-group remark
```

#Configure rules to allow data traffic to pass without changing the 802.1p priority of packets.

```
Device(config-std-nacl)#permit host 100.0.0.2
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

Step 4: Configure applying of the standard IP ACL.

#Apply the standard IP ACL numbered 1 to the ingress direction of port gigabitethernet0/1 of Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip access-group 1 in
Device(config-if-gigabitethernet0/1)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
----------Interface-----Bind-----Instance--------------
Interface----------------Direction----AclType----AclName
gi0/1                IN        IP       1
```

Step 5: Check the result.

#After video traffic and data traffic are processed by Device, the 802.1p priority of the video traffic packets sent from port gigabitethernet0/2 is modified into 5, and that of the data traffic packets remains unchanged.

57.3.3 Configure Traffic Shaping

Network Requirements

- There are two servers on the network, namely Video Server and Data Server;
- Configure the traffic shaping function to ensure that the video traffic rate is 20,000 kbps but the maximum is less than 20,000 kbps, and the sum of the video traffic rate and data traffic rate does not exceed 50,000 kbps. If the video traffic rate is greater than 20,000 kbps, you need to limit the video traffic rate to 20,000 kbps. If the video traffic rate is less than 20,000 kbps, the remaining bandwidth can be occupied by data traffic.

Network Topology

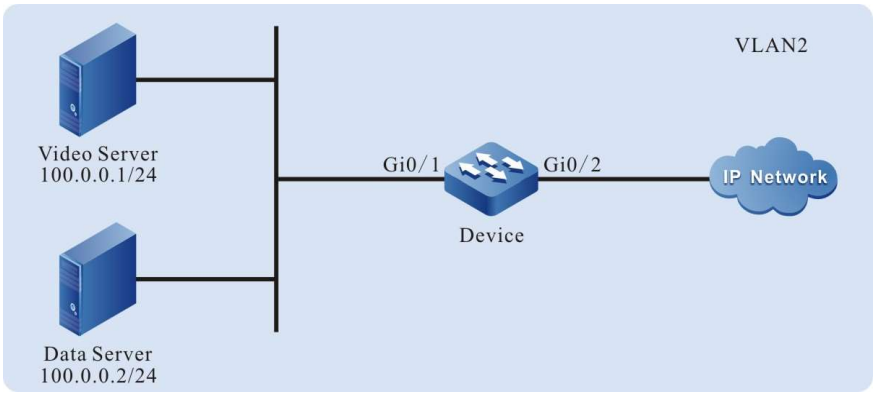


Figure 5 Network Topology for Configuring Traffic Shaping

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
```

#Configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 2 to pass.

```
Device(config-if-gigabitethernet0/1)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the L3 action group.

#Configure the L3 action group named LP7. The action is to remark the packets to queue 7.

```
Device(config)#l3-action-group LP7
Device(config-action-group)#remark l2-priority 1p 7
Device(config-action-group)#exit
```

#Configure the L3 action group named LP6. The action is to remark the packets to queue 6.

```
Device(config)#l3-action-group LP6
```

```
Device(config-action-group)#remark l2-priority 1p 6
Device(config-action-group)#exit
```

Step 3: Configure the standard IP ACL.

#Configure the standard IP ACL numbered 1 on Device.

```
Device(config)#ip access-list standard 1
```

#Configure binding of rules to the L3 action group named LP7 so that the video traffic packets can be remarked to the queue 7.

```
Device(config-std-nacl)#permit host 100.0.0.1 l3-action-group LP7
```

#Configure binding of rules to the L3 action group named LP6 so that the data traffic packets can be remarked to the queue 6.

```
Device(config-std-nacl)#permit host 100.0.0.2 l3-action-group LP6
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

Step 4: Configure applying of the standard IP ACL.

#Apply the standard IP ACL numbered 1 to the ingress direction of port gigabitethernet0/1 of Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip access-group 1 in
Device(config-if-gigabitethernet0/1)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
----------Interface-----Bind-----Instance----------
Interface----------Direction----AclType----AclName
gi0/1                IN         IP        1
```

Step 5: Configure the traffic shaping function.

#Configure queue-based traffic shaping on port gigabitethernet0/2. The traffic rate of the queue 7 is limited to 20000 kbps.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#traffic-shape queue 7 cir 20000 cbs 4096 pir 20000 pbs 4096
```

#Configure queue-based traffic shaping on port gigabitethernet0/2. The traffic rate of the whole port is limited to 50000 kbps.

```
Device(config-if-gigabitethernet0/2)#traffic-shape pir 50000 pbs 4096
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Check the result.

#After video traffic and data traffic are processed by Device, the sum of the video traffic rate and data traffic rate from port gigabitethernet0/2 does not exceed 50000 kbps. If the video traffic rate is greater than 20,000 KBPS, limit the video traffic rate to 20000 kbps. If the video traffic rate is less than 20000 kbps, the remaining bandwidth can be occupied by data traffic.

57.3.4 Configure Rate Limiting

Network Requirements

- There are two servers on the network, namely Video Server and Data Server;
- Configure the rate limiting function to limit the sum of the video traffic rate and data traffic rate to not exceed 50000 kbps with the data traffic rate not exceeding 20000 kbps.

Network Topology

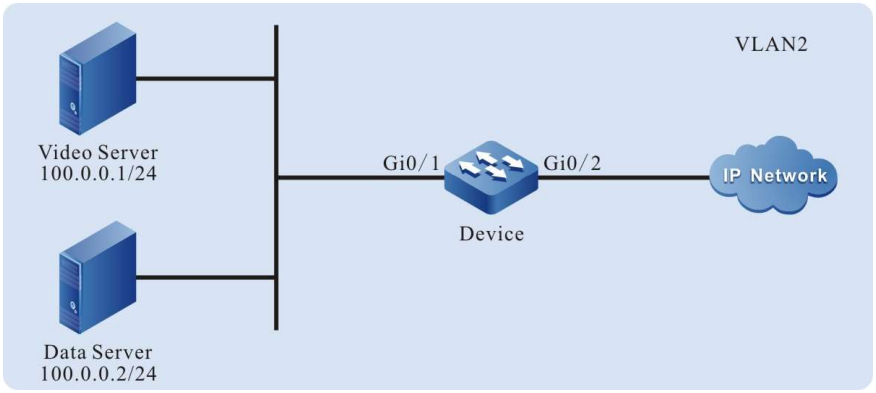


Figure 6 Network Topology for Configuring Rate Limiting

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
```

```
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
```

#Configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 2 to pass.

```
Device(config-if-gigabitethernet0/1)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the rate limiting function.

#Configure queue-based traffic limiting on port gigabitethernet0/1. The traffic rate is limited to 50000 kbps.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#rate-limit default 50000 4096
Device(config-if-gigabitethernet0/1)#exit
```

Step 3: Configure the meter function.

#Configure the traffic meter named data_stream. The traffic rate is limited to 20000 kbps.

```
Device(config)#traffic-meter data_stream
Device(config-meter)#meter mode srtcm 20000 4096 4096
Device(config-meter)#exit
```

Step 4: Configure the egress action group.

#Configure the egress action group named data_stream, and apply the traffic meter in the egress action group.

```
Device(config)#egr-action-group data_stream
Device(config-egract-group)#meter data_stream
Device(config-egract-group)#exit
```

Step 5: Configure the standard IP ACL.

#Configure the standard IP ACL numbered 1 on Device.

```
Device(config)#ip access-list standard 1
```

#Configure binding of rules to the egress action group named data_stream. The data rate is limited to 20000 kbps.

```
Device(config-std-nacl)#permit host 100.0.0.2 egr-action-group data_stream
```

#Configure rules to allow video traffic to pass.

```
Device(config-std-nacl)#permit host 100.0.0.1
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

Step 6: Configure applying of the standard IP ACL.

#Apply the standard IP ACL numbered 1 to the egress direction of port gigabitethernet0/2 of Device.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#ip access-group 1 out
Device(config-if-gigabitethernet0/2)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
----------Interface-----Bind-----Instance--------------
Interface----------------Direction----AclType----AclName
gi0/2                OUT        IP       1
```

Step 7: Check the result.

#After video traffic and data traffic are processed by Device, the sum of the video traffic rate and data traffic rate from port gigabitethernet0/2 does not exceed 50000 kbps with the data traffic rate not exceeding 20000 kbps.

57.3.5 Configure WRED

Network Requirements

- Numerous terminals download files from the FTP server.
- Configure the WRED function on Device to prevent the global synchronization of TCP from causing intermittent FTP connections.

Network Topology

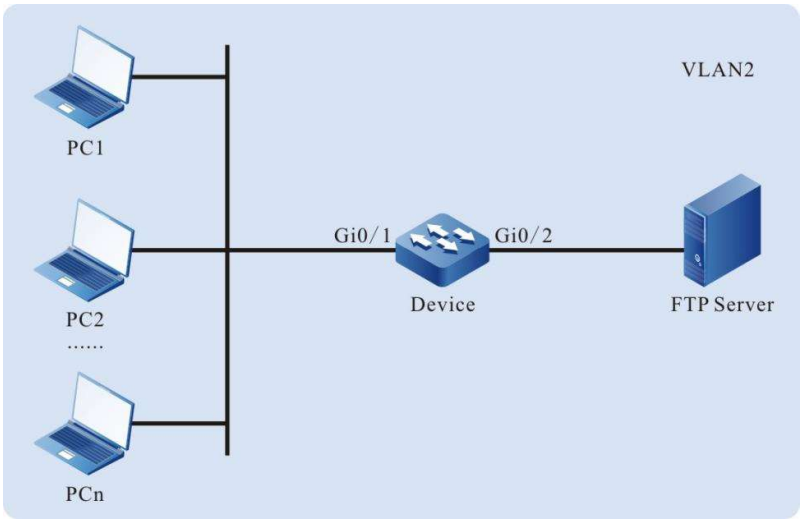


Figure 7 Network Topology for Configuring WRED

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
```

#Configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 2 to pass.

```
Device(config-if-gigabitethernet0/1)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the WRED function.

#Configure the drop-start value of queue 0 packets on port gigabitethernet0/2 to 80, with drop rate of 45.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#drop-mode 0 wred drop-start 80 drop-rate 45 Device(config-if-gigabitethernet0/2)#exit
```

Note

- The packets sent by PC are all Untag packets and enter the queue 0 by default.

Step 3: Check the result.

#When numerous terminals download files from the FTP server, there will be no intermittent connection to FTP.

57.3.6 Configure SP

Network Requirements

- There are authentication server (AAA Server), video server (Video Server) and one terminal device (PC) on the network;
- Configure the SP function to guarantee, when egress port traffic is congested, the traffic of the authentication server first, the video traffic second, and the terminal traffic last.

Network Topology

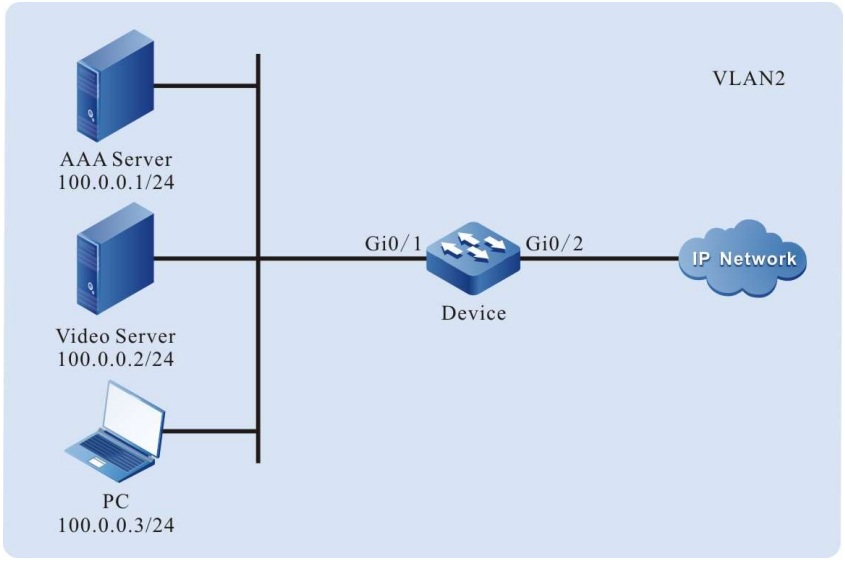


Figure 8 Configuring SP Network Topology

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
```

#Configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 2 to pass.

```
Device(config-if-gigabitethernet0/1)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the L3 action group.

#Configure the L3 action group named LP7. The action is to remark the packets to queue 7.

```
Device(config)#l3-action-group LP7
Device(config-action-group)#remark l2-priority 1p 7
Device(config-action-group)#exit
```

#Configure the L3 action group named LP6. The action is to remark the packets to queue 6.

```
Device(config)#l3-action-group LP6
Device(config-action-group)#remark l2-priority 1p 6
Device(config-action-group)#exit
```

#Configure the L3 action group named LP5. The action is to remark the packets to queue 5.

```
Device(config)#l3-action-group LP5
Device(config-action-group)#remark l2-priority 1p 5
Device(config-action-group)#exit
```

Step 3: Configure the standard IP ACL.

#Configure the standard IP ACL numbered 1 on Device.

```
Device(config)#ip access-list standard 1
```

#Configure binding of rules to the L3 action group named LP7 so that the authentication traffic packets can be remarked to the queue 7.

```
Device(config-std-nacl)#permit host 100.0.0.1 l3-action-group LP7
```

#Configure binding of rules to the L3 action group named LP6 so that the video traffic packets can be remarked to the queue 6.

```
Device(config-std-nacl)#permit host 100.0.0.2 l3-action-group LP6
```

#Configure binding of rules to the L3 action group named LP5 so that the terminal traffic packets can be remarked to the queue 5.

```
Device(config-std-nacl)#permit host 100.0.0.3 l3-action-group LP5
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

Step 4: Configure applying of the standard IP ACL.

#Apply the standard IP ACL numbered 1 to the ingress direction of port gigabitethernet0/1 of Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip access-group 1 in
Device(config-if-gigabitethernet0/1)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
----------Interface-----Bind-----Instance----------
Interface----------Direction----AclType----AclName
gi0/1                IN        IP       1
```

Step 5: Configure the SP function.

#Configure the SP function on port gigabitethernet0/2 to perform strict priority scheduling on packets.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#queue-schedule sp
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Check the result.

#When the traffic of the egress port gigabitethernet0/2 is congested, the authentication traffic is given priority to pass, the video traffic is then allowed to pass, and finally the terminal traffic is allowed to pass.

57.3.7 Configure WDRR

Network Requirements

- There are authentication server (AAA Server), video server (Video Server) and one terminal device (PC) on the network;

- Configure the WDRR function to enable terminal traffic, video traffic, and authentication traffic to pass in a specific ratio when the egress port traffic is congested.

Network Topology

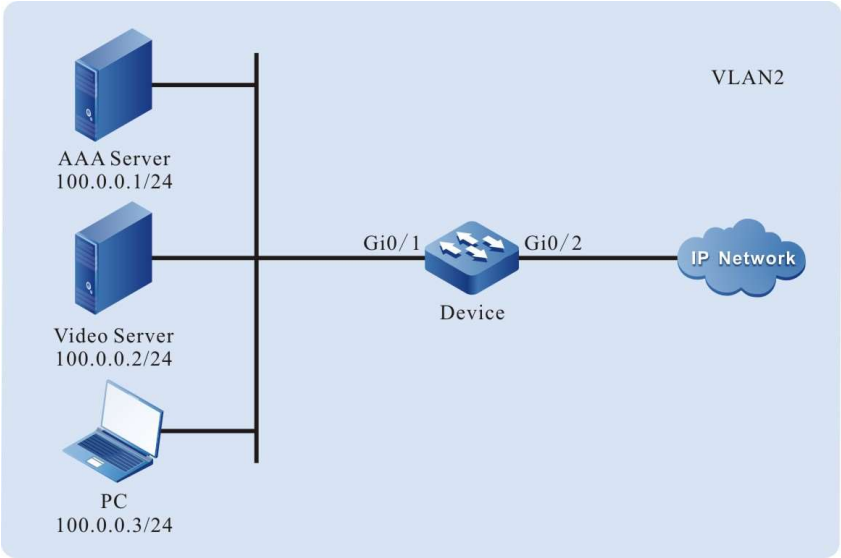


Figure 9 Network Topology for Configuring WDRR

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
```

#Configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 2 to pass.

```
Device(config-if-gigabitethernet0/1)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the L3 action group.

#Configure the L3 action group named LP7. The action is to remark the packets to queue 7.

```
Device(config)#l3-action-group LP7
Device(config-action-group)#remark l2-priority 1p 7
Device(config-action-group)#exit
```

#Configure the L3 action group named LP6. The action is to remark the packets to queue 6.

```
Device(config)#l3-action-group LP6
Device(config-action-group)#remark l2-priority 1p 6
Device(config-action-group)#exit
```

#Configure the L3 action group named LP5. The action is to remark the packets to queue 5.

```
Device(config)#l3-action-group LP5
Device(config-action-group)#remark l2-priority 1p 5
Device(config-action-group)#exit
```

Step 3: Configure the standard IP ACL.

#Configure the standard IP ACL numbered 1 on Device.

```
Device(config)#ip access-list standard 1
```

#Configure binding of rules to the L3 action group named LP7 so that the authentication traffic packets can be remarked to the queue 7.

```
Device(config-std-nacl)#permit host 100.0.0.1 l3-action-group LP7
```

#Configure binding of rules to the L3 action group named LP6 so that the video traffic packets can be remarked to the queue 6.

```
Device(config-std-nacl)#permit host 100.0.0.2 l3-action-group LP6
```

#Configure binding of rules to the L3 action group named LP5 so that the terminal traffic packets can be remarked to the queue 5.

```
Device(config-std-nacl)#permit host 100.0.0.3 l3-action-group LP5
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

Step 4: Configure applying of the standard IP ACL.

#Apply the standard IP ACL numbered 1 to the ingress direction of port gigabitethernet0/1 of Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip access-group 1 in
Device(config-if-gigabitethernet0/1)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
----------Interface-----Bind-----Instance--------------
Interface----------------Direction----AclType----AclName
gi0/1                IN         IP        1
```

Step 5: Configure the WDRR function.

#Configure the WDRR function on port gigabitethernet0/2 to schedule respectively the packets in queues 5, 6, and 7 according to the ratio of 1:2:3.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#queue-schedule wdrr 1 1 1 1 1 1 2 3
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Check the result.

#terminal traffic, video traffic, and authentication traffic pass according to the ratio of 1:2:3 when traffic of the egress port gigabitethernet0/2 is congested; in the case of inconsistent packet byte counts, the terminal traffic, the video traffic, and the authentication traffic pass according to the ratio of (1*authentication packet byte count) : (2*video packet byte count) : (3*terminal packet byte count).

57.3.8 Configure SP+WRR

Network Requirements

- There are authentication server (AAA Server), video server (Video Server) and one terminal device (PC) on the network.
- Configure the SP+WRR function to guarantee that when the traffic of the egress port is congested, all the traffic of the authentication server is given priority to pass, and the terminal traffic and video traffic can pass according to the ratio of 1:2.

Network Topology

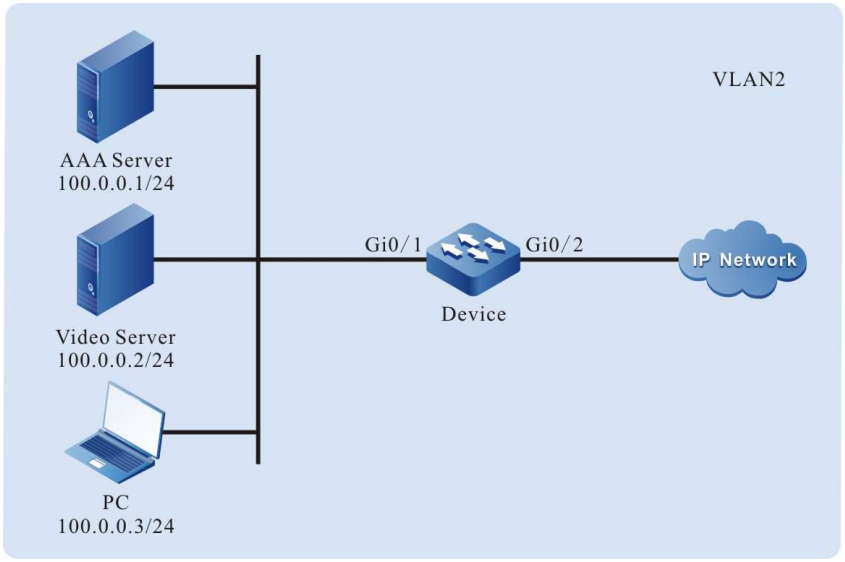


Figure 10 Configuring SP+WRR Network Topology

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
```

#Configure the link type of port gigabitethernet0/2 to Trunk to allow services of VLAN 2 to pass.

```
Device(config-if-gigabitethernet0/1)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode trunk
Device(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure the L3 action group.

#Configure the L3 action group named LP7. The action is to remark the packets to queue 7.

```
Device(config)#l3-action-group LP7
Device(config-action-group)#remark l2-priority 1p 7
Device(config-action-group)#exit
```

#Configure the L3 action group named LP6. The action is to remark the packets to queue 6.

```
Device(config)#l3-action-group LP6
Device(config-action-group)#remark l2-priority 1p 6
Device(config-action-group)#exit
```

#Configure the L3 action group named LP5. The action is to remark the packets to queue 5.

```
Device(config)#l3-action-group LP5
Device(config-action-group)#remark l2-priority 1p 5
Device(config-action-group)#exit
```

Step 3: Configure the standard IP ACL.

#Configure the standard IP ACL numbered 1 on Device.

```
Device(config)#ip access-list standard 1
```

#Configure binding of rules to the L3 action group named LP7 so that the authentication traffic packets can be remarked to the queue 7.

```
Device(config-std-nacl)#permit host 100.0.0.1 l3-action-group LP7
```

#Configure binding of rules to the L3 action group named LP6 so that the video traffic packets can be remarked to the queue 6.

```
Device(config-std-nacl)#permit host 100.0.0.2 l3-action-group LP6
```

#Configure binding of rules to the L3 action group named LP5 so that the terminal traffic packets can be remarked to the queue 5.

```
Device(config-std-nacl)#permit host 100.0.0.3 l3-action-group LP5
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

Step 4: Configure applying of the standard IP ACL.

#Apply the standard IP ACL numbered 1 to the ingress direction of port gigabitethernet0/1 of Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip access-group 1 in
Device(config-if-gigabitethernet0/1)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
----------Interface-----Bind-----Instance----------
Interface----------Direction----AclType----AclName
gi0/1              IN       IP       1
```

Step 5: Configure the SP+WRR function.

#Configure the SP+WRR function on port gigabitethernet0/2 to allow all the packets in the queue 7 to pass. The packets in the queue 5 and queue 6 are scheduled according to the ratio of 1:2.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#queue-schedule wrr 1 1 1 1 1 1 2 0
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Check the result.

#All the authentication traffic is given priority to pass when the traffic of the egress port gigabitethernet0/2 is congested. The terminal traffic and the video traffic pass in the ratio of 1:2.

57.3.9 Configure Flow Mirror

Network Requirements

- PC 1, PC 2, and PC 3 are connected to Device, and PC 1 and PC 2 communicate in VLAN 2;
- Configure the flow mirror function on Device, so that PC 3 monitors packets received by Device port gigabitethernet0/1.

Network Topology

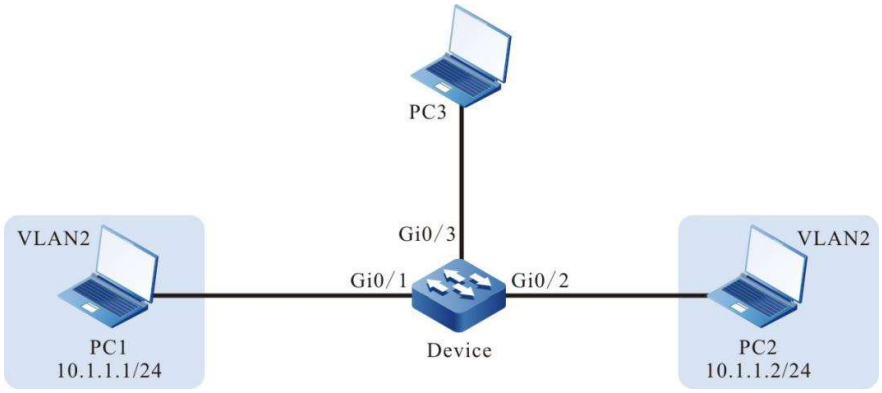


Figure 11 Network Topology for Configuring Flow Mirror

Configuration Steps

Step 1: Configure VLANs and the link type of the ports.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 on Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1-0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure the flow mirror function.

#Configure the L3 action group named mirror to mirror the packets to port gigabitethernet0/3.

```
Device(config)#l3-action-group mirror
Device(config-action-group)#mirror interface gigabitethernet 0/3
Device(config-action-group)#exit
```

Step 3: Configure the counter function.

#Configure the egress action group named count to count the packets.

```
Device(config)#egr-action-group count
Device(config-egract-group)#count all-colors
Device(config-egract-group)#exit
```

Step 4: Configure the standard IP ACL.

#Configure the standard IP ACL numbered 1 on Device.

```
Device(config)#ip access-list standard 1
```

#Configure binding of rules to the L3 action group named mirror so that all the packets can be mirrored to the port gigabitethernet0/3.

```
Device(config-std-nacl)#permit any l3-action-group mirror
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

#Configure the standard IP ACL numbered 2 on Device.

```
Device(config)#ip access-list standard 2
```

#Configure binding of rules to the egress action group named count so that all the packets can be counted.

```
Device(config-std-nacl)#permit any egr-action-group count
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

Step 5: Configure applying of the standard IP ACL.

#Apply the standard IP ACL numbered 1 to the ingress direction of port gigabitethernet0/1 of Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip access-group 1 in
Device(config-if-gigabitethernet0/1)#exit
```

#Apply the standard IP ACL numbered 2 to the egress direction of port gigabitethernet0/3 of Device.

```
Device(config)#interface gigabitethernet 0/3
Device(config-if-gigabitethernet0/3)#ip access-group 2 out
Device(config-if-gigabitethernet0/3)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
----------Interface-----Bind-----Instance--------------
Interface----------------Direction----AclType----AclName
gi0/1                IN         IP        1
gi0/3                OUT        IP        2
```

Step 6: Check the result.

#When PC 1 and PC 2 communicate with each other, the packets received on port gigabitethernet0/1 can be captured on PC 3.

#View on the Device, the count of the packets counted by the counter.

```
Device#show traffic-count inst-interface gigabitethernet 0/3 ip-out
Interface            Instance_type              Acl_name                  Frame_gap
gigabitethernet0/3   Ip Acl Bind Interface Out  2                         No
---------------------------------------------------------------------------
seq                :                    10
counter_mode       :                    count all color
all packets number :                    5
  all packets byte :                    640
---------------------------------------------------------------------------
```

It is indicated that there are 5 packets in the egress direction of port gigabitethernet0/3.

58 ARP Check

58.1 Overview

ARP Check is used to check the legality of ARP packets so as to prevent illegal ARP packets from passing and improve network security.

The legality of ARP packets is checked according to the entries bound to the port, including the two types below:

Static binding entries manually configured;

Dynamic binding entries, dynamically generated by the valid entries of DHCP Snooping function and 802.1 function.

The specific detection principle of ARP Check is shown below:

For the ARP packets received by the port, if the IP address of sending end and source MAC address fully match the entries bound to the ARP Check of the port upon check, these ARP packets are legal and forwarded; otherwise, they are illegal and discarded.

58.2 ARP Check Function Configuration

Table 58-1 ARP Check Function Configuration List

Configuration Task	
Enable ARP Check Function of the Port	Enable ARP Check Function of the Port
Configure Binding Static Entries of ARP Check	Configure Binding Static Entries of ARP Check
Configure to Reinstall the Entries Failed in Writing Hardware	Configure to Reinstall the Entries Failed in Writing Hardware

58.2.1 Enable ARP Check Function of the Port

Configuration Condition

None

Enable ARP Check Function of the Port

After enabling the ARP Check function of the port, ARP Check will dynamically obtain entries from the DHCP Snooping database and write ACL hardware.

Table 58-1 Configuring to Enable ARP Check Function of the Port

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable ARP check function of the port	**arp-check enable**	Mandatory By default, the ARP Check function of the port is disabled.

58.2.2 Configure Binding Static Entries of ARP Check

Configuration Condition

None

Configure Binding Static Entries of ARP Check

Table 58-3 Configuring Binding Static Entries of ARP Check

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure Binding Static Entries of ARP Check	**arp-check binding** *mac-address ip-address* **rate** *limit-value*	Mandatory By default, no static binding entry of ARP Check is configured.

58.2.3 Configure to Reinstall the ARP Check Entries Failed in Writing Hardware

Configuration Condition

None

Configure to Reinstall the ARP Check Entries Failed in Writing Hardware

Table 58-4 Configuring to Reinstall ARP Check Entries Failed in Writing Hardware

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		effect only within the aggregation group.
Configure to reinstall the ARP Check entries failed in writing hardware	**arp-check install**	Mandatory By default, the ARP Check entries failed in writing hardware are not reinstalled on the port.

58.2.4 ARP Check Monitoring and Maintaining

Table 58-5 ARP Check Monitoring and Maintaining

Command	Description
show arp-check [**active** | **brief** | **inactive** | **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	A command used to show the information in ARP Check entries

58.3 Typical Configuration Example of ARP Check

58.3.1 Configure Basic Functions of ARP Check

Network Requirements

- PC1 and PC2 access IP network through the Device;
- Configure the basic functions of ARP Check so that PC1 instead of PC2 can normally access the IP Network.

Network Topology

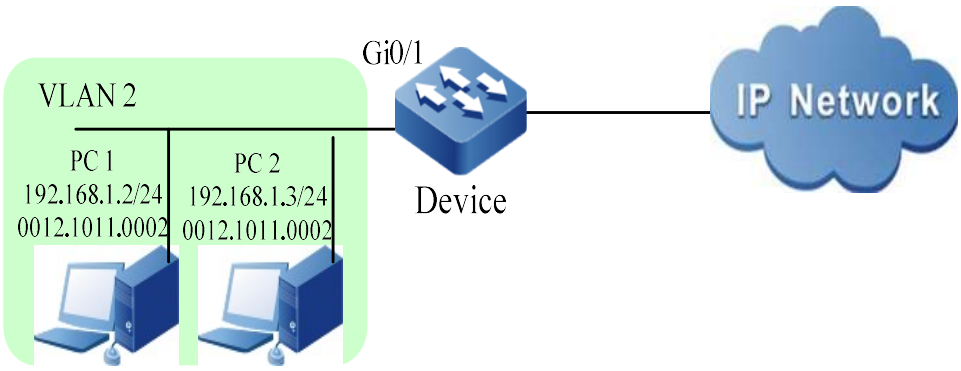


Figure 1 Network

Topology for Configuring Basic Functions of ARP Check

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 2: Configure ARP Check function on the Device.

#Enable the ARP Check function on port gigabitethernet0/1, and configure ARP Check binding entries with MAC address of 0012.1011.0002 and IP address of 192.168.1.2.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#arp-check enable
Device(config-if-gigabitethernet0/1)#arp-check binding 0012.1011.0002 192.168.1.2 rate 10
Device(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#View ARP Check-related configuration information.

```
Device#show arp-check brief
------------------------------------------------------------
Interface Name      Status    Binding Table
------------------------------------------------------------
gi0/1               Enable    Yes
```

It is indicated that the port gigabitethernet0/1 has enabled the ARP Check function and has ARP Check entries.

View ARP Check binding entries of the port.

```
Device#show arp-check interface gigabitethernet0/1
--------------------------ARP Check Table-----------------------------------
Interface-Name  Status  MAC-Address  IP-Address  Rate  PolicySource   SetHardware
------------------------------------------------------------------------------
gi0/1           enable  0012.1011.0002  192.168.1.2  10   STATIC        active
total number: 1
```

#PC1 instead of PC2 can normally access the IP Network.

58.3.2 Combination of ARP Check with DHCP Snooping

Network Requirements

- PC1 which uses static IP address and PC2 which obtains IP address through DHCP access the IP Network through the Device;
- Configure DHCP Snooping and ARP Check function for the Device so that PC2 instead of PC1 can normally access the IP Network.

Network Topology

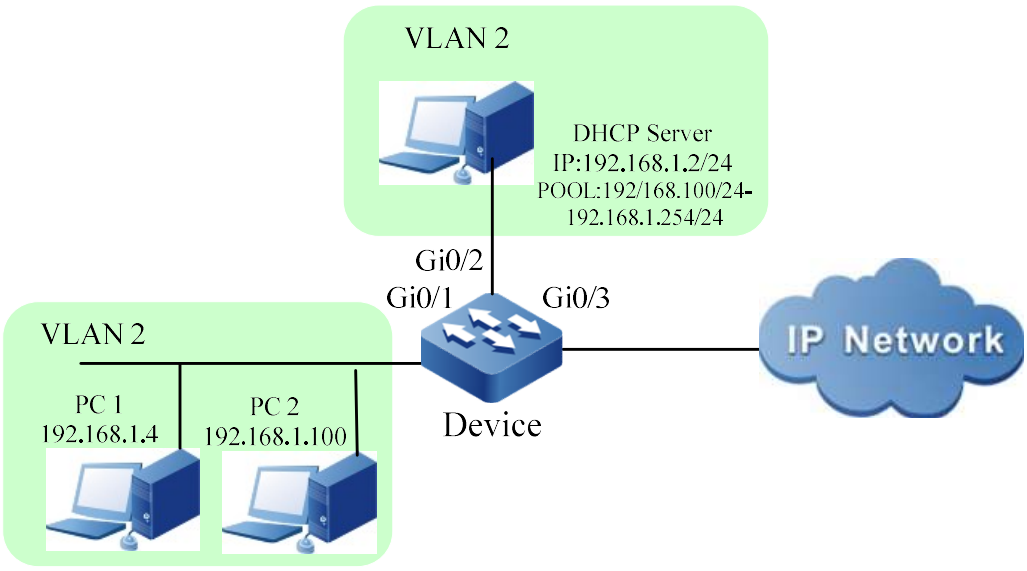


Figure 2 Network Topology for Combination of ARP Check and DHCP Snooping

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of the ports gigabitethernet0/1, gigabitethernet0/2 and gigabitethernet0/3 as Access, permitting the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1-0/3
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure DHCP Snooping function on the Device.

#Enable the DHCP Snooping function and configure gigabitethernet0/2 as a trusted port.

```
Device(config)#dhcp-snooping
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dhcp-snooping trust
Device(config-if-gigabitethernet0/2)#exit
```

Step 3: Configure ARP Check function on the Device.

#Enable the ARP Check function on the port gigabitethernet0/1.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#arp-check enable
Device(config-if-gigabitethernet0/1)#exit
```

Step 4: Check the result.

#After PC2 successfully obtains the IP address, view the dynamic entries of DHCP Snooping on the Device.

```
Device#show dhcp-snooping database
    dhcp-snooping database:
    database entries count:1
    database entries delete time :300
    ---------------------------------
    macAddr        ipAddr         transtion-id    vlan  interface          leaseTime(s)    status
    0013.0100.0001  192.168.1.100  2              2     gi0/1              107990          active
     ------
```

#View ARP Check binding entries of the port gigabitethernet0/1.

```
Device#show arp-check interface gigabitethernet0/1
---------------------------ARP Check Table-----------------------------------

Interface-Name  Status  MAC-Address  IP-Address  Rate  PolicySource   SetHardware
-------------------------------------------------------------------------------
gi0/1          enable  0013.0100.0001 192.168.1.100  15   DHCPSP        active
total number: 1
```

#PC2 instead of PC1 can normally access the IP Network.

58.3.3 Combination of ARP Check with 802.1X

Network Requirements

- PC1 accesses IP network through the Device which uses 802.1X access control;
- RADIUS authentication is used as an authentication method;
- PC1 cannot access network without successful authentication. It is permitted to access the IP Network once it passes the authentication;
- After the successful authentication, users can generate ARP Check entries to check the legality of their ARP packets.

Network Topology

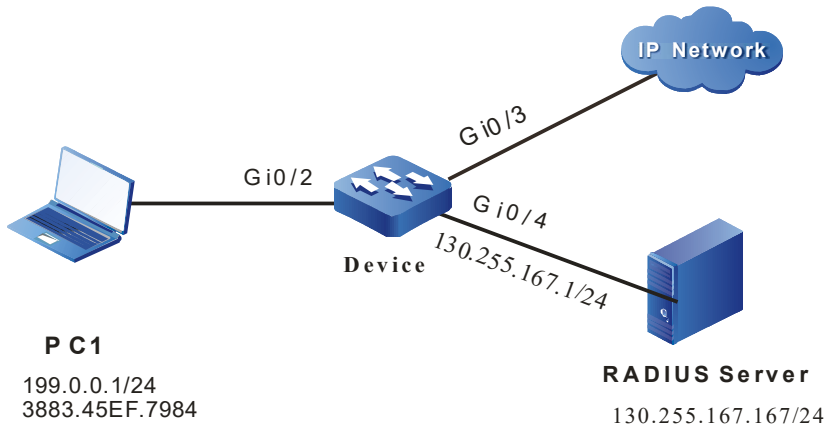


Figure 1-3 Network Topology for Combination of ARP Check and 802.1X

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN2~VLAN4 on the Device.

```
Device#configure terminal
Device(config)#vlan 2-4
Device(config)#exit
```

#Configure the link type of the port gigabitethernet 0/2 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport access vlan 2
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the link type of the ports gigabitethernet 0/3~gigabitethernet 0/4 on the Device as Access, allowing the services of VLAN3~VLAN4 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN4 as 130.255.167.1/24.

```
Device(config)#interface vlan 4
Device(config-if-vlan4)#ip address 130.255.167.1 255.255.255.0
Device(config-if-vlan4)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
Device(config-isp-system)#aaa authentication dot1x radius-group radius
```

```
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure 802.1X authentication.

#Enable 802.1X authentication on the port and configure the authentication mode as Macbased.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x port-control enable
Device(config-if-gigabitethernet0/2)#authentication port-method macbased
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Configure ARP Check function on the Device.

#Enable the ARP Check function on the port gigabitethernet0/2.

```
Device(config)#interface gigabitethernet 0/2

Device(config-if-gigabitethernet0/2)#arp-check enable

Device(config-if-gigabitethernet0/2)#exit
```

Step 7: Authentication succeeds.

#Before passing the authentication, PC1 cannot access the network.

#After PC1 users initiate authentication and the authentication succeeds, PC1 can access the IP network.

```
Device#show dot1x user
--------------------
NO 1   : MAC_ADDRESS= 3883.45ef.7984  STATUS=      Authorized        USER_NAME=   admin
       VLAN=       2              INTERFACE=   gi0/2              USER_TYPE=   DOT1X
       AUTH_STATE=  AUTHENTICATED   BACK_STATE=  IDLE           IP_ADDRESS=  199.0.0.1
       IPV6_ADDRESS= Unknown

       Online time: 0 week 0 day 0 hours 0 minute 51 seconds

 Total: 1    Authorized: 1   Unauthorized/guest/critical: 0/0/0   Unknown: 0
```

Step 8: Check the result.

```
Device#show arp-check interface gigabitethernet0/2

--------------------------ARP Check Table-----------------------------------

Interface-Name  Status  MAC-Address  IP-Address  Rate  PolicySource    SetHardware

-------------------------------------------------------------------------------

gi0/2           enable   3883.45ef.7984 199.0.0.1   15    DOT1X        active
```

total number: 1

#If the APR packets and entries sent by PC1 can be fully matched, they can be normally forwarded and limited in speed; otherwise, they will be directly discarded.

59 CPU Protection

59.1 Overview

There are lots of protocol packets in the device that need to be sent to CPU for processing and we need to specify the queue for each kind of protocol packets. The CPU protection function classifies the protocol packets sent to CPU and the packets enter different CPU queues according to the different protocol priorities. We can set the rate limitation of each queue.

The device totally has eight queues, numbering from 0 to 7. They adopt the strict priorities. The smaller the number is, the lower the priority is. That is to say, the priority of queue 0 is the lowest and the priority of queue 7 is the highest. The packets in the queue with the high priority are earlier sent to the CPU for processing that the packets in the queue with low priority. We can specify them to different priorities of queues according to the importance of each kind of packets, ensuring that the important packets are first sent to the CPU for processing.

Meanwhile, the device can perform the rate limitation for the packets entering each CPU queue, preventing the vicious protocol packet attack in the network from causing the too high CPU utilization of the device and resulting in the abnormal running of the device.

59.2 Configure CPU Protection Function

Table 2-1 CPU Protection Function Configuration List

Configuration Task	
Configure CPU Queue of Protocol Packets	Configure CPU Queue of Protocol Packets
Configure Rate Limitation of CPU Queue	Configure Total Rate Limitation of All CPU Queues
	Configure Rate Limitation of Each CPU Queue

Configuration Task	
Make Users' Custom Protocol Packets Delivered to CPU for Processing	Configure the Match Rules of Delivering Users' Custom Protocol Packets to CPU for Processing
	Configure the Method of Delivering Users' Custom Protocol Packets to CPU for Processing

59.2.1 Configure CPU Queue of Protocol Packets

Configuration Condition

None

Configure CPU Queue of Protocol Packets

The device has 8 CPU queues. Users can configure to make different protocol packets enter different queues. The device can deliver protocol packets to CPU for processing by the priority of queues from high to low according to user's configuration. The protocol packets in the queue with a high priority will be first delivered to CUP for processing. Users can specify important packets to enter the queue with a high priority so that they can be first delivered to CUP for processing. By default, different protocol packets enter default CPU queues or the specified CPU queue through a command.

Table 2-2 Configuring CPU Queue of Protocol Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure CPU Queue of Protocol Packets	**cpu-packet** *protocol* **cos** *cos-value*	Mandatory By default, different protocol packets enter their default CPU queue.

59.2.2 Configure Total Rate Limitation of All CPU Queues

Configuration Condition

None

Configure Total Rate Limitation of All CPU Queues

Malicious network attack will make the device unable to operate due to a very high CPU utilization rate. In order to prevent this, users can configure the total rate limitation of all CPU queues. If any attack occurs, and the total packet rate of all the queues exceeds the total rate limitation, the packets will be discarded to avoid a very high CPU utilization rate.

Table 2-3 Configuring Total Rate Limitation of All CPU Queues

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Total Rate Limitation of All CPU Queues	**cpu-packet cos global pps** *pps-value*	Mandatory By default, the total rate limit of all queues is 2000PPS.

59.2.3 Configure Rate Limitation of Each CPU Queue

Configuration Condition

None

Configure Rate Limitation of Each CPU Queue

Malicious network attack will make the device unable to operate due to a very high CPU utilization rate. In order to prevent this, users can configure the rate limitation of each CPU queue. If any attack occurs, and the packet rate in the queue exceeds the rate limit of this queue, the packets will be discarded to avoid a very high CPU utilization rate. By default, different rate limits are set for different CPU queues. Users may modify the rate limit as needed.

Table 2-4 Configuring Rate Limitation of Each CPU Queue

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Rate Limitation of Each CPU Queue	**cpu-packet cos** *cos-value* **pps** *pps-value*	Mandatory By default, each queue has a unique rate limit.

59.2.4 Make Users' Custom Protocol Packets Delivered to CPU for Processing

Configuration Condition

None

Configure the Match Rules of Delivering Users' Custom Protocol Packets to CPU for Processing

The match rules of delivering users' custom protocol packets to CPU for processing must be used with the method of delivering users' custom protocol packets to CPU for processing. It will conduct corresponding action processing for the packets meeting the match rules. The match rules include dst-mac (destination MAC address), ingress (interface), vlan-id (VLAN number), ether-type (ether type), IP (IPV4), IPV6, 0x0000 (custom Ethernet type), Ip-protocol (IP protocol, such as IGMP and TCP), dst-ip (destination IP), src-port (source port), and dst-port (destination port). Users can combine the match rules mentioned above as needed.

Table 2-5 Configuring the Match Rules of Delivering Users' Custom Protocol Packets to CPU

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the rules of matching users' custom protocol packets	**cpu-packet user-define** *user-id* **match** { **dst-mac** *dst-mac* | **ether-type** { *ether-type-value* | **ip** [**dst-ip** *dst-ip-address* | **dst-mac** *dst-mac* | **ingress** *ingress-interface* | **ip-protocol** *protocol-type* | **vlan-id** *vlan-id* [**dst-ip** *dst-ip-address* | **ingress** *ingress-interface* | **ip-protocol** *protocol-type*]] | **ipv6** [**dst-ip6** *dst-ipv6-address* | **dst-mac** *dst-mac* / **ingress** *ingress-interface* | **ip-protocol** *protocol-type* | **vlan-id** *vlan-id* [**dst-ip** *dst-ip-address* | **ingress** *ingress-interface* | **ip-protocol** *protocol-type*]] } | **ingress** *ingress-interface* |	Mandatory By default, there are no match rules.

Step	Command	Description
	vlan-id *vlan-id* [**ingress** *ingress-interface*] }	

Configure the Method of Delivering Users' Custom Protocol Packets to CPU for Processing

The match rules of delivering users' custom protocol packets to CPU for processing must be used with the method of delivering users' custom protocol packets to CPU for processing. It will conduct corresponding action processing for the packets meeting the match rules. For example, if the configuration method is copy, the original forwarding process of the packets will not be changed. Instead, the packets will be delivered to CPU for processing by copying. If the configuration method is drop, the packets are not permitted to be delivered to CPU for processing, but discarded. If the configuration method is remark, the priority of delivering packets to CPU for processing is modified. If the configuration method is trap, the original forwarding process of packets is changed. The packets are delivered to CPU for processing instead of being forwarded.

Table 2-6 Configuring Method of Delivering Users' Custom Protocol Packets to CPU

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the Method of Delivering Users' Custom Protocol Packets to CPU for Processing	**cpu-packet user-define** *user-id* **action** { **drop** | { **copy** | **remark** | **trap** } **cos** *cos-value* }	Mandatory By default, no action processing is conducted for the packets meeting the match rules. When the method of delivering users' custom protocol packets to CUP for processing is copy, remark or trap, the cos value can be specified.

59.2.5 CPU protection Monitoring and Maintaining

Table 2-7 CPU Protection Monitoring and Maintaining

Command	Description
show cpu-packet protocol-config-table	Show the configuration information of delivering all protocol packets to CPU
show cpu-packet cos	Show current and default queue information of delivering protocol packets to CPU for processing
show cpu-packet pps	Show the rate limitation information of each CPU queue
show cpu-packet udf-table	Show the information of users' all custom ACL entries set through CPU protection module

59.3 Typical Configuration Example of CPU Protection

59.3.1 Configure Basic Functions of CPU Protection

Network Requirements

- PC can access IP Network through the Device.
- Make SVI-IP packets enter queue 5 on the Device so that the SVI-IP packets reaching the device can be first processed by CPU.
- Limit the rate of the ARP queue on the Device so that the packets with a low priority can be normally processed even if the Device has a very high CPU utilization rate.

Network Topology

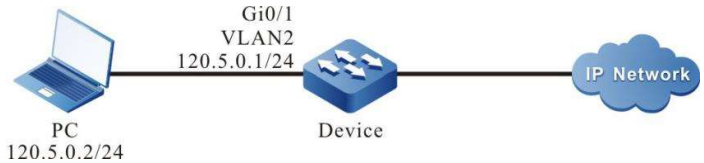


Figure 2-1 Network Topology for Configuring Basic Functions of CPU Protection

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure CPU queue of SVI-IP packets.

#Make SVI-IP packets enter queue 5 on the Device.

```
Device#configure terminal
Device(config)#cpu-packet svi-ip cos 5
```

Step 4: Configure rate limitation of CPU queue.

#Configure the rate limit of CPU queue as 50pps on the Device.

```
Device(config)#cpu-packet cos 1 pps 50
```

Step 5: Check the result.

#View the CPU queue of each protocol packet on the Device.

```
Device#show cpu-packet cos
Type                    Current-CoS    [Default-CoS]
-------------------------------------------------------------
random                    0            [0]
ipv6-all                  0            [0]
pppoe                     0            [0]
udp-broadcast             0            [0]
icmp                      0            [0]
ip-e-packet               0            [0]
ip                        0            [0]
mpls-unicast              0            [0]
mpls-multicast            0            [0]
LBD_l2-src-miss           0            [0]
ipaddr-0                  0            [0]
ipaddr-127                0            [0]
ipv4-all                  0            [0]
src-martian-addr          0            [0]
arp                       1            [1]
ip6-solicited-node        1            [1]
host-group                1            [1]
router-group              1            [1]
ND                        1            [1]
trill-oam                 1            [1]
rarp                      1            [1]
lldp                      2            [2]
dot1x                     2            [2]
dhcp                      2            [2]
dhcpv6                    2            [2]
http                      2            [2]
svi-ip                    5            [2]
vxlan                     2            [2]
pim                       3            [3]
pim6                      3            [3]
igmp-dvmrp                3            [3]
ip6-interface-multicast   3            [3]
ike                       3            [3]
ntp                       3            [3]
mld                       3            [3]
rsvp                      4            [4]
ospf                      4            [4]
ospfv3                    4            [4]
```

```
irmp                    4           [4]
rip                     4           [4]
ripng                   4           [4]
is-is                   4           [4]
bgp                     4           [4]
ldp                     4           [4]
ipsec-esp               4           [4]
ipsec-ah                4           [4]
mlag-keep-alive         4           [4]
mvst                    5           [5]
l2-interface-unicast    5           [5]
gvrp                    5           [5]
mvst-inspection         5           [5]
ulfd                    5           [5]
l2pt                    5           [5]
svi-icmp                5           [5]
ethernet-cfm            5           [5]
ethernet-lmi            5           [5]
mlag-pts                5           [5]
mpls-oam                5           [5]
bfd                     6           [6]
vbrp                    6           [6]
vrrp                    6           [6]
vrrp3                   6           [6]
telnet                  6           [6]
ssh                     6           [6]
loopback-detect         6           [6]
slow-protocols          6           [6]
stp-bpdu                6           [6]
stp-vist                6           [6]
radius-tacacs           6           [6]
trill                   6           [6]
bfdv6-echo              6           [6]
eips                    7           [7]
ulpp                    7           [7]
mad-fast-hello          7           [7]
erps                    7           [7]
mlag                    7           [7]
```

It is indicated that the CPU queue of SVI-IP on the Device is changed from the default queue 2 to queue 5.

#View the rate limit of each queue on the Device.

```
Device#show cpu-packet pps
CoS   Current-PPS   [Default-PPS]
-----------------------------------
0    200         [200]
1    50          [250]
2    500         [500]
3    600         [600]
4    1000        [1000]
5    400         [400]
6    300         [300]
7    100         [100]
TOTAL 2000       [2000]
```

It is indicated that the rate limit of queue 1 where ARP is located on the Device is changed from the default 250pps to 50pps.

59.3.2 Configure Custom rules of CPU Protection

Network Requirements

- Device is directly connected to PC1 and PC2 respectively.

- Configure the custom rules of CPU protection on the Device, and make the packets meeting the match conditions delivered to CPU for processing through trap and enter corresponding queue.

Network Topology

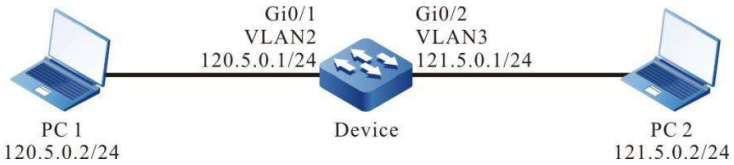


Figure 2-2 Network Topology for Configuring Custom Rules of CPU Protection

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure custom rules of CPU protection.

#Configure the custom rules of CPU protection, and make the packets with a destination address of 121.5.0.2 delivered to CPU for processing in trap mode and set the COS value as 5.

```
Device#configure terminal
Device(config)#cpu-packet user-define 1 match ether-type ip dst-ip host 121.5.0.2
Device(config)#cpu-packet user-define 1 action trap cos 5
```

Step 4: Check the result.

#View custom rules on the Device.

```
Device#show cpu-packet udf-table
user-define 1
 ether-type: 0x0800(IPv4)
 dst-ip: host 121.5.0.2
 location: global
 valid: yes
 action: trap
 CoS: 5
```

#When PC1 accesses PC2, the custom rules of CPU protection take effect. The packets with a destination address of 121.5.0.2 on the Device are delivered to CPU for processing in trap mode and enter queue 5.

Note

1) Please see this configuration when the custom rules match other conditions and execute other methods.

60 Port Security

60.1 Overview

60.1.1 Introduction

Port security is a security mechanism used to control the device assessed to the network. Generally applied in the access layer, it can limit the host using device ports and permits some specific hosts to access the network only.

The port security function flexibly binds four elements of the user, i.e. MAC address, IP address, VLAN ID, and port number, to prevent illegal users from accessing the network. This can ensure the network data are secure and valid users have enough bandwidth.

60.1.2 Port Security Rules

Port security rules can be classified into four types:

MAC rules: They control whether the host can communicate according to its MAC address. Their binding methods include MAC binding, MAC+VLAN binding, MAC+IP binding, and MAC+IPv6 binding;

IP rules: They control whether the host can communicate according to its IP address. IP rules can be bound to a single IP address or an IP address segment;

IPv6 rules: They control whether the host can communicate according to its IPv6 address. IPv6 rules can be bound to a single IPv6 address or an IPv6 address segment;

MAX rules: They control the communication of the host by limiting the number of MAC address entries that the port can freely learn. They don't include the legal MAC address entries generated by MAC rules, IP rules and IPv6 binding;

STICKY rules: They control whether the host can communicate according to its MAC address. Their binding methods include MAC binding, MAC+VLAN binding, MAC+IP binding, and MAC+IPv6 binding. STICKY rules can be both automatically learned and manually configured. They are saved in running configuration. If the running configuration is saved prior to restarting the device, these STICKY rules can take effect automatically after the device is restarted. When the STICKY function is enabled under the port and the

STICKY learning mode is MAC, the dynamic MAC entries learned by the MAX rules will be transformed into STICKY rules and saved in the running configuration;

VOICE VLAN rules: They control the communication of the host by identifying whether the MAC address belongs to the OUI configured by VOICE-VLAN. They don't include the legal MAC address entries generated by MAC rules, IP rules and IPv6 binding.

60.1.3 Working Principle of Port Security

If only port security is enabled, the port security will discard all the packets received on the port. The port security rules are triggered by the ARP packets and IP packets of the terminal device. When the device receives the ARP packets and IP packets, the port security extracts packet information from them, and matches them with the configured rules. The matching order is shown below: MAC rules, STICKY rules, IP rules, and MAX rules. It controls the layer-2 forwarding table of the port according to the matching result so as to control the port's behavior of forwarding packets. If the packets that match MAX rules or STICKY rules are legal, they will be forwarded. For the packets that match MAC rules or IP rules, if the action performed by the rule on the packet is permit, then the packet is legal and will be forwarded; otherwise, the packet is illegal and will be discarded.

For the MAC rules and IP rules with the action of permit, after they take effect, their corresponding MAC address is written into the layer-2 forwarding table so that the packets matching the rules can be forwarded in layer 2. For the MAC rules and IP rules with the action of reject, their corresponding MAC is not written into the layer-2 forwarding table, and the packets need to be discarded through port security.

After MAX rules and STICKY rules take effect, they are written into the MAC address entries to form valid entries so that the packets can be forwarded in layer 2. IPv6 packets are processed in similar ways.

60.2 Port Security Function Configuration

Table 60 Basic Function Configuration List of Port Security

Configuration Task	
Configure Basic Functions of Port Security	Enable Port Security Function
Configure Port Security Rules	Configure MAC Rules
	Configure IP Rules
	Configure IPv6 Rules
	Configure MAX Rules
	Configure STICKY Rules

Configuration Task	
	Configure VOICE VLAN Rules
Configure STICKY Rules Learning Mode	Configure STICKY Rules Learning Mode
Configure Static MAC Address Aging Function	Enable Static MAC Address Aging Function
	Configure Static MAC Address Aging Time
Configure Processing Mode After Receiving Illegal Packets	Configure Processing Mode After Receiving Illegal Packets
Configure Log Sending Interval After Receiving Illegal Packets	Configure Log Sending Interval After Receiving Illegal Packets
Configure Port Security to Use ACL Function	Configure Port Security to Use ACL Function

60.2.1 Configure Basic Functions of Port Security

In the various configuration tasks of port security, you must first enable port security so that the configuration of the other function features can take effect.

Configuration Condition

None

Enable Port Security Function

After port security is enabled, if no port security rule is configured, the port cannot learn MAC address.

Table 1 Configuring Basic Functions Port Security

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enable Port Security Function	**port-security enable**	Mandatory By default, the port security function is not enabled.

Note

- The IP rules and MAX rules of port security cannot be used with 802.1x on the same port.
- The IP rules and MAX rules of port security cannot be used with MAC address authentication on the same port.
- Port security cannot be used with the secure channel authentication function on the same port.
- Port security cannot be used with DAI (Dynamic ARP Inspection) on the same port.

60.2.2 Configure Port Security Rules

Configuration Condition

Before configuring port security rules, ensure that:

- Enable the port security function.

Configure MAC Rules

To control the communication of a terminal with MAC address, users may use MAC rules. The packets of the rules matching the action of permit can be forwarded, while those of the rules matching the action of reject will be discarded.

Table 2 Configuring MAC Rules

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure MAC rules with the action of permit	**port-security permit mac-address** *mac-address-value* [**desc** *security-rule-description* **| ip-address** *ip-address-value* [**desc** *security-rule-description*] | **ipv6-address** *ipv6-address-value* [**desc** *security-rule-description*] **| vlan-id** *vlan-id* [**desc** *security-rule-description*]]	At least one option must be selected. By default, MAC rules are not configured under the port.
Configure MAC rules with the action of reject	**port-security deny mac-address** *mac-address-value* [**ip-address** *ip-address-value* | **ipv6-address** *ipv6-address-value* **| vlan-id** *vlan-id*]	

Configure IP Rules

To control the communication of a terminal with IP address, users may use IP rules. The packets of the rules matching the action of permit can be forwarded, while those of the rules matching the action of reject will be discarded.

Table 3 Configuring IP Rules

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure IP rules with the action of permit	**port-security permit ip-address** *ip-address-value* [**to** *ip-address-value*]	At least one option must be selected. By default, IP rules are not configured under the port.
Configure IP rules with the action of reject	**port-security deny ip-address** *ip-address-value* [**to** *ip-address-value*]	

Configure IPv6 Rules

To control the communication of a terminal with IPv6 address, users may use IP rules. The packets of the rules matching the action of permit can be forwarded, while those of the rules matching the action of reject will be discarded.

Table 4 Configuring IPv6 Rules

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure IPv6 rules with the action of permit	**port-security permit ipv6-address** *ipv6-address-value* [**to** *ipv6-address-value*]	At least one option must be selected. By default, IPv6 rules are not configured under the port.
Configure IPv6 rules with the action of reject	**port-security deny ipv6-address** *ipv6-address-value* [**to** *ipv6-address-value*]	

Note

Port security provides secure access in the data link layer. For the IPv6 rules currently supported like MAC+IPv6 and IPv6, once corresponding valid entries are generated, subsequent packets can be normally forwarded only if they match the MAC+VLAN entries that have been generated. Their IPv6 addresses are not checked.

Configure MAX Rules

Under the port where port security function has been enabled, if users hope the terminal accessed can communicate event if it doesn't match the MAC rules and IP rules, they can configure MAX rules which will limit the number of terminals permitted to be access.

Table 5 Configuring MAX Rules

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure MAX Rules	**port-security maximum** *maximum-number*	Mandatory By default, MAX rules permit the number of MAC addresses learned to be 0.

Note

- The actual number of dynamic addresses learned by the MAX rules is limited by the number of ports, VLANs, and system MAC addresses.

Configure STICKY Rules

If users wish the MAC address and VLAN information corresponding to the terminal permitted by MAX rules are saved in the configuration, they can enable the STICKY function on the device so that the entries learned by the device through MAX rules can be transformed into STICKY rules. Upon completion of the transformation, the number of MAX rules can be adjusted by the number of current STICKY rules so that only the terminals that match STICKY rules can communicate. Then, the device can automatically learn the MAC address of the terminal accessed, transform it into STICKY rules, and save them in the configuration without manually configuring MAC rules.

Table 6 Configuring STICKY Rules

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure MAX Rules	**port-security maximum** *maximum-number*	Mandatory By default, the number of dynamic MAC addresses that MAX rules permit to learn is 0. STICKY rules can be configured only after the number of MAX rules is configured.
Enable the STICKY function	**port-security permit mac-address sticky**	Mandatory By default, the STICKY function is not enabled. STICKY rules can be configured only after the STICKY function is enabled.
Configure STICKY Rules	**port-security permit mac-address sticky** [*mac-address-value* [**desc** *security-rule-description* | **vlan-id** *vlan-id* [**desc** *security-rule-description*] | **ip-address** *ip-address-value* [**desc** *security-rule-description*] | **ipv6-address**	Mandatory By default, STICKY rules are not configured under the port.

Step	Command	Description
	ipv6-address-value [**desc** *security-rule-description*]]]	

60.2.3 Configure STICKY Rules Learning Mode

Configuration Condition

Before configuring STICKY rules learning mode, ensure that:

- Enable the port security function.

Configure STICKY Rules Learning Mode

If users wish the STICKY rules learning is conducted by MAC or AC+VLAN, the STICKY rules learning mode can be configured as MAC; if users wish the STICKY rules learning is conducted by MAC+IP, the STICKY rules learning mode can be configured as MAC+IP.

Table 7 Configuring STICKY Rules Learning Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure STICKY Rules Learning Mode	**port-security permit mac-address sticky mode** { **mac** | **mac-ip** }	Mandatory By default, the STICKY rules learning mode is MAC.

Configure VOICE VLAN Rules

Under the port where port security function has been enabled, if users hope that the terminal accessed can communicate event if it doesn't match the VOICE-VLAN packets of MAC rules and IP rules, and that it is not limited by the number of addresses of MAX rules, they can configure VOICE VLAN rules which will permit all the packets of OUI configured for VOICE-VLAN by OUI to pass.

Table 8 Configuring VOICE VLAN Rules

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure VOICE VLAN Rules	**port-security permit voice vlan**	Mandatory By default, VOICE VLAN rules are not configured under the port.

Note

- The source MAC permitted by voice vlan rules comes from the OUI configured by VOICE-VLAN.
- After MAX rules are enabled, voice vlan rules will not take effect.

60.2.4 Configure Static MAC Address Aging Function

Configuration Condition

Before configuring the static MAC address aging function, ensure that:

- Enable the port security function.

Enable Static MAC Address Aging Function

In order to detect whether the terminal corresponding to the valid entries of MAC rules or IP rules is online, the static MAC address aging function can be enabled. After the static MAC address aging function is enabled, if the terminal is checked offline, the valid entries corresponding to this terminal will be deleted so that the chip resources can be released.

Table 9 Enabling Static MAC Address Aging Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable Static MAC Address Aging Function	**port-security aging static**	Mandatory By default, the static MAC address aging function is closed.

Configure Static MAC Address Aging Time

Users can configure a reasonable aging time based on the actual network environment. In general applications, keep the default value.

Table 10 Configuring Static MAC Address Aging Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Static MAC Address Aging Time	**port-security aging time** *time-value*	Mandatory By default, the static MAC address aging time is 1 minute.

60.2.5 Configure Processing Mode After Receiving Illegal Packets

Configuration Condition

Before configuring the processing mode when illegal packets are received, ensure that:

- Enable the port security function.

Configure Processing Mode After Receiving Illegal Packets

Port security provides three processing modes for illegal packets, i.e. protect, restrict, and shutdown. Users can select them according to their requirements for security. The specific functions of these three processing modes are shown below:

- **Protect**: Discard the illegal packets after receiving them;
- **Restrict**: Discard the packets and trap the information to network management after receiving them;
- **Shutdown**: Discard the packets, close the port which receives them, and trap the information to network management after receiving them.

Table 11 Configuring Processing Mode After Receiving Illegal Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the processing mode of illegal packets	**port-security violation** { **protect** | **restrict** | **shutdown** }	Mandatory By default, the processing mode of port security after receiving illegal packets is **protect.**

60.2.6 Configure Log Sending Interval After Receiving Illegal Packets

Configuration Condition

Before configuring the log sending interval after receiving illegal packets, ensure that:

- Enable the port security function.

Configure Log Sending Interval After Receiving Illegal Packets

Users may configure the log sending interval after receiving illegal packets as needed. In general applications, keep the default value.

Table 12 Configuring Processing Mode After Receiving Illegal Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Log Sending Interval After Receiving Illegal Packets	**port-security violation log-interval** *log-interval-value*	Mandatory By default, the log sending interval is 5 seconds when the port security receives illegal packets.

60.2.7 Configure Port Security to Use ACL Function

Configuration Condition

Before configuring MAC+IP rules to use ACL function, do the following:

- Enable the port security function.

Configure port security to use ACL function

Users may configure port security to use ACL or not as needed. When using ACL, MAC+IP, MAC+IPv6, STICKY MAC+IP, and STICKY MAC+IPv6 rules can accurately match users' source MAC address and source IP/IPv6 address to prevent the illegal users with matched source MAC address and unmatched source IP/IPv6 address from accessing.

Table 13 Configuring Processing Mode After Receiving Illegal Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		only within the aggregation group.
Configure port security to use ACL function	**port-security use-acl**	Mandatory By default, port security doesn't use ACL.

60.2.8 Port Security Monitoring and Maintaining

Table 14 Port Security Monitoring and Maintaining

Command	Description
clear port-security statistics	Clear statistics of sending and receiving packets
show port-security	Show port summary with port security configuration
show port-security ip-address	Show the IP rules configured
show port-security ipv6-address	Show the IPv6 rules configured
show port-security mac-address	Show the MAC rules and STICKY rules configured
show port-security active-address	Show the information of all valid entries
show port-security detect-mac	Show the new MAC entries currently detected
show port-security violation log-interval	Show the log printing cycle when any illegal MAC entry is detected
show port-security violation-mac	Show the illegal MAC entries currently detected
show port-security statistics	Show statistics of sending and receiving packets

60.3 Typical Configuration Example of Port Security

60.3.1 Configure MAC and IP Rules for Port Security

Network Requirements

- PC1, PC2 and network printer access the server through the Device.
- Configure port security function on the Device. Allow PC1 to pass, reject PC2, and permit the network printer to perform the printing task assigned by the server and PC1 users.

Network Topology

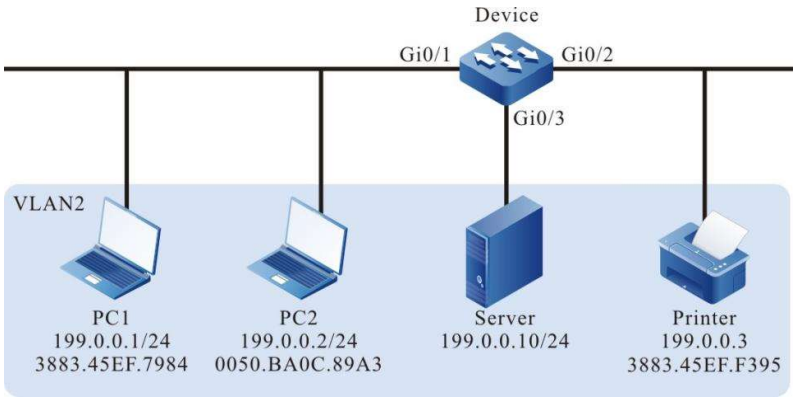


Figure 3-1 Network Topology for Configuring MAC and IP Rules for Port Security

Configuration Steps

Step 1: Configure VLAN.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1~gigabitethernet0/3 on the Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1-0/3
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure the port security function.

#Configure MAC+IP rules on gigabitethernet0/1 of the Device to permit PC1 to pass, and configure IP rules to reject PC2.

```
Device#config terminal
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#port-security enable
Device(config-if-gigabitethernet0/1)#port-security permit mac-address 3883.45ef.7984 ip-address 199.0.0.1
Device(config-if-gigabitethernet0/1)#port-security deny ip-address 199.0.0.2
Device(config-if-gigabitethernet0/1)#exit
```

#Configure MAC rules on gigabitethernet0/2 of the Device, permitting the network printer to access the network.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#port-security enable
Device(config-if-gigabitethernet0/2)#port-security permit mac-address 3883.45ef.f395
Device(config-if-gigabitethernet0/2)#exit
```

Step 3: Check the result.

#View valid entries of port security on the Device. It is indicated that the MAC of PC1 and network printer has been written into the valid entries of port security.

```
Device#show port-security active-address
-------------------------------------------------------------------------------------------
Entry Interface        MAC address      VID  IP/IPv6 Addr   Derivation     Age(Sec)
-------------------------------------------------------------------------------------------
1    gi0/1             38:83:45:EF:79:84 2   199.0.0.1      MAC+IP          0
2    gi0/2             38:83:45:EF:F3:95 2   199.0.0.3      MAC             0
```

#Through verification, it is indicated that PC1 can access the server and the network printer can perform the printing task assigned by PC1 and the server.

#Through verification, it is indicated that PC2 cannot ping the server and network printer.

60.3.2 Configure MAX Rules for Port Security

Network Requirements

- PC1, PC2, and PC3 simultaneously access the server through the Device. The PC and the server are in the same LAN.
- Configure port security rules on the Device to permit PC1 and PC2 instead of PC3 to access the server.

Network Topology

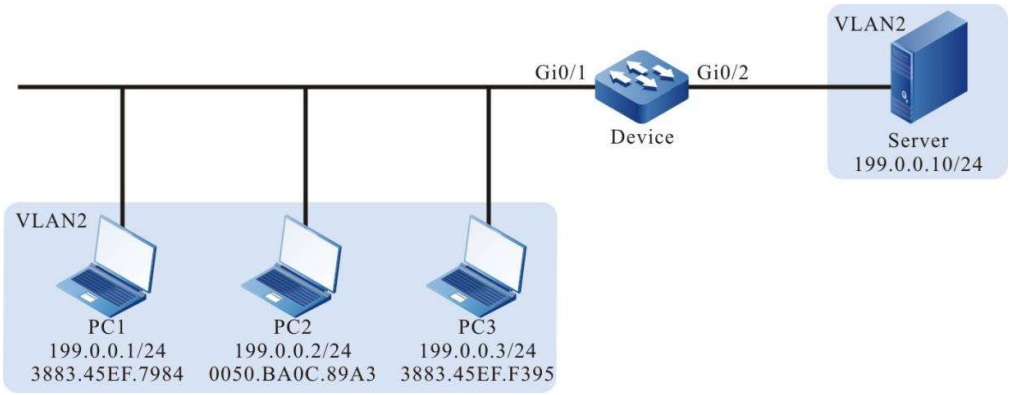


Figure 3-2 Network Topology for Configuring MAC Rules for Port Security

Configuration Steps

Step 1: Configure VLAN.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 on the Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1-0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure port security rules on the Device.

#Configure MAX rules on gigabitethernet0/1 of the Device, 3 at most.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#port-security enable
Device(config-if-gigabitethernet0/1)#port-security maximum 3
Device(config-if-gigabitethernet0/1)exit
```

#Reject PC3 to access the server on giabitethernet0/1 of the Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#port-security deny mac-address 3883.45ef.f395
Device(config-if-gigabitethernet0/1)exit
```

Step 3: Check the result.

#Three PCs try to communicate with the server. It is indicated that PC1 and PC2 can access the server, but PC3 cannot do so. #View valid entries of port security on gigabitethernet0/1 of the Device. It is indicated that the MAC addresses of PC1 and PC2 have been written into the valid entries of port security.

```
Device#show port-security active-address
-------------------------------------------------------------------------------------
Entry Interface        MAC address      VID  IP/IPv6 Addr   Derivation     Age(Sec)
-------------------------------------------------------------------------------------
1    gi0/1          00:50:ba:0c:89:a3 2   ---          FREE          0
2    gi0/1          38:83:45:EF:79:84 2   ---          FREE          0
Total Mac Addresses for this criterion: 2
```

60.3.3 Configure STICKY Rules for Port Security

Network Requirements

- PC1, PC2, and PC3 access the server through the Device. The PC and the server are in the same LAN.
- Configure port security rules on the Device, permitting two PCs to pass.
- After saving the configuration and restarting the Device, the STICKY rules before restarting can take effect immediately.

Network Topology

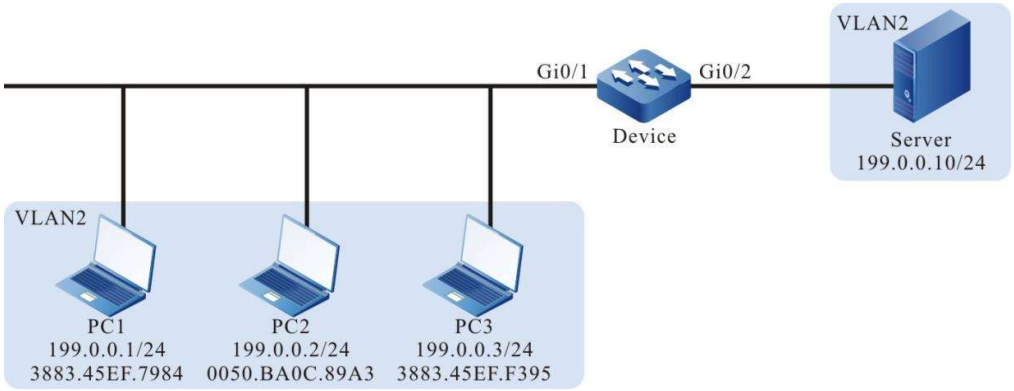


Figure 3-3 Network Topology for Configuring STICKY Rules for Port Security

Configuration Steps

Step 1: Configure VLAN.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 on the Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1-0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure MAX rules for port security on the Device.

#Configure MAX rules on gigabitethernet0/1 of the Device, 2 at most.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#port-security enable
Device(config-if-gigabitethernet0/1)#port-security maximum 2
Device(config-if-gigabitethernet0/1)exit
```

Step 3: Configure STICKY rules for port security on the Device.

#On gigabitethernet0/1 of the Device, enable the STICKY function.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#port-security permit mac-address sticky
Device(config-if-gigabitethernet0/1)#exit
```

Step 4: #Check the configuration result.

#PC1, PC2 and PC3 try to communicate with the server. By checking the valid entries of port security on gigabitethernet0/1 of the Device, it is indicated that the rules on gigabitethernet0/1 are STICKY rules.

```
Device#show port-security active-address
-------------------------------------------------------------------------------------------
Entry Interface        MAC address      VID  IP/IPv6 Addr     Derivation     Age(Sec)
-------------------------------------------------------------------------------------------
1    gi0/1             38:83:45:EF:79:84 2   199.0.0.1        STICKY          0
2    gi0/1             38:83:45:EF:F3:95 2   199.0.0.3        STICKY          0
Total Mac Addresses for this criterion: 2
```

#After saving the configuration and restarting the Device, the STICKY rules before restarting exist and take effect.

```
Device#show port-security active-address
-------------------------------------------------------------------------------------------
Entry Interface        MAC address      VID  IP/IPv6 Addr     Derivation     Age(Sec)
-------------------------------------------------------------------------------------------
1    gi0/1             38:83:45:EF:79:84 2   199.0.0.1        STICKY          0
2    gi0/1             38:83:45:EF:F3:95 2   199.0.0.3        STICKY          0
Total Mac Addresses for this criterion: 2
```

61 IP Source Guard

61.1 Overview

IP Source Guard is a packet filtering function. It can filter and control the packets forwarded by the port to prevent illegal packets from passing through the port and improve the security of the port. This function has two types:

1. Port IP Source Guard, i.e. filter the IP packets received by the specified port. The filtering methods include IP, MAC, and IP+MAC. For the specific processing method, see the content below:

- IP: If the source IP address and VLAN ID in the packets are the same as the IP address and VLAN ID recorded in the binding entries, the port will forward the packets; otherwise, it will discard them;
- MAC: If the source MAC address in the packets is the same as the MAC address and VLAN ID recorded in the binding entries, the port will forward the packets; otherwise, it will discard them;
- IP+MAC: If the source IP address, source MAC address and VLAN ID in the packets are the same as the IP address, MAC address and VLAN ID recorded in the binding entries, the port will forward the packets; otherwise, it will discard them.
- The setting of filtration type is valid for dynamic binding entries instead of static ones.
- The binding entries of port IP Source Guard have two types:
- Static binding entries, manually configured static binding entries of port IP Source Guard;
- Dynamic binding entries, dynamically generated by the valid entries of DHCP Snooping function.

2. Global IP Source Guard, i.e. filter the packets received by all the ports, including ARP (Address Resolution Protocol) and IP packets. The filtering methods are shown below:

- If the source IP address in the IP packets is the same as the IP address in the binding entries of global IP Source Guard yet the source MAC address is different, and the source MAC address in the IP packets is the same as the MAC address in the binding entries of global IP Source Guard yet the source IP address is different, the packets will be discarded;

- If the IP address of sending end in the ARP packets is the same as the IP address in the binding entries yet the source MAC address is different, the source MAC address in the ARP packets is the same as the MAC address in the binding entries yet the IP address of sending end is different, the packets will be discarded.

61.2 IP Source Guard Function Configuration

Table 61 IP Source Guard Function Configuration List

Configuration Task	
Configure static binding entries for port IP Source Guard	Configure static binding entries for port IP Source Guard
Configure the port IP Source Guard function	Configure the port IP Source Guard function
	Configure port IP Source Guard to filter packet type
Configure global IP Source Guard function	Configure global IP Source Guard function

61.2.1 Configure Static Binding Entries for Port IP Source Guard

Configuration Condition

Before configuring the static binding entries for port IP Source Guard, do the following:

- Enable the port IP Source Guard function or port Dynamic ARP Inspection function.

Configure Static Binding Entries for Port IP Source Guard

The static binding entries of port IP Source Guard serve as the basis of filtering the IP packets received by the specified port.

When the port Dynamic ARP Inspection function is enabled, the static binding entries of the port IP Source Guard can serve as the basis of checking the legality of ARP packets only when the static entries of mac, ip and vlan are configured.

Table 1 Configuring Static Binding Entries for Port IP Source Guard

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure static binding entries for port IP Source Guard	**ip source binding** { **ip-address** *ip-address* [**mac-address** *mac-address* [**vlan** *vlan-id*] | **vlan** *vlan-id*] | **mac-address** *mac-address* [**vlan** *vlan-id*] }	Mandatory By default, there are no static binding entries of port IP Source Guard.

Note

- For the port Dynamic ARP Inspection function, see the Dynamic ARP Inspection-related chapter in the User Manual.

61.2.2 Configure the port IP Source Guard function

Configuration Condition

None

Configure the Port IP Source Guard Function

After the port IP Source Guard function is enabled, first write the binding entries of port into the chip, including static binding entries with a higher priority and dynamic binding entries. Then, control security of the IP packets received by the port according to the entries written into the chip to prove security.

Table 61 Configure Port IP Source Guard Function

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable the port IP Source Guard function	**ip verify source**	Mandatory By default, the port IP Source Guard function is disabled.

Note

- After the port IP Source Guard function is enabled, the binding entries of port IP Source Guard are written into the chip, the number of which depends on the available sources of chip entries. If the sources of chip entries are not available, and it's necessary to add binding entries or enable the port IP Source Guard function on other ports, then the binding entries related to the sources of chip entries need to be deleted.
- If some binding entries of the port IP Source Guard fail to be written into the chip due to inadequate sources of chip entries, the system will automatically try to rewrite these binding entries into the chip every 60 seconds until all the binding entries that fail to be written into the chip are written into the chip or deleted.
- If both port IP Source Guard and global IP Source Guard are enabled, the IP packets received by the port can be forwarded only when they match the binding entries of port IP Source Guard and global IP Source Guard; otherwise, they will be discarded.
- Before enabling the port IP Source Guard function, if the terminal device connected to this port is a non-DHCP (Dynamic Host Configuration) client, or if the terminal device is a DHCP client, but it doesn't enable the DHCP Snooping function, the MAC address, IP address and corresponding VLAN number of the terminal device need to be configured as the static binding entries of port IP Source Guard to ensure that after this function is enabled, the

terminal device can normally communicate. For the DHCP Snooping function, refer to the DHCP Snooping-related chapters in the User Manual.

61.2.3 Configure port IP Source Guard to filter packet type

Configuration Condition

Before configuring the port IP Source Guard to filter packet type, do the following:

- Enable the port IP Source Guard function

Configure Port IP Source Guard to Filter Packet Type

After enabling the port IP Source Guard function, filter the IP packets in ip mode. When the source IP address and VLAN number in the IPv4 packets received by the port are both the same as those in the binding entries of port IP Source Guard, this port will forward these packets; otherwise, it will discard them.

After the IP Source Guard function of the port is enabled, filter the IP packets in ip-mac mode. When the source MAC address, source IP address and VLAN number in the IP packets received by the port are all the same as the MAC address, IP address and VLAN number in the binding entries of port IP Source Guard, the port will forward these packets; otherwise, it will discard them.

After enabling the IP Source Guard function of the port, filter the IP packets in mac mode. When the source MAC address and VLAN number in the IP packets received by the port are both the same as the MAC address and VLAN number in the binding entries of port IP Source Guard, this port will forward these packets; otherwise, it will discard them.

Table 61 Configuring Port IP Source Guard to Filter Packet Type

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		only within the aggregation group.
Enable the port IP Source Guard function	**ip verify source type** { **ip | ip-mac | mac** }	Mandatory By default, the filtering method is ip, which takes effect for dynamic entries only.

61.2.4 Configure the Function of Binding Static Entries of Port MAC

Configuration Condition

None

Configure the Function of Binding Static Entries of Port MAC

After configuring the function of binding static entries of port MAC, corresponding mac address, vlan number and port number are obtained to distribute corresponding static MAC entries from the static entries of IP Source Guard configured and the dynamic entries obtained on the port.

Table 61 Configuring Function of Binding Static MAC Entries

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		only within the aggregation group.
Enable the port IP Source Guard function	**ip source sticky-mac**	Mandatory By default, the function of binding static entries of port MAC is disabled.

61.2.5 Configure Global IP Source Guard Function

Configuration Condition

None

Configure Global IP Source Guard Function

In order to protect the security of users' IP address and prevent other users from embezzling their IP address, the IP Source Guard function can be configured to bind users' IP address and MAC address. The binding entries of global IP Source Guard of users' IP address and MAC address configured will be directly written into the chip to realize the filtration of illegal IP and ARP packets.

When the global Dynamic ARP Inspection function is enabled, the binding entries of the global IP Source Guard configured can serve as the basis of checking the legality of ARP packets by the global Dynamic ARP Inspection function.

Table 2 Configuring Global IP Source Guard Function

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure global IP Source Guard function	**source binding** *mac-address ip-address*	Mandatory By default, there are no binding entries of global IP Source Guard. This function is disabled. This command enables the global IP Source Guard function, and configures a

Step	Command	Description
		binding entry of global IP Source Guard.

Note

- At most 40 binding entries of global IP Source Guard are supported. The configuration will fail once the number exceeds 40.
- The binding entries of global IP Source Guard configured are directly written into the chip, the number of which depends on the available sources of chip entries. If the sources of chip entries are not available, and it's necessary to add the binding entries of global IP Source Guard, then the binding entries related to the sources of chip entries need to be deleted.
- If both port IP Source Guard and global IP Source Guard are enabled, the IP packets received by the port can be forwarded only when they match the binding entries of port IP Source Guard and global IP Source Guard; otherwise, they will be discarded.

Note

- For the global Dynamic ARP Inspection function, see the Dynamic ARP Inspection-related chapter in the User Manual.

61.2.6 IP Source Guard Monitoring and Maintaining

Table 3 IP Source Guard Monitoring and Maintenance

Command	Description
show ip binding table [**interface** *interface-name* | **link-aggregation** *link-aggregation-id* | **slot** | **summary**]	Show the binding entries of port IP Source Guard and the statistics of the number of binding entries
show ip source guard [**interface** { *interface-name* | **link-aggregation** *link-aggregation-id* }]	Show the configuration of port IP Source Guard function
show source binding	Show the binding entries of global IP Source Guard and the statistics of the number of entries

61.3 Typical Configuration Example of IP Source Guard

61.3.1 Configure Valid Port IP Source Guard Function Based on Dynamic Entries of DHCP Snooping

Network Requirements

- PC1 and PC2 access IP network through the Device.
- Configure the DHCP Snooping function.
- Configure the port IP Source Guard function so that PC1 instead of PC2 can normally access the IP Network.

Network Topology

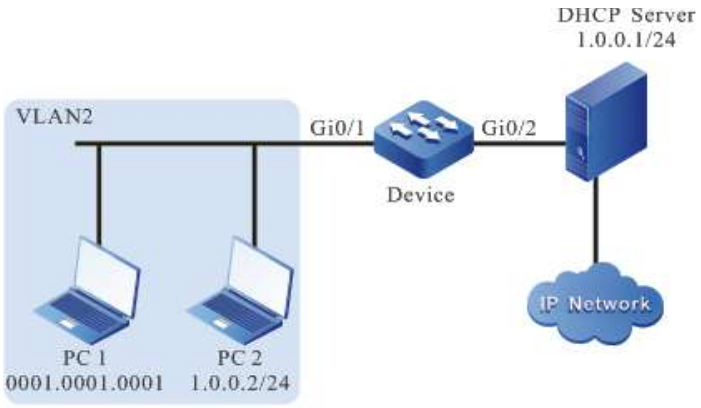


Figure 61 Network Topology for Configuring Valid Port IP Source Guard Function Based on Dynamic Entries of DHCP Snooping

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 2: On the Device, enable the global DHCP Snooping function, and configure the gigabitethernet0/2 connected to DHCP Server as a trusted port.

```
Device(config)#dhcp snooping enable
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dhcp snooping trust
Device(config-if-gigabitethernet0/2)#exit
```

Step 3: Configure the address pool of DHCP Server as 1.0.0.0/24. (omitted)

Step 4: On the Device, configure the port IP Source Guard function.

#On the port gigabitethernet0/1, enable the port IP Source Guard function.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip verify source
Device(config-if-gigabitethernet0/1)#exit
```

Step 5: Check the result.

#View DHCP Snooping-related configuration information.

```
Device#show dhcp-snooping
dhcp-snooping configuration information:
dhcp-snooping status:enable
dhcp-snooping option82 information status:disable
dhcp-snooping option82 information policy:replace
dhcp-snooping option82 information format:default
dhcp-snooping option82 information remote id:default(mac address)
dhcp-snooping information relay-address :None
dhcp-snooping binding agent save mode :auto-flash
dhcp-snooping binding agent save delay :1800
dhcp-snooping binding agent save pool :30
dhcp-snooping interface information :
-----------------------------------------------------------------
interface          trust-status     rate-limit(pps)  circuit-Id
gi0/0/1            untrust          40               default(vlan-mod-interface)
gi0/0/2            trust            ----             default(vlan-mod-interface)
gi0/0/3            untrust          40               default(vlan-mod-interface)
gi0/0/4            untrust          40               default(vlan-mod-interface)
gi0/0/5            untrust          40               default(vlan-mod-interface)
 ……
```

#View IP Source Guard-related configuration information.

```
Device#show ip source guard
-------------------------------------------
IP source guard interfaces on slot 0 :
   Total number of enabled interfaces : 1
-------------------------------------------------------------
Interface Name          Status      Verify Type  L2 Status
-------------------------------------------------------------
gi0/1                Enabled          ip          Disabled
gi0/2                Disabled         ip          Disabled
gi0/3                Disabled         ip          Disabled
gi0/4                Disabled         ip          Disabled
gi0/5                Disabled         ip          Disabled
```

……

It is indicated that the port gigabitethernet0/1 has enabled the IP Source Guard function, and the Verify Type is ip. Therefore, in the example mentioned above, dynamic entries will take effect based on ip+vlan.

#View the binding entries of port IP Source Guard.

```
Device#show ip binding table
-----------------------------------------------
IP Source Guard binding table on slot 0
    Total binding entries    : 1
    Static binding entries   : 0
    Dynamic binding entries  : 1
    Dynamic not write entries : 0
    PCE writing entries      : 1

-----------------------------------------------------------------------------------------------

Interface-Name  MAC-Address     IP-Address    VLAN-ID   Type-Flag   Writing-Flag   L2-Flag

-----------------------------------------------------------------------------------------------

gi0/1        0001.0001.0001   1.0.0.2      2       dynamic      Write        Not Write
```

#PC1 instead of PC2 can normally access the IP Network.

61.3.2 Configure the Port IP Source Guard Function which Takes Effect Based on Static Entries

Network Requirements

- PC1 and PC2 access IP network through the Device.
- Configure the port IP Source Guard function which takes effect based on static entries so that PC1 instead of PC2 can normally access the IP Network.

Network Topology

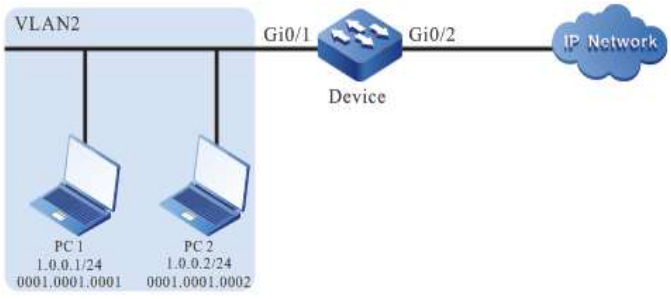


Figure 61-2 Network Topology for Configuring Valid Port IP Source Guard Function Based on Static Entries

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 2: On the Device, configure the port IP Source Guard function.

#Enable the port IP Source Guard function based on MAC+VLAN filtering method on port gigabitethernet0/1, and configure the binding entries of port IP Source Guard with IP address of 1.0.0.1 and VLAN 2.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip verify source
Device(config-if-gigabitethernet0/1)#ip source binding ip-address 1.0.0.1 vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#View IP Source Guard-related configuration information.

```
Device#show ip source guard
-----------------------------------------
IP source guard interfaces on slot 0 :
   Total number of enabled interfaces : 1
-----------------------------------------------------------------
Interface Name        Status      Verify Type    L2 Status
-----------------------------------------------------------------
gi0/1              Enabled         IP         Disabled
gi0/2              Disabled        IP        Disabled
gi0/3              Disabled        IP        Disabled
```

```
gi0/4              Disabled        IP        Disabled
……
```

It is indicated that the port gigabitethernet0/1 has enabled the IP Source Guard function. The static IP Source Guard entries that take effect according to the IP+VLAN entries configured have nothing to do with Verify Type value. Therefore, the example mentioned above takes effect based on IP+VLAN.

#View the binding entries of port IP Source Guard.

```
Device #show ip binding table
-------------------------------------------
IP Source Guard binding table on slot 0
    Total binding entries    : 1
    Static binding entries   : 1
    Dynamic binding entries  : 0
    Dynamic not write entries : 0
    PCE writing entries      : 1
-------------------------------------------------------------------------------------------
Interface-Name  MAC-Address   IP-Address   VLAN-ID   Type-Flag  Writing-Flag   L2-Flag
-------------------------------------------------------------------------------------------
gi0/1           ---       1.0.0.1    2         Static      Write        Not Write
```

#PC1 instead of PC2 can normally access the IP Network.

62 IPv6 Source Guard

62.1 Overview

IPv6 Source Guard is a packet filtering function. It can filter and control the packets forwarded by the port to prevent illegal packets from passing through the port and improve the security of the port. This function has two types:

1. Port IPv6 Source Guard, i.e. filter the IPv6 packets received by the specified port. The filtering methods include IP, IP+MAC and MAC. For the specific processing method, see the content below:

- IP: If the source IPv6 address and VLAN ID in the packets are the same as the IPv6 address and VLAN ID recorded in the binding entries, the port will forward the packets; otherwise, it will discard them;

- IP+MAC+VLAN: If the source IPv6 address, source MAC address and VLAN ID in the packets are the same as the IPv6 address, MAC address and VLAN ID recorded in the binding entries, the port will forward the packets; otherwise, it will discard them.
- MAC+VLAN: If the source MAC address and VLAN ID in the packets are the same as the MAC address and VLAN ID recorded in the binding entries, the port will forward the packets; otherwise, it will discard them.
- The setting of filtration type is valid for dynamic binding entries instead of static ones.

The binding entries of port IPv6 Source Guard have two types:

- Static binding entries, manually configured static binding entries of port IPv6 Source Guard;
- Dynamic binding entries, dynamically generated by the valid entries of DHCPv6 Snooping function.

2. Global IPv6 Source Guard, i.e. filter the packets received by all the ports. The filtering methods are shown below:

- If the source IPv6 address and MAC address in IPv6 packets are different from any one of the IPv6 address and source MAC address in the binding entries of global IPv6 Source Guard, the packets will be discarded.

62.2 IPv6 Source Guard Function Configuration

Table 5-1 IPv6 Source Guard Function Configuration List

Configuration Task	
Configure Basic Functions of Port IPv6 Source Guard	Enable Port IPv6 Source Guard Function
	Configure Number of Binding Entries of Port IPv6 Source Guard
Configure Port IPv6 Source Guard to Filter Packet Type	Configure Port IPv6 Source Guard to Filter Packet Type
Configuring Static Binding Entries for Port IPv6 Source Guard	Configuring Static Binding Entries for Port IPv6 Source Guard
Configure the function of binding static entries of port MAC	Configure the function of binding static entries of port MAC
Configure Global IPv6 Source Guard Function	Configure Global IPv6 Source Guard Function

62.2.1 Enable Port IPv6 Source Guard Function

Configuration Condition

- None

Enable Port IPv6 Source Guard Function

After the port IPv6 Source Guard function is enabled, the binding entries (static and dynamic entries) on the port will be written into the hardware. Only the packets that completely match the characteristics of the binding entries can be forwarded. Others will be discarded. This can achieve the purpose of security protection. After IPv6 Source Guard is enabled, the DHCPv6 packets and ND packets under this port are permitted to pass by default.

Table 5-2 Enabling Port IPv6 Source Guard Function

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable Port IPv6 Source Guard Function	**ipv6 verify source**	Mandatory By default, the IPv6 Source Guard function is disabled on the port.

62.2.2 Configure Number of Binding Entries of Port IPv6 Source Guard

Configuration Condition

Before configuring the number of binding entries for port IPv6 Source Guard, do the following:

- Enable port IPv6 Source Guard function.

Configure Number of Binding Entries of Port IPv6 Source Guard

The upper limit of the number of binding entries (including static and dynamic binding entries) supported by the port, to prevent a single port from being attached and occupying device resources.

Table 5-3 Configuring Number of Binding Entries of Port IPv6 Source Guard

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Number of Binding Entries of Port IPv6 Source Guard	**ipv6 verify source max-entries** *number*	Mandatory By default, 536 binding entries can be configured for each port.

62.2.3 Configure Port IPv6 Source Guard to Filter Packet Type

Configuration Condition

Before configuring the port IPv6 Source Guard to filter packet type, do the following:

- Enable port IPv6 Source Guard function.

Configure Port IPv6 Source Guard to Filter Packet Type

After enabling the port IPv6 Source Guard function, filter the IPv6 packets in ip mode. When the source IPv6 address and VLAN number in the IPv6 packets received by the port are both the same as those in the

binding entries of port IPv6 Source Guard, this port will forward these packets; otherwise, it will discard them.

After the port IPv6 Source Guard function is enabled, filter the IPv6 packets in ip-mac mode. When the source MAC address, source IPv6 address and VLAN number in the IPv6 packets received by the port are all the same as the MAC address, IPv6 address and VLAN number in the binding entries of port IPv6 Source Guard, the port will forward these packets; otherwise, it will discard them.

After enabling the port IPv6 Source Guard function, filter the IPv6 packets in mac mode. When the source MAC address and VLAN number in the IPv6 packets received by the port are both the same as the MAC address and VLAN number in the binding entries of port IPv6 Source Guard, this port will forward these packets; otherwise, it will discard them.

Table 5-4 Configuring Port IPv6 Source Guard to Filter Packet Type

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**Interface link-aggregation** *link-aggregation-id*	
Configure Port IPv6 Source Guard to Filter Packet Type	**ipv6 verify source type** {**ip** | **ip-mac** | **mac**}	Mandatory By default, the port filters packets in ip-only mode.

Note

- After the port IPv6 Source Guard function is enabled, the binding entries of port IPv6 Source Guard are written into the chip, the number of which depends on the available sources of chip entries. If the sources of chip entries are not available, and it's necessary to add binding entries or enable the port IPv6 Source Guard function on other ports, then the binding entries related

to the sources of chip entries need to be deleted.

- If some binding entries of the port IPv6 Source Guard fail to be written into the chip due to inadequate sources of chip entries, the system will automatically try to rewrite these binding entries into the chip every 60 seconds until all the binding entries that fail to be written into the chip are written into the chip or deleted.
- Configure port IPv6 Source Guard to filter packet type and make it take effect for the dynamic entries generated by DHCPv6 Snooping only

62.2.4 Configuring Static Binding Entries for Port IPv6 Source Guard

Configuration Condition

Before configuring static binding entries for port IPv6 Source Guard, do the following:

- Enable port IPv6 Source Guard function.

Configure Static Binding Entries of Port IP Source Guard

The static binding entries of port IPv6 Source Guard serve as the basis of filtering the IPv6 packets received by the specified port.

Table 5-5 Configuring Number of Static Binding Entries of Port IPv6 Source Guard

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configuring Static Binding Entries for Port IPv6 Source Guard	**ipv6 source binding** { **ipv6-address** *ipv6-address* [**mac-address** *mac-address* [**vlan** *vlan-id*] | **vlan** *vlan-*	Mandatory By default, there are no static binding entries of port IPv6 Source Guard.

Step	Command	Description
	id] | **mac-address** *mac-address* [**vlan** *vlan-id*] }	

62.2.5 Configure the Function of Binding Static Entries of Port MAC

Configuration Condition

The function of binding static entries of port MAC is not configured

After configuring the function of binding static entries of port MAC, corresponding mac address, vlan number and port number are obtained to distribute corresponding static MAC entries from the static entries of IPv6 Source Guard configured and the dynamic entries obtained on the port.

Table 5-6 Configuring Function of Binding Static MAC Entries

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable the port IP Source Guard function	**ipv6 source sticky-mac**	Mandatory By default, the function of binding static entries of port MAC is disabled.

62.2.6 Configure Global IPv6 Source Guard Function

Configuration Condition

None

Configure Global IPv6 Source Guard Function

In order to protect the security of users' IPv6 address and prevent other users from embezzling their own IPv6 address, you can configure the global IPv6 Source Guard function to bind users' IPv6 address and MAC address. The binding entries of global IPv6 Source Guard of users' IPv6 address and MAC address configured will be directly written into the chip to realize the filtration of illegal IPv6 packets.

Table 5-7 Configuring Global IPv6 Source Guard Function

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure Global IPv6 Source Guard Function	**ipv6 source binding mac-address** *mac-address* **ipv6-address** *ipv6_address*	Mandatory By default, there are no binding entries of global IPv6 Source Guard. This function is disabled.

Note

- At most 40 binding entries of global IPv6 Source Guard are supported. The configuration will fail once the number exceeds 40.
- The binding entries of global IPv6 Source Guard configured are directly written into the chip, the number of which depends on the available sources of chip entries. If the sources of chip entries are not available, and it's necessary to add the binding entries of global IPv6 Source Guard, then the binding entries related to the sources of chip entries need to be deleted.
- If both port IPv6 Source Guard and global IPv6 Source Guard are enabled, the IPv6 packets received by the port can be forwarded only when they match the binding entries of port IPv6 Source Guard and global IPv6 Source Guard; otherwise, they will be discarded.

62.2.7 IPv6 Source Guard Monitoring and Maintaining

Table 5-8 IPv6 Source Guard Monitoring and Maintaining

Command	Description
show ipv6 binding table [**dynamic** | **static** | **interface** *interface-name* | **slot** | **summary**]	Show the binding entries of port IPv6 Source Guard and the statistics of the number of binding entries
show ipv6 source guard [**interface** *interface-name*]	Show the configuration of port IPv6 Source Guard function

62.3 Typical Example of Configuration of IPv6 Source Guard

62.3.1 Configure Valid Port IPv6 Source Guard Function Based on Dynamic Entries of DHCPv6 Snooping

Network Requirements

- PC1 and PC2 access IP network through the Device.
- Configure the global DHCPv6 Snooping function.
- Configure the port IPv6 Source Guard function so that PC1 instead of PC2 can normally access the IP Network.

Network Topology

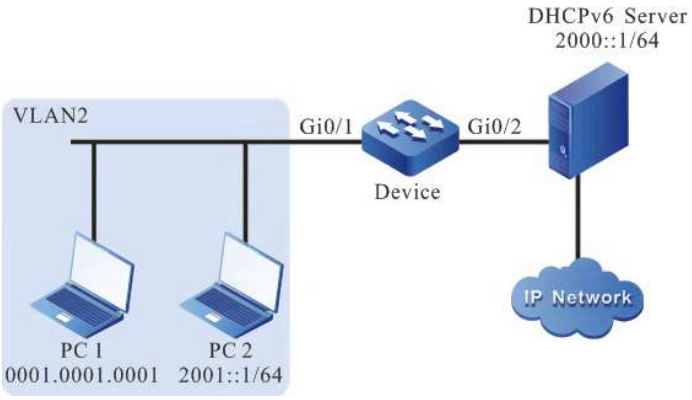


Figure 5-1 Network Topology for Configuring Valid Port IPv6 Source Guard Function Based on Dynamic Entries of DHCPv6 Snooping

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
```

```
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 2: On the Device, enable the global DHCPv6 Snooping function, and configure the gigabitethernet0/2 connected to DHCPv6 Server as a trusted port.

```
Device(config)#ipv6 dhcp snooping enable
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#ipv6 dhcp snooping trust
Device(config-if-gigabitethernet0/2)#exit
```

Step 3: Configure the address pool of DHCPv6 Server as 2000::2/64. (omitted)

Step 4: Configure port IPv6 Source Guard function on the Device.

#On the port gigabitethernet0/1, enable the port IPv6 Source Guard function.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ipv6 verify source
Device(config-if-gigabitethernet0/1)#exit
```

Step 5: Check the result.

#View DHCPv6 Snooping-related configuration information.

```
  Device#show ipv6 dhcp snooping
dhcpv6-snooping configuration information:
dhcpv6-snooping status:enable
dhcpv6-snooping entry aged time:300
dhcpv6-snooping binding agent save delay time:1800
dhcpv6-snooping binding agent save type :FLASH
dhcpv6-snooping binding agent save file :dhcpv6sp_binding.db
dhcpv6-snooping binding agent save pool time:30
dhcpv6-snooping interface information :
-------------------------------------------------------------
interface          trust-status    max-learning-num option-policy   option18-status  option37-status
gi0/1              untrust         1024             keep            disable         disable
        gi0/2              trust           1024             keep            disable         disable
gi0/3              untrust         1024             keep            disable         disable
gi0/4              untrust         1024             keep            disable         disable
gi0/5              untrust         1024             keep            disable         disable
 ……
```

#View IPv6 Source Guard-related configuration information.

```
Device#show ipv6 source guard
-----------------------------------------
IPv6 source guard interfaces on slot 0 :
   Total number of enabled interfaces : 1
-------------------------------------------------------------
```

```
Interface Name          Status      Verify Type  L2 Status    Max Entry
-------------------------------------------------------------
gi0/1               Enabled          ip          Disabled      536
gi0/2               Disabled         ip         Disabled      536
gi0/3               Disabled         ip         Disabled      536
gi0/4               Disabled         ip         Disabled      536
gi0/5               Disabled         ip         Disabled      536
```

……

It is indicated that the port gigabitethernet0/1 has enabled the IPv6 Source Guard function, and the Verify Type is ip. Therefore, in the example mentioned above, dynamic entries will take effect based on ip+vlan.

#View the binding entries of port IPv6 Source Guard.

```
Device#show ipv6 binding table
-------------------------global Ipv6 and mac binding entry ----------------------------
 total :0
-------------------------------------------------------------------------------------------
-----------------------------------------
IPv6 Source Guard binding table on slot 0
    Total binding entries     : 1
    Static binding entries    : 0
    Static not write entries  : 0
    Dynamic binding entries   : 1
    Dynamic not write entries : 0
    PCE writing entries       : 1

-------------------------------------------------------------------------------------------
Interface-Name  MAC-Address    VLAN-ID    Type-Flag   Writing-Flag    L2-Flag    IP-Address
-------------------------------------------------------------------------------------------
gi0/1         0001.0001.0001     2        dynamic       Write         Not Write    2000::2
```

#PC1 instead of PC2 can normally access the IP Network.

62.3.2 Configure the Port IPv6 Source Guard Function which Takes Effect Based on Static Entries

Network Requirements

- PC1 and PC2 access IP network through the Device.
- Configure the port IPv6 Source Guard function which takes effect based on static entries so that PC1 instead of PC2 can normally access the IP Network.

Network Topology

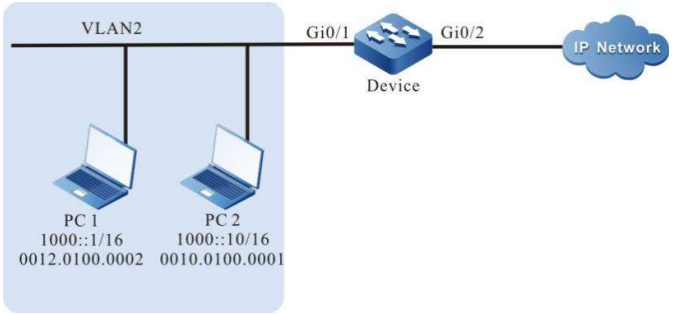


Figure 5-2 Network Topology for Configuring Valid Port IPv6 Source Guard Function Based on Static Entries

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 2: Configure port IPv6 Source Guard function on the Device.

#Enable the port IPv6 Source Guard function based on MAC+VLAN filtering method on port gigabitethernet0/1, and configure the binding entries of port IPv6 Source Guard with IP address of 1000::1 and VLAN 2.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ipv6 verify source
Device(config-if-gigabitethernet0/1)#ipv6 source binding ip-address 1000::1 vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#View IPv6 Source Guard-related configuration information.

```
Device#show ipv6 source guard
-----------------------------------------
IP source guard interfaces on slot 0 :
   Total number of enabled interfaces : 1
-----------------------------------------------------------------
Interface Name          Status      Verify Type  L2 Status
-----------------------------------------------------------------
gi0/1               Enabled         IP         Disabled
gi0/2               Disabled        IP        Disabled
gi0/3               Disabled        IP        Disabled
```

```
gi0/4                Disabled          IP          Disabled
……
```

It is indicated that the port gigabitethernet0/1 has enabled the IPv6 Source Guard function. The static IPv6 Source Guard entries that take effect according to the IP+VLAN entries configured have nothing to do with Verify Type value. Therefore, the example mentioned above takes effect based on IP+VLAN.

#View the binding entries of port IPv6 Source Guard.

```
Device #show ipv6 binding table
------------------------------global Ipv6 and mac binding entry ------------------------------
 total :0
-----------------------------------------------------------------------------------------------
-------------------------------------------
IPv6 Source Guard binding table on slot 0
    Total binding entries     : 1
    Static binding entries    : 1
    Static not write entries  : 0
    Dynamic binding entries   : 0
    Dynamic not write entries : 0
    PCE writing entries       : 1
-----------------------------------------------------------------------------------------------
Interface-Name  MAC-Address    VLAN-ID    Type-Flag   Writing-Flag    L2-Flag    IP-Address
-----------------------------------------------------------------------------------------------
gi0/1            ---        2          Static      Write          Not Write   1000::1
```

#PC1 instead of PC2 can normally access the IP Network.

63 ND Snooping

63.1 Overview

ND Snooping

ND Snooping is a security feature of IPv6 ND (Neighbor Discovery), used in layer-2 switching network environment. It builds ND Snooping dynamic binding table by snooping the NS (Neighbor Solicitation) packets of DAD (Duplicate Address Detection) to record the source IPv6 address, source MAC address, VLAN, ingress port, etc. of packets so as to prevent from being attacked by the ND packets of subsequent fake users and gateways.

Trusted Interface/Untrusted Interface of ND Snooping

Trusted interface of ND Snooping: This type of interface is used to connect trusted IPv6 nodes. The ND packets received from this type of interface will be normally forwarded by the device.

Untrusted interface of ND Snooping: This type of interface is used to connect untrusted IPv6 nodes. For the RA packets and redirected packets received from this type of interface, the device considers them to be illegal and directly discards them; for the NA/NS/RS packets received, if the interface or the VLAN where the interface is located enables the ND packet legality check function, the device will check the binding table matching of NA/NS/RS packets according to the dynamic binding table of ND Snooping. When the packets fail to comply with the binding table relationship, they will be considered as illegal users' packets and directly discarded; for other types of ND packets received, the device forwards them normally.

ND Snooping Binding Table

After the ND Snooping function is configured, the device builds a dynamic binding table of ND Snooping by snooping users' NS packets for DAD. The entries include the requested IPv6 address, source MAC address, VLAN and ingress interface in DAD packets. The dynamic binding table of ND Snooping can be used for the device to check the binding table matching of NA/NS/RS packets received from untrusted interface so as to filter illegal NA/NS/RS packets.

63.2 ND Snooping Function Configuration

Table 63 ND Snooping Function Configuration List

Configuration Task	
Configure Enabling the ND Snooping Function	Configure Enabling the ND Snooping Function

Configuration Task	
Configure Specifying Trusted Interface of ND Snooping	Configure Specifying Trusted Interface of ND Snooping
Configure Static Binding Entries for ND Snooping	Configure Static Binding Entries for ND Snooping
Configure Dynamic Binding Table Detection Function for ND Snooping	Configure Dynamic Binding Table Detection Function for ND Snooping
Configure Enabling ND Snooping Attack Detection Log Function	Configure Enabling ND Snooping Attack Detection Log Function

63.2.1 Configure to Enable the ND Snooping Function

Configuration Condition

None

Configure Enabling the ND Snooping Function

Table 63 Configuring to Enable ND Snooping Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to enable the global ND Snooping function	**nd snooping enable**	Mandatory By default, the global ND Snooping function is disabled.
Enter the layer-2 VLAN configuration mode	**vlan** *vlan-id*	Mandatory After entering the Layer-2 VLAN configuration mode, subsequent configurations only take effect on current VLAN.
Configure to enable the ND Snooping function under vlan	**nd snooping enable**	Mandatory By default, the ND Snooping function under VLAN is disabled.

63.2.2 Configure Specifying Trusted Interface of ND Snooping

Configuration Condition

None

Configure Specifying Trusted Interface of ND Snooping

Table 63 Configuring to Specify Trusted Interface of ND Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to enable the global ND Snooping function	**nd snooping enable**	Mandatory By default, the global ND Snooping function is disabled.
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	Mandatory The subsequent configuration takes effect only on the current port after you enter the Layer-2 Ethernet interface configuration mode.
Configure to specify trusted interface	**nd snooping trusted**	Mandatory By default, the interface is an untrusted interface.

63.2.3 Configure Static Binding Entries for ND Snooping

Configuration Condition

None

Configure Static Binding Entries for ND Snooping

Table 1 Configuring Static Binding Entries of ND Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to enable the global ND Snooping function	**nd snooping enable**	Mandatory By default, the global ND Snooping function is disabled.
Configure Static Binding Entries for ND Snooping	**nd snooping user-bind** *ipv6-address mac-address* **vlan** *vlan-id* **interface** *interface-name*	Optional By default, no static binding entry of ND Snooping is configured. When there is a static binding entry, match this static binding entry first; when static binding entry is not configured, use dynamic binding entry directly.

63.2.4 Configure Dynamic Binding Table Detection Function for ND Snooping

Configuration Condition

None

Configure Dynamic Binding Table Detection Function for ND Snooping

Table 2 Configuring Dynamic Binding Table Detection Function of ND Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to enable the global ND Snooping function	**nd snooping enable**	Mandatory By default, the global ND Snooping function is disabled.
Configure Dynamic Binding Table Detection Function for ND Snooping	**nd snooping detect retransmit** *retransmits-times* **interval** *time*	Mandatory By default, the dynamic binding table detection function of ND Snooping is disabled.

63.2.5 Configure Enabling ND Snooping Attack Detection Log Function

Configuration Condition

None

Configure Enabling ND Snooping Attack Detection Log Function

Table 63 Configuring to Enable ND Snooping Attack Detection Log Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to enable the global ND Snooping function	**nd snooping enable**	Mandatory By default, the global ND Snooping function is disabled.
Configure Enabling ND Snooping Attack Detection Log Function	**nd snooping attack-log enable**	Mandatory By default, the ND Snooping attack detection log function is disabled.

63.2.6 ND Monitoring and Maintaining

Table 63 ND Monitoring and Maintaining

Command	Description
clear nd fast-response statistics	The command is used to clear the ND fast response statistics.
clear nd snooping dynamic-user-bind	The command is used to delete dynamic binding entries of ND Snooping.
clear nd snooping prefix	The command is used to delete prefix entries of ND Snooping.
clear nd snooping statistics	The command is used to clear the statistics of ND Snooping.
show nd fast-response statistics	The command is used to display the ND fast response statistics.
show nd proxy address	The command is used to show nd as the address of external module pickup.
show nd snooping prefix	The command is used to show prefix entries of ND Snooping.
show nd snooping user-bind	The command is used to show binding entries of ND Snooping.
show nd snooping statistics	The command is used to show the statistics of ND Snooping.

63.3 Typical Example of Configuration of ND Snooping

63.3.1 Configure Basic Functions of ND Snooping

Network Requirements

- Device1 connects the gateway device Device2 through gigabitethernet0/3.
- Enable RA service on Device2 (enable RA packet sending function).
- Enable ND Snooping function on Device1. When an attacker sends illegal NS/NA/ RS /RA packets in the network, Device1 will discard these illegal ND packets to guarantee the communication between legal users and gateway.

Network Topology

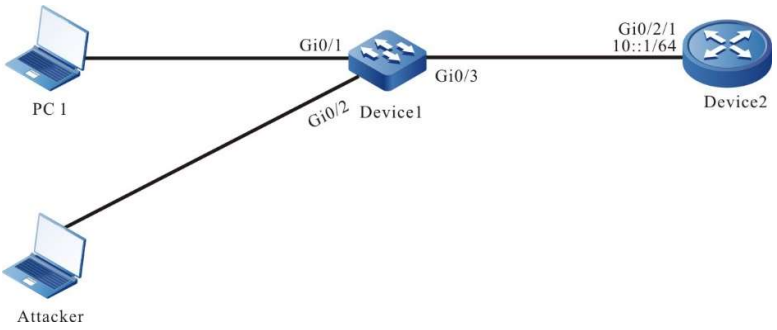


Figure 63 Network Topology for Configuring Basic Functions of ND Snooping

Configuration Steps

Step 1: Configure VLAN and port link type on Device1.

#Create VLAN 2.

```
Device1#configure terminal
Device1(config)#vlan 2
Device1(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1~gigabitethernet0/3 as Access, allowing the services of VLAN2 to pass.

```
Device1(config)#interface gigabitethernet 0/1-0/3
Device1(config-if-range)#switchport mode access
Device1(config-if-range)#switchport access vlan 2
Device1(config-if-range)#exit
```

Step 2: Configure IPv6 address on the layer-3 interface gigabitethernet0/2/1 of the gateway device Device 2.

```
Device2(config)#interface gigabitethernet 0/2/1
Device2 (config-if-gigabitethernet0/2/1)#ipv6 address 10::1/64
Device2 (config-if-gigabitethernet0/2/1)#exit
```

Step 3: Enable RA service on the gateway device Device2 (enable RA packet sending function).

```
Device2(config)#interface gigabitethernet 0/2/1
Device2 (config-if-gigabitethernet0/2/1)#no ipv6 nd suppress-ra period
Device2 (config-if-gigabitethernet0/2/1)#no ipv6 nd suppress-ra response
Device2 (config-if-gigabitethernet0/2/1)#exit
```

Step 4: Configure ND Snooping function on Device1.

#Globally enable the ND Snooping function.

```
Device1(config)#nd snooping enable
```

#Enable ND Snooping function on VLAN 2.

```
Device1(config)#vlan 2
Device1(config-vlan2)#nd snooping enable
Device1(config-vlan2)#exit
```

#Configure the port gigabitethernet0/3 as a trusted interface.

```
Device1(config)#interface gigabitethernet 0/3
Device1(config-if-gigabitethernet0/3)#nd snooping trusted
```

```
Device1(config-if-gigabitethernet0/3)#exit
```

Step 5: Check the result.

#View the prefix information obtained by Device1 from the gateway device Device2.

```
Device1#show nd snooping prefix
  prefix                    length   valid-time      preferred-time
  ------------------------------------------------------------------------------
  10::                      64       2592000         604800

  Total number: 1
```

#After the Ipv6 address 10 ::3 within the prefix 10::/64 administration scope is configured on PC1, view ND Snooping entries on the Device.

```
Device1#show nd snooping user-bind dynamic
ipv6-address     mac-address      vlan    interface        type
10::3        0857.00da.4715     2       gi0/1           dynamic
```

The ND Snooping entries of the IP, MAC, VLAN, and access port information of PC1 are generated on Device1.

#Atttacker simulates the IP of PC1 to send NS, NA and RS packets to the gateway. The Device receives the Attacker's NS, NA, and RS packets, discards them if they are found inconsistent with the recorded ND Snooping entries, and makes relevant records in the statistics of ND Snooping.

```
Device1#show nd snooping statistics

  Statistics for lpu 0 nd snooping:

  lladdrInvalid:          0
  dadPacketDeal:          0
  nsPacketPass:           0
  nsPacketDrop:           1
  naPacketPass:           0
  naPacketDrop:           1
  rsPacketDrop:           1
  rsPacketPass:           0
  raPacketPass:           0
  raPacketDrop:           0
  rdPacketDrop:           0
  rdPacketPass:           0
  sendDtPktFail:          0
  sendDtPktOk:            0
```

#Atttacker simulates the gateway to send RA packets to PC1. The Device receives the Attacker's RA packets, discards them if they are received from an untrusted port, and makes relevant records in the statistics of ND Snooping.

```
Device1#show nd snooping statistics

  Statistics for lpu 0 nd snooping:

  lladdrInvalid:          0
  dadPacketDeal:          0
  nsPacketPass:           0
  nsPacketDrop:           0
  naPacketPass:           0
  naPacketDrop:           0
  rsPacketDrop:           0
  rsPacketPass:           0
  raPacketPass:           0
  raPacketDrop:           1
```

```
rdPacketDrop:          0
rdPacketPass:          0
sendDtPktFail:         0
sendDtPktOk:           0
```

64 DHCP snooping

64.1 Overview

64.1.1 Basic Functions of DHCP Snooping

DHCP snooping is a security feature of DHCP (Dynamic Host Configuration Protocol). It has the following two functions:

1. Record the corresponding relation between MAC address and IP address of DHCP client:

For the sake of security, the network administrator may need to record the IP address used when users surf the Internet, and confirm the corresponding relation between the MAC address of users' host and the IP address obtained from the DHCP server.

DHCP snooping records the MAC address of DHCP client and the IP address obtained by snooping the DHCP request packets and the DHCP response packets received by the trusted port. The administrator can view the IP address information obtained by the DHCP client through the binding entries recorded by DHCP snooping.

2. Guarantee the client obtains IP address from a legal server:

If there is DHCP server set up in the network without permission, the DHCP client is likely to obtain incorrect IP address, causing abnormal communication or safety hazard. To ensure that the DHCP client can obtain an IP address through a legal DHCP server, the DHCP snooping function permits to configure the port as a trusted port or an untrusted port:

- Trusted port is directly or indirectly connected to a legitimate DHCP server. Trusted port normally forwards the DHCP response packets received so as to ensure that the DHCP client can obtain a correct IP address;
- An untrusted port is not directly or indirectly connected to a legitimate DHCP server. If a DHCP response packet sent by the DHCP server is received from an untrusted port, it will be discarded to prevent the DHCP client from obtaining incorrect IP address.

64.1.2 DHCP Snooping Option82

DHCP snooping supports the addition, forwarding and management of Option82. Option82 is a DHCP packet option used to record the location of DHCP client. The administrator can locate DHCP client according to this option for security control, e.g. limit the number of IP addresses that can be assigned by a port or VLAN. Depending on the type of DHCP packets, Option82 can be processed by the following ways:

1. When the device receives a DHCP request packet, it will process the packet according to whether it contains Option82, the processing policy and fill format configured by the user, and forward the processed packet to the DHCP server;

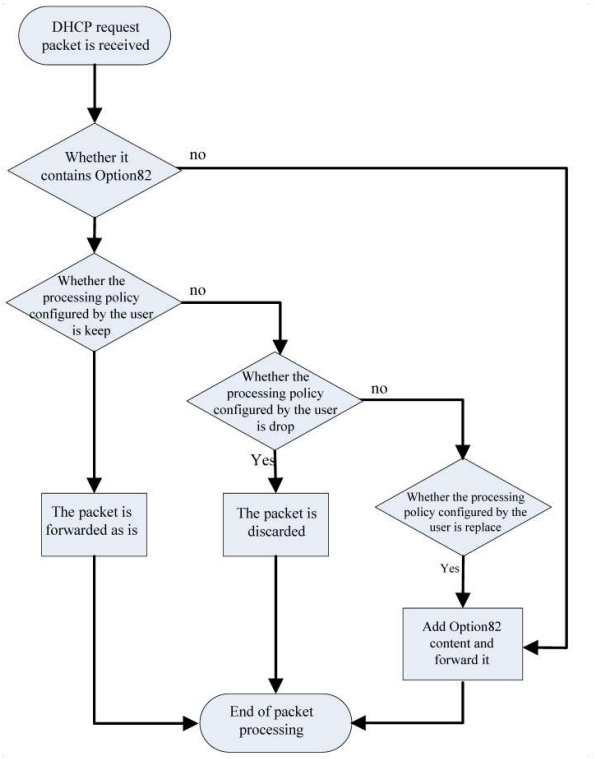


Figure 64 Processing Flow of Option82

2. When the device receives a response packet from the DHCP server, if the packet contains Option82, Option 82 is deleted and the packet is forwarded to the DHCP client. If the packet does not contain Option 82, it is directly forwarded to the DHCP client.

64.2 DHCP Snooping Function Configuration

Table 64 DHCP Snooping Function Configuration List

Configuration Task	
Configure Basic Functions of DHCP snooping	Configure DHCP Snooping Function
	Configure Trust Status of Port
	Configure Rate Limiting Function for DHCP Snooping
Configure DHCP snooping Option82	Configure Processing Policy of Option82
	Configure Content of Remote ID
	Configure Content of Circuit ID
	Configure Fill Format of Option82
	Configure Packet Processing Policy of Option82
Configure Binding Entries Storage for ND Snooping	Configure Automatic Storage of Binding Entries for DHCP Snooping
	Configure Manual Storage of Binding Entries for DHCP Snooping

64.2.1 Configure Basic Functions of DHCP Snooping

The basic functions of DHCP snooping include enabling DHCP snooping, configuring trust status of port, and limiting DHCP packet rate.

Configuration Condition

None

Configure DHCP Snooping Function

After the DHCP snooping function is enabled, the DHCP packets received by all ports of the device will be monitored:

- For the request packets received, corresponding binding entries will be generated according to the information in the packets;
- For the response packets received from the trusted port, the status and lease time of corresponding binding entries will be updated;

- The response packets received from the untrusted port will be directly discarded.

Table 1 Configure DHCP Snooping Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the DHCP snooping function	**dhcp-snooping**	Mandatory By default, the DHCP snooping function is disabled.

Configure Trust Status of Port

To prevent the DHCP client from obtaining addresses from illegal DHCP server, you can configure the port directly or indirectly connected to legitimate server as a trusted one.

When the port is configured as a trusted one, the DHCP response packets are permitted to be normally forwarded; otherwise, they will be discarded.

Table 64 Configure Trust Status of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure Trust Status of Port	**dhcp-snooping trust**	Mandatory By default, all ports are untrusted ones.

Note

- The port connected to DHCP server must be configured as a trusted one; otherwise, the DHCP client cannot obtain any address.
- After the port is configured as a trusted one, it will not limit the rate of the DHCP packets that pass through this port.
- After the port status is changed to untrusted from trusted, the upper limit of the port rate is 40 by default.

Configure Rate Limiting Function for DHCP Snooping

Configuring rate limiting function for DHCP Snooping can limit the number of DHCP packets processed per second. This can avoid the following circumstance: other protocol packets cannot be processed in a timely manner due to the processing of DHCP packets in long term.

When the number of DHCP packets received in one second exceeds the upper limit of rate, subsequent DHCP packets will be discarded. If the DHCP packets continuously received by the port in 20 seconds all exceed the rate limit, corresponding port will be closed to isolate the source of packet impact.

Table 2 Configuring Rate Limiting Function of DHCP Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode,
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		the subsequent configuration takes effect only within the aggregation group.
Configure Rate Limiting Function for DHCP Snooping	**dhcp-snooping rate-limit** *limit-value*	Mandatory By default, the upper limit of the rate of DHCP packet is 40pps.

Note

- After configuring the upper limit of the rate of DHCP packet in aggregation group configuration mode, it is applicable to each member port of the aggregation group.
- The DHCP packet rate limiting function is effective for untrusted port only.
- After the port is automatically closed, it can be automatically enabled by configuring Error-Disable. By default, the port auto closing function is enabled; if the DHCP packets received by the port exceed the rate limit for 20 consecutive seconds, and corresponding port cannot be automatically closed, you need to check the Error-Disable configuration. For the Error-Disable function, refer to the Error-Disable-related chapters in the User Manual.

64.2.2 Configure DHCP Snooping Option82

The DHCP snooping function supports Option82 which can contain 255 sub-options at most. Our company's devices support two sub-options, i.e. Circuit ID and Remote ID.

Configuration Condition

Before configuring the DHCP snooping Option82, do the following:

- Enable the DHCP snooping function.

Configure Processing Policy of Option82

When disabling information is configured on the port, all the option packets received by the port will be forwarded as is.

Table 64 Configuring Content of Circuit ID

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable Option82 of DHCP Snooping	**dhcp-snooping information enable**	Mandatory By default, Option82 of DHCP Snooping function is disabled.
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Processing Policy of Option82	**dhcp-snooping information disable**	Optional By default, the processing policy for the DHCP request packets containing Option82 is replace, i.e. replace prior to forwarding.

Configure Content of Remote ID

The content of Remote ID has two types, i.e. default and non-default. The default fill format of Remote ID is shown as follows:

Remote ID Suboption Frame Format

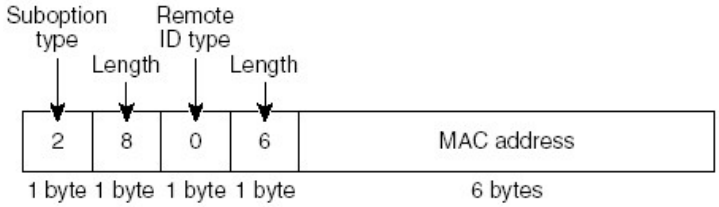


Figure 64-2 Fill Format of Default Remote ID Content

Non-default content has two types, i.e. custom character string and device name. It is required to be configured in the fill format to take effect under user configuration format. The fill format of the non-default Remote ID content is shown as follows:

Remote ID Suboption Frame Format (for user-configured string):

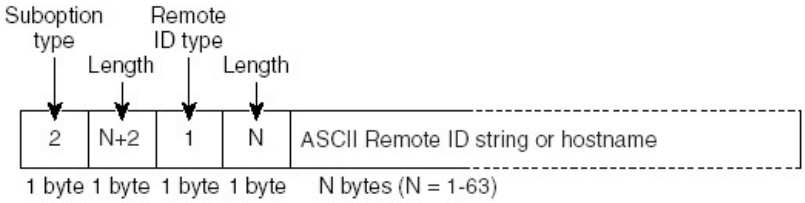


Figure 64-3 Fill Format of Non-default Remote ID Content

Table 64-6 Configuring Content of Remote ID

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Content of Remote ID	**dhcp-snooping information format remote-id** { *string* | **default** | **hostname** }	Mandatory By default, the content of Remote ID is default content, i.e. the MAC address of device port.

Configure Content of Circuit ID

The content of Circuit ID has two types, i.e. default and non-default. The fill format of the default Circuit ID content is shown as follows:

Circuit ID Suboption Frame Format

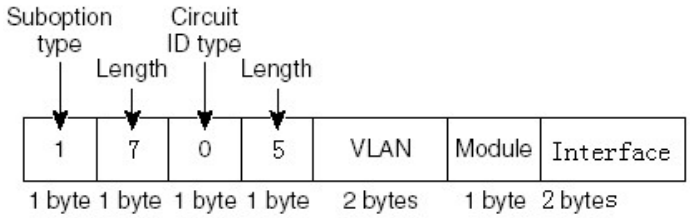


Figure 64-4 Fill Format of Non-default Circuit ID Content

Non-default content needs to be configured in the fill format to take effect under user configuration format. The fill format of the non-default Circuit ID content is shown as follows:

Circuit ID Suboption Frame Format (for user-configured string):

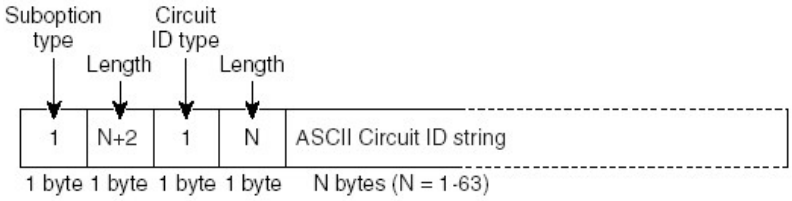


Figure 64-5 Fill Format of Non-default Circuit ID Content

Table 64-7 Configuring Content of Circuit ID

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure Content of Circuit ID	**dhcp-snooping information format circuit-id** { *string* | **default** }	Mandatory By default, the content of Circuit ID is default content.

Configure Fill Format of Option82

The fill format of Option82 has two types, default format and user configuration format.

When the fill format is default format, the content of both Remote ID and Circuit ID is default content; only when the fill format is configured as user configuration format will the non-default content of Remote ID and Circuit ID take effect.

Table 64-8 Configuring Fill Format of Option82 Option

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Fill Format of Option82	**dhcp-snooping information format** { **default** | **user-config** }	Mandatory By default, the fill format is default format.

Configure Packet Processing Policy of Option82

Configure the packet processing policy of Option82. You may take different forwarding policies for the DHCP request packets containing Option82.

Table 64-9 Configuring Packet Processing Policy of Option82 Option

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Packet Processing Policy of Option82	**dhcp-snooping information policy** { **drop** | **keep** | **replace** }	Mandatory By default, the processing policy is replace.

64.2.3 Configure Binding Entries Storage for ND Snooping

The DHCP snooping function supports automatic or manual storage of binding entries in the specified path. If the device restarts, the stored binding entries can be restored to prevent the communication from being affected due to the loss of binding entries.

The specified path can be device FLASH, FTP server or TFTP server.

Configuration Condition

Before configuring the binding entries storage path as FTP/TFTP server, do the following:

- Normally, the FTP/TFTP server function is enabled on the FTP/TFTP server;
- The device can ping the IP address of FTP/TFTP server.

Configure Automatic Storage of Binding Entries for DHCP Snooping

The binding entries of DHCP snooping can be configured as auto storage mode, i.e. the system stores the binding entries by timing.

The system periodically refreshes the binding entries to detect whether the binding entries have been updated. If yes, the updated entries will be stored in the specified path only after the storage delay expires. Storage delay can prevent and control frequent system storage due to the continuous updating of entries.

Table 64-10 Configure Automatic Storage of Binding Entries of DHCP Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Automatic Storage of Binding Entries for DHCP Snooping	**dhcp-snooping database savetype auto** { **flash** *file-name* | **ftp** *dest-ip-address ftp-username ftp-password file-name* | **tftp** *dest-ip-address file-name* }	Mandatory By default, the binding entries storage mode is auto mode, storage path flash, and storage file name "dhcpsp_binding.db".
Configure binding entries storage delay	**dhcp-snooping database savedelay** *seconds*	Optional By default, the binding entries storage delay is 1800 seconds.
Configure binding entries refresh interval	**dhcp-snooping database savepool** *seconds*	Optional

Step	Command	Description
		By default, the binding entries refresh interval is 30 seconds.

Configure Manual Storage of Binding Entries for DHCP Snooping

The binding entries of DHCP snooping can be configured as manual storage mode, i.e. the binding entries are stored by executing a storage command.

Table 64-11 Configure Manual Storage of Binding Entries of DHCP Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Manual Storage of Binding Entries for DHCP Snooping	**dhcp-snooping database savetype manual** { **flash** *file-name* | **ftp** *dest-ip-address ftp-username ftp-password file-name* | **tftp** *dest-ip-address file-name* }	Mandatory By default, the binding entries storage mode is auto mode, storage path flash, and storage file name "dhcpsp_binding.db".
Configure storage binding files	**dhcp-snooping database save**	Mandatory Store binding entries in the specified path By default, the binding entries are not stored in the specified path.

64.2.4 DHCP Snooping Monitoring and Maintaining

Table 64-12 DHCP Snooping Monitoring and Maintaining

Command	Description
clear dhcp-snooping database { **interface** { *interface-list* | **link-aggregation** *link-aggregation-id* } | **ip-address** *ip-address* |	Clear binding entries

Command	Description
mac-address *mac-address* | **vlan** *vlan-id* | **all** }	
clear dhcp-snooping packet statistics [interface { *interface-name* **| link-aggregation** *link-aggregation-id* **}]**	Clear statistics of receiving and sending DHCP packets
show dhcp-snooping [**interface** { *interface-name* | **link-aggregation** *link-aggregation-id* } | **save** | detail]	#Show the configuration information of DHCP Snooping
show dhcp-snooping database [**|** { { **begin** | **exclude** | **include** } *expression* | **redirect** { **file** *file-name* | **ftp** [**vrf** *vrf-name*] { *hostname* | *dest-ip-address* } *ftp-username ftp-password file-name* } }] [**interface** { *interface-name* | **link-aggregation** *link-aggregation-id* } **| ip-address** *ip-address* **| vlan** *vlan-id***| mac-address** *mac-address* [**|** { { **begin** | **exclude** | **include** } *expression* | **redirect** { **file** *file-name* | **ftp** [**vrf** *vrf-name*] { *hostname* | *dest-ip-address* } *ftp-username ftp-password file-name* } }] | **detail**]	Show the information about binding entries of DHCP Snooping
show dhcp-snooping packet statistics [**interface** { *interface-name* **| link-aggregation** *link-aggregation-id* }]	Show the statistics of receiving and sending DHCP packets

64.3 Typical Example of Configuration of DHCP Snooping

64.3.1 Configure Basic Functions of DHCP Snooping

Network Requirements

- DHCP Server1 is a legal DHCP server, and DHCP Server2 is an illegal DHCP server.
- After the DHCP snooping function is configured, both PC1 and PC2 can obtain addresses from DHCP Server1 only.

Network Topology

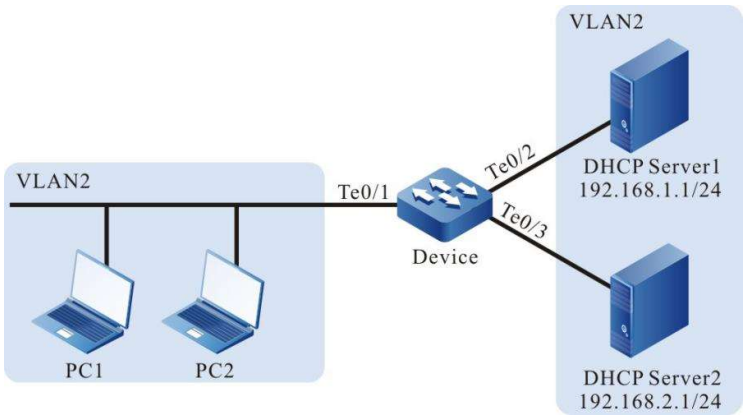


Figure 64-6 Network Topology for Configuring Basic Functions of DHCP Snooping

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports tengigabitethernet0/1~tengigabitethernet0/3 as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface tengigabitethernet 0/1-0/3
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure the address pool of DHCP Server1 as 192.168.1.100~192.168.1.199 and that of DHCP Server2 as 192.168.2.100~192.168.2.199. (omitted)

Step 3: Configure DHCP Snooping function on the Device.

#Enable the DHCP snooping function.

```
Device(config)#dhcp-snooping
```

#Configure the port tengigabitethernet0/2 as a trusted port.

```
Device(config)#interface tengigabitethernet 0/2
Device(config-if-tengigabitethernet0/2)#dhcp-snooping trust
Device(config-if-tengigabitethernet0/2)#exit
```

Step 4: Check the result.

#After both PC1 and PC2 successfully obtain the address, view the entries of DHCP Snooping on the Device.

```
Device#show dhcp-snooping database
    dhcp-snooping database:
    database entries count:2
    database entries delete time :300
    ---------------------------------
    macAddr        ipAddr       transtion-id  vlan  interface   leaseTime(s)  status
  0013.0100.0002  192.168.1.101    1          2    te0/1          107990      active
    ------
  0013.0100.0001  192.168.1.100    0          2    te0/1          107989      active
    ------
Total valid DHCP Client binding table for this criterion: 2
```

Both PC1 and PC2 can obtain addresses from DHCP Server1 only.

65 DHCPv6 Snooping

65.1 Overview

65.1.1 Basic Functions of DHCPv6 Snooping

DHCPv6 snooping is a security feature of DHCPv6 (Dynamic Host Configuration Protocol for IPv6). It has the following two functions:

1. Record the corresponding relation between MAC address and IPv6 address of DHCPv6 client:

For the sake of security, the network administrator may need to record the IPv6 address used when users surf the Internet, and confirm the corresponding relation between the MAC address of users' host and the IPv6 address obtained from the DHCPv6 server.

DHCPv6 snooping records the MAC address of DHCPv6 client and the IPv6 address obtained by snooping DHCPv6 request packets and the DHCPv6 response packets received by the trusted port. The administrator may view the IPv6 address information obtained by the DHCPv6 client through the binding entries recorded by DHCPv6 snooping.

2. Guarantee the client obtains IPv6 address from a legitimate server:

If there is DHCPv6 server set up in the network without permission, the DHCPv6 client is likely to obtain incorrect IPv6 address, causing abnormal communication or safety hazard. In order to ensure that the DHCPv6 client can obtain IPv6 address through a legitimate DHCPv6 server, the DHCPv6 snooping function permits the port to be configured as a trusted or an untrusted one:

- Trusted port is directly or indirectly connected to a legitimate DHCPv6 server. Trusted port normally forwards the DHCPv6 response packets received so as to ensure that the DHCPv6 client can obtain a correct IPv6 address;
- An untrusted port is not directly or indirectly connected to a legitimate DHCPv6 server. If a DHCPv6 response packet sent by the DHCPv6 server is received from an untrusted port, it will be discarded to prevent the DHCPv6 client from obtaining incorrect IPv6 address.

65.1.2 DHCPv6 Snooping Option18/37

In order that the DHCPv6 Server can obtain the physical location of DHCPv6 client, Option18 and Option37 can be added to the DHCPv6 request packet.

When the device is snooping DHCPv6 packets, some user-related device information can be added to the DHCPv6 request packet in DHCPv6 Option mode. In particular, Option18 which records the interface information of the client is called Interface ID option. Option37 recording the MAC address information of the client is called Remote ID option.

When Option18/37 is enabled, after the device receives the DHCPv6 request packets, it may process them by the following manners according to the processing policy and fill method of Option18/37 configured by users:

Table 7-1 DHCPv6 Request Packet Processing Policy

DHCPv6 request packet	Processing policy	Fill method	Packet processing principle
Without Option18/37	Add	Default fill format	Fill and forward in default format
	Add	Extend fill format	Fill and forward in the user-defined format
With Option18/37	maintained	Not filled	No processing or forwarding of Option18/37
	Replacements	Default fill format	Replace the original Option18/37 in default format and forward
		Extend fill format	Replace the original Option18/37 in the user-defined format and forward

65.2 DHCPv6 Snooping Function Configuration

Table 7-2 DHCPv6 Snooping Function Configuration List

Configuration Task	
Configure Basic Functions of DHCPv6 Snooping	Enable DHCPv6 Snooping
	Configure Trust Status of Port
	Configure Number of Binding Entries of Port
Configure DHCPv6 Snooping Option18/37	Configure Option18
	Configure Option37
	Configure Packet Processing Policy of Option18/37
Configure Delay Time of Deleting Invalid Entries of DHCPv6 Snooping	Configure Delay Time of Deleting Invalid Entries of DHCPv6 Snooping
Configure Storage of Binding Entries of DHCPv6 Snooping	Configure Storage of Binding Entries of DHCPv6 Snooping

65.2.1 Configure Basic Functions of DHCPv6 Snooping

The basic functions of DHCPv6 snooping include enabling DHCPv6 snooping, configuring trust status of port, and configuring the number of DHCPv6 snooping entries bound to the port.

Configuration Condition

None

Enable DHCPv6 Snooping

After the DHCPv6 snooping function is enabled, the DHCPv6 packets received by all ports of the device will be monitored:

- For the DHCPv6 request packets received, corresponding binding entries will be generated according to the information in the packets;
- For the response packets received from the trusted port, the status and lease time of corresponding binding entries will be updated;

- The response packets received from the untrusted port will be directly discarded.

Table 7-3 Enabling DHCPv6 Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable DHCPv6 snooping	**ipv6 dhcp snooping enable**	At least one option must be selected. By default, the DHCPv6 snooping function is disabled.
Enable the DHCPv6 snooping function of the specified VLAN	**ipv6 dhcp snooping vlan** *vlanlist*	

Configure Trust Status of Port

To prevent the DHCPv6 client from obtaining addresses from illegal DHCPv6 server, you can configure the port directly or indirectly connected to legitimate server as a trusted one.

When the port is configured as a trusted one, the DHCPv6 response packets are permitted to be normally forwarded; otherwise, they will be discarded.

Table 7-4 Configuring Trust Status of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure Trust Status of Port	**ipv6 dhcp snooping trust**	Mandatory By default, all ports are untrusted ones.

Note

- The port connected to DHCPv6 server must be configured as a trusted one; otherwise, the DHCPv6 client cannot obtain any address.

Configure the Number of Binding Entries of Port DHCPv6 Snooping

Configure the number of binding entries of DHCPv6 snooping. You can limit the maximum number of dynamic entries to be learned by the port to prevent them from occupying too many resources.

Table 7-5 Configuring the Number of Binding Entries of Port DHCPv6 Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the number of binding entries of DHCPv6 snooping	**ipv6 dhcp snooping max-learning-num** *number*	Mandatory

Step	Command	Description
		By default, 1024 binding entries can be learned by the port.

65.2.2 Configure DHCPv6 Snooping Option18/37

The DHCPv6 snooping function supports Option18 and Option37, both of which support the default and extended fill format.

Configuration Condition

Before configuring the DHCP snooping Option18 and Option37, do the following:

- Enable the DHCPv6 snooping function.

Configure Option18

The content of Interface ID has two types of fill format, i.e. default and extended. The fill format of the default Interface ID content is shown as follows:

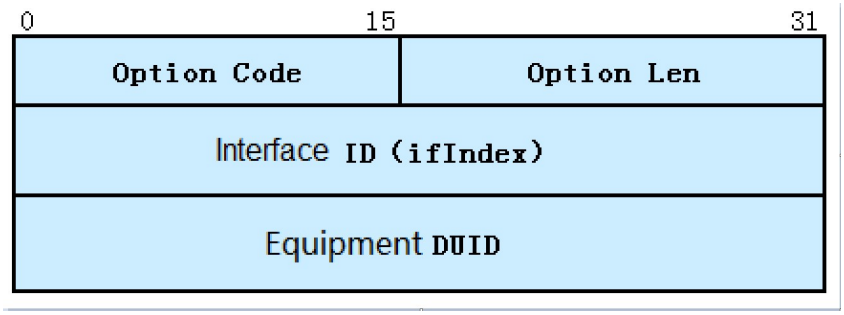


Figure 7-1 Fill Format of Default Interface ID Content

For the extended fill format, the fill format needs to be configured to take effect under user configuration format. The extended fill format of the Interface ID content is shown as follows:

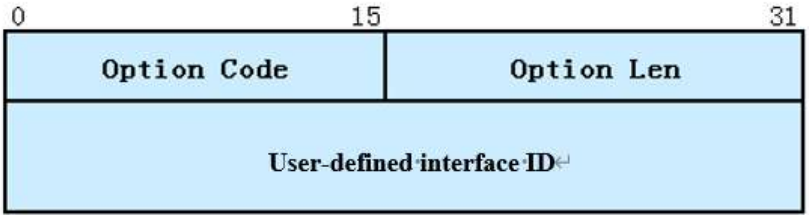


Figure 7-2 Extended Fill Format of Interface ID

Table 7-6 Configuring Option18 Option

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable the Option18 function	**ipv6 dhcp snooping option interface-id enable**	Mandatory By default, the Option18 function is disabled.
Configure the content of Interface ID option	**ipv6 dhcp snooping option format interface-id** *string*	Optional By default, the content of Interface ID in Option18 is in interface id - duid format.

Configure Option37

The content of Remote ID has two types of fill format, i.e. default and extended. The default fill format of Remote ID is shown as follows:

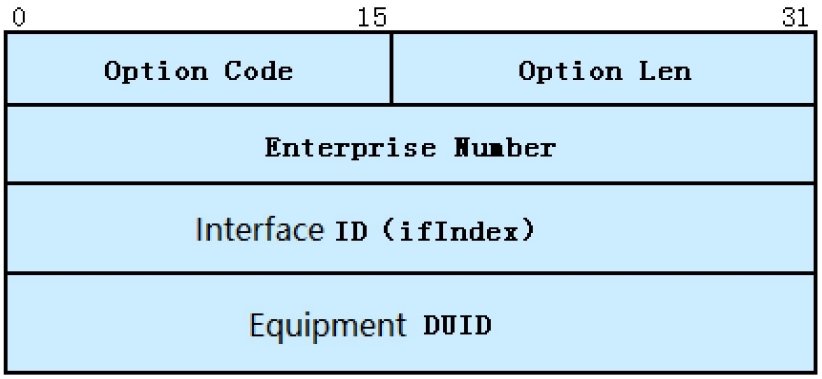


Figure 7-3 Fill Format of Default Remote ID Content

For the extended fill format, the fill format needs to be configured to take effect under user configuration format. The extended fill format of the Remote ID content is shown as follows:

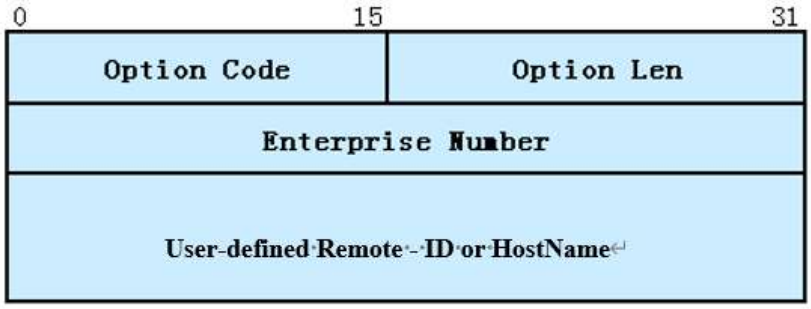


Figure 7-4 Fill Format of Non-default Remote ID Content

Table 7-7 Configuring Option37 Option

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		only within the aggregation group.
Enable the Option37 function	**ipv6 dhcp snooping option remote-id enable**	Mandatory By default, the Option37 function is disabled.
Configure Content of Remote ID	**ipv6 dhcp snooping option format remote-id** { *string* | **hostname** }	Mandatory By default, the content of Remote ID in Option37 is in enterprise num - interface id-duid format.

Configure Packet Processing Policy of Option18/37

Configure the packet processing policy of Option18/37. You may take different processing policies for the DHCPv6 request packets containing Option18/37.

Table 7-2 Configuring Packet Processing Policy of Option18/37 Option

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure Packet Processing Policy of Option18/37	**ipv6 dhcp snooping option policy replace**	Mandatory By default, the content of Option18/37 in DHCPv6 request packets is not replaced.

65.2.3 Configure Delay Time of Deleting Invalid Entries of DHCPv6 Snooping

Configuration Condition

Before configuring the delay time of deleting invalid binding entries for DHCPv6 snooping, do the following:

- Enable the DHCPv6 snooping function.

Configure Delay Time of Deleting Invalid Entries of DHCPv6 Snooping

After the binding relation is cancelled, the binding entries are updated as invalid. These invalid entries will not be deleted until the delay time expires. During this period of time, if the client renews the lease, they can be reactivated without reestablishing binding entries.

Table 7-3 Configuring Delay Time of Deleting Invalid Entries of DHCP Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Delay Time of Deleting Invalid Entries of DHCPv6 Snooping	**ipv6 dhcp snooping database timeout** *seconds*	Mandatory By default, the delay time of deleting invalid binding entries is 300 seconds.

65.2.4 Configure Storage of Binding Entries of DHCPv6 Snooping

The DHCPv6 snooping function supports automatic storage of binding entries in FLASH. If the device restarts, the stored binding entries can be restored to prevent the communication from being affected due to the loss of binding entries.

Configuration Condition

Before configuring the storage of binding entries of DHCPv6 snooping, do the following:

- Enable the DHCPv6 snooping function.

Configure Storage of Binding Entries of DHCPv6 Snooping

The system periodically refreshes the binding entries of DHCPv6 snooping to detect whether the binding entries have been updated. If yes, the updated entries will be automatically stored in the specified path after the storage delay expires. At the same time, the binding entries may also be stored in FLASH immediately.

Table 7-10 Configuring Storage of Binding Entries of DHCPv6 Snooping

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the refresh interval of binding entries of DHCPv6 snooping	**ipv6 dhcp snooping database save pool** *seconds*	Optional By default, the refresh interval of binding entries is 30 seconds.
Configure the storage delay of binding entries of DHCPv6 snooping	**ipv6 dhcp snooping database save interval** *seconds*	Optional By default, the binding entries storage delay is 1800 seconds.
Configure to perform storage of binding entries immediately	**ipv6 dhcp snooping database save now**	Optional By default, the storage delay of binding entries is 1800 seconds.
Configure the storage of binding entries of DHCPv6 snooping in the specified file	**ipv6 dhcp snooping database save filename** *string*	Mandatory By default, the name of the storage file is "/flash/dhcpv6sp_binding.db".

65.2.5 DHCPv6 Snooping Monitoring and Maintaining

Table 7-4 DHCPv6 Snooping Monitoring and Maintaining

Command	Description
clear ipv6 dhcp snooping database [**interface** { *interface-list* } | **ipv6-address** *ipv6-address* | *mac-address* | **vlan** *vlan-id*]	Clear binding entries of DHCPv6 Snooping

Command	Description
clear ipv6 dhcp snooping statistics [**interface** { *interface-name* }]	Clear the statistics of receiving and sending DHCPv6 packets
show ipv6 dhcp snooping [**interface** { *interface-name* }]	#Show DHCPv6 Snooping-related configuration information on the specified interface
show ipv6 dhcp snooping database [**|** { { **begin** | **exclude** | **include** } *expression* | **redirect** { **file** *file-name* | **ftp** [**vrf** *vrf-name*] { *hostname* | *dest-ip-address* } *ftp-username ftp-password file-name* } }] [**interface** { *interface-name* } | **ipv6-address** *ipv6-address* | **mac-address** *mac-address* | **vlan** *vlan-id*] [**|** { { **begin** | **exclude** | **include** } *expression* | **redirect** { **file** *file-name* | **ftp** [**vrf** *vrf-name*] { *hostname* | *dest-ip-address* } *ftp-username ftp-password file-name* } }]]	Show the information of binding entries of DHCPv6 Snooping
show ipv6 dhcp snooping statistics [**interface** { *interface-name* }]	Show the statistics of receiving and sending DHCPv6 packets

65.3 Typical Configuration Example of DHCPv6 Snooping

65.3.1 Configure Basic Functions of DHCPv6 Snooping

Network Requirements

- DHCPv6 Server1 is a legitimate DHCPv6 server, and DHCPv6 Server2 is an illegal DHCPv6 server.
- After the DHCPv6 snooping function is configured, both PC1 and PC2 can obtain addresses from DHCPv6 Server1 only.

Network Topology

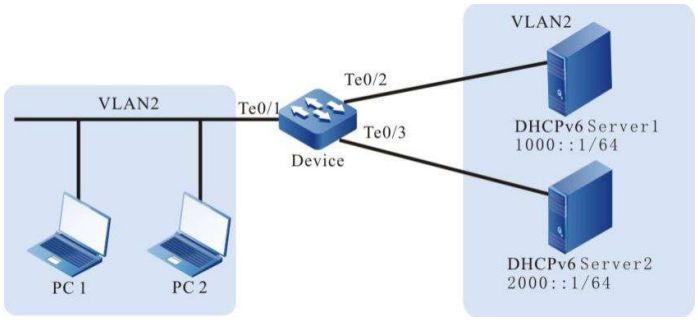


Figure 7-1 Network Topology for Configuring Basic Functions of DHCPv6 Snooping

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports tengigabitethernet0/1~tengigabitethernet0/3 as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface tengigabitethernet 0/1-0/3
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure the address pool of DHCPv6 Server1 as 1000::2/64 and that of DHCP Server2 as 2000::2/64. (omitted)

Step 3: Configure the DHCPv6 Snooping function on the Device.

#Enable the DHCPv6 snooping function.

```
Device(config)#ipv6 dhcp snooping enable
```

#Configure the port tengigabitethernet0/2 as a trusted port.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-tengigabitethernet0/2)#ipv6 dhcp snooping trust
Device(config-if-tengigabitethernet0/2)#exit
```

Step 4: Check the result.

#After both PC1 and PC2 successfully obtain the address, view the entries of DHCPv6 Snooping on the Device.

```
Device#show ipv6 dhcp snooping database
```

Interface-Name	MAC-Address	VLAN-ID	ValidTime	AgedTime	IP-Address
te0/1	0001.0001.0008	2	120	0	1000::2
te0/1	0001.0001.0007	2	120	0	1000::3

Both PC1 and PC2 can obtain addresses from DHCPv6 Server1 only.

66 Dynamic ARP Inspection

66.1 Overview

Dynamic ARP Inspection is called DAI function for short. It can increase network security by detecting the legality of ARP (Address Resolution Protocol) packets to discover and prevent ARP spoofing attack. The DAI function has two types:

- Port DAI: Detect the legality of the ARP packets received by the specified port to discover and prevent ARP spoofing attack;

The legality of ARP packets is checked according to the binding entries of port IP Source Guard. The specific principle is shown below:

For the ARP packets received, if the IP address of sending end, source MAC address and VLAN ID fully match the entries bound to the ARP Check of the port, these ARP packets are legal and forwarded; otherwise, they are illegal and discarded, and the log information is recorded.

- Global DAI: Detect the legality of all ARP packets received by the port to prevent fake users from sending fake ARP packets so that the device establishes incorrect ARP entries.

The legality of ARP packets is checked according to the binding entries of global IP Source Guard. The specific principle is shown below:

For the ARP packets received, if the IP address of sending end is the same as that in the binding entries of global IP Source Guard yet the MAC address is different, these ARP packets are considered fake and discarded, and the log information is not recorded.

The port DAI and global DAI function can also check the legality of ARP packets. The specific principle is shown below:

If the source MAC address in the ARP packets received is different from the MAC address of the sending end, these packets are invalid ones and discarded, and the log information is not recorded.

- Detection of port ARP attack: record the log information instead of detecting the legality of the ARP packets received by the specified to look for ARP attack.

66.2 Dynamic ARP Inspection Function Configuration

Table 66 Dynamic ARP Inspection Function Configuration List

Configuration Task	
Configure Dynamic ARP Inspection Function of Port	Configure Dynamic ARP Inspection Function of Port
Configure Global Dynamic ARP Inspection Function	Configure Global Dynamic ARP Inspection Function

66.2.1 Configure Dynamic ARP Inspection Function of Port

Configuration Condition

Before configuring Dynamic ARP Inspection function of port, the following tasks should be completed:

- Configure binding entries for port IP Source Guard.

Configure Dynamic ARP Inspection Function of Port

After the port DAI function is enabled, the system will check the legality of the ARP packets received by this port according to the binding entries of port IP Source Guard. Illegal packets will be discarded and recorded in the log.

The content recorded in the log includes VLAN ID, receiving port, IP address of sending end, destination IP address, MAC address of sending end, destination MAC address, and the number of identical ARP packets. Users may make further analysis according to the log information recorded, such as locating the host initiating ARP attack.

By default, log information is output on a periodic basis. The recording, output and aging of packets can be controlled by configuring log output interval. Log output interval serves as the basic value of the following log-related parameter:

- Log refresh cycle: Identify whether the log needs to be output or has been aged. If the log output interval configured is less than 5 seconds, the log refresh cycle is 1 second; otherwise, the log refresh cycle is one fifth of the log output interval;
- Log aging time: After the aging time expires, the log will be deleted. The log aging time is twice the log output interval;
- Log token: During the log refresh cycle, the allowable maximum number of logs. The number of log tokens is 15 times the value of log refresh cycle.

After the port DAI function is enabled, you can also configure rate limiting function for port ARP, i.e., limiting the number of ARP packets processed per second to prevent the system from processing a large number of ARP packets for a long time so that other protocol packets cannot be processed in a timely manner.

Note

- The rate limiting function of port ARP, i.e. limiting the number of ARP packets processed per second to prevent the system from processing a large number of ARP packets for a long time so that other protocol packets cannot be processed in a timely manner. When the number of ARP packets received in one second exceeds the upper limit of rate, subsequent ARP packets received will be discarded. If the ARP packets continuously received by the port in 20 seconds all exceed the rate limit, corresponding port will be closed to isolate the source of packet impact.

Table 66 Configuring Dynamic ARP Inspection of the Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable the DAI function of the port	**ip arp inspection**	Mandatory By default, the DAI function of the port is disabled.

Step	Command	Description
Configure the upper limit of processing ARP packets by the port	**ip arp inspection rate-limit** *limit-value*	Optional By default, the upper limit of processing ARP packets by the port is 15pps.
Return to the global configuration mode	**exit**	-
Configure the number of cache logs	**ip arp inspection log-buffer** *buffer-size*	Optional By default, the system can cache 32 logs. If it is configured as 0, no log is cached, i.e. the log is directly output to the terminal after an illegal ARP packet is detected.
Configure the log output interval	**ip arp inspection log-interval** *seconds*	Optional By default, the log output interval is 20 seconds. If it is configured as 0, the log is output immediately, i.e. the log is directly output to the terminal after an illegal ARP packet is detected.
Configure the log output level	**ip arp inspection log-level** *log-level*	Optional By default, the log output level is 6.

Note

- After the DAI function is enabled, all the ARP packets (broadcast and unicast ARP) received by corresponding port are redirected to CPU for detection, software forwarding and log recording. When there are a large number of ARP packets, they will consume a lot of CPU resources. Therefore, when the device communication is normal, enabling the DAI function of the port is not recommended. Only when you suspect ARP spoofing attack occurs in the network will the DAI function of the port be enabled for detection and locating.
- Under the same port, the port DAI function cannot be enabled simultaneously with the port

security function.

- After configuring the upper limit of the rate of APR packet processed by the port in aggregation group configuration mode, it is applicable to each member port of the aggregation group.
- If the ARP packets received by the port in 20 consecutive seconds exceed the upper limit, and the port is not closed automatically, you should refer to Error-Disable-related chapters in the User Manual.

66.2.2 Configure Global Dynamic ARP Inspection Function

Configuration Condition

Before configuring global Dynamic ARP Inspection function, the following tasks should be completed:

- Configure the binding entries of global IP Source Guard.

Configure Global Dynamic ARP Inspection Function

After the global DAI function is enabled, the system will check the legality of the ARP packets received by this port according to the binding entries of global IP Source Guard. Illegal packets will be discarded directly without being recorded in the log.

Table 1 Configuring Global Dynamic ARP Inspection Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable global DAI function	**arp-security**	Mandatory By default, the global DAI function is disabled.

66.2.3 Configure Dynamic ARP Inspection to Detect ARP Attack

Configuration Condition

None

Configure Dynamic ARP Inspection to Detect ARP Attack

After ARP attack detection is enabled, the system will record log instead of checking the legality of ARP packets received.

Table 2 Configuring Dynamic ARP Inspection to Detect ARP Attack

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable ARP attack detection of the port	**ip arp inspection attack**	Mandatory By default, ARP attack detection is disabled on the port.

66.2.4 Dynamic ARP Inspection Monitoring and Maintaining

Table 3 Dynamic ARP Inspection Monitoring and Maintaining

Command	Description
clear ip arp inspection { **log-information** | **log-statistics | pkt-statistics** [**interface** { *interface-name* | **link-aggregation** *link-aggregation-id* }] }	Delete the statistics of DIA function record
show arp-security	Show the status of global DAI function
show ip arp inspection [**interface** { *interface-name* | **link-aggregation** *link-aggregation-id* }]	Show the configuration information of port DAI function

Command	Description
show ip arp inspection log-information	Show the log information of port DIA function record
show ip arp inspection log-statistics	Show the statistics of the number of logs
show ip arp inspection pkt-statistics [**interface** { *interface-name* | *link-aggregation link-aggregation-id* }]	Show the statistics of ARP packets

66.3 Typical Configuration Example of DAI

66.3.1 Configure Basic Functions of DAI

Network Requirements

- PC1 and PC2 access IP network through the Device.
- On the Device, configure the port DAI function to prevent from ARP attack and spoofing.

Network Topology

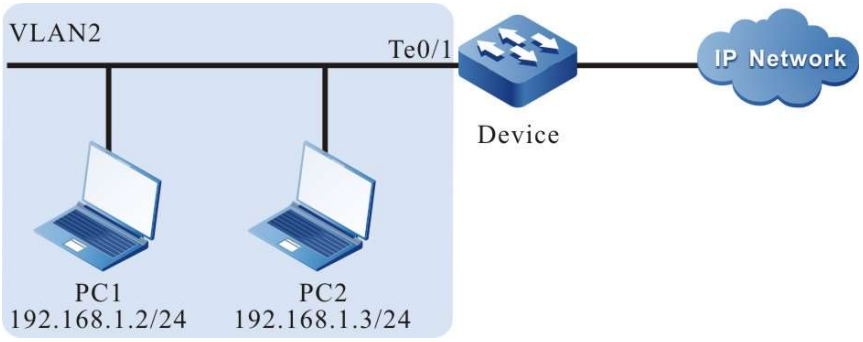


Figure 66 Network Topology for Configuring Basic Functions of DAI

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port tengigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface tengigabitethernet 0/1
Device(config-if-tengigabitethernet0/1)#switchport mode access
Device(config-if-tengigabitethernet0/1)#switchport access vlan 2
Device(config-if-tengigabitethernet0/1)#exit
```

Step 2: Configure port DAI function on the Device.

#Enable the port DAI function on the port tengigabitethernet0/1, and configure the upper limit of processing ARP packets by this port as 30pps.

```
Device(config)#interface tengigabitethernet 0/1
Device(config-if-tengigabitethernet0/1)#ip arp inspection
Device(config-if-tengigabitethernet0/1)#ip arp inspection rate-limit 30
Device(config-if-tengigabitethernet0/1)#exit
```

Step 3: Configure binding entries on the Device.

#On the port gigabitethernet0/1, configure the binding entries of port IP Source Guard with MAC address of 0012.0100.0001, IP address of 192.168.1.2, and VLAN of 2.

```
Device(config)#interface tengigabitethernet 0/1
Device(config-if-tengigabitethernet0/1)#ip source binding ip-address 192.168.1.2 mac-address 0012.0100.0001 vlan 2
Device(config-if-tengigabitethernet0/1)#exit
```

Step 4: Check the result.

#View DHCP-related configuration information.

```
Device#show ip arp inspection
    Dynamic ARP Inspection information:
    Dynamic ARP Inspection log buffer size: 30
    Dynamic ARP Inspection log Interval:    20
    Dynamic ARP Inspection log Level:       6
    Dynamic ARP Inspection interface information :
    ---------------------------------------------
    interface          status    rate-limit(pps)  attack
     te0/1             enable    30               OFF
     te0/2             disable   15               OFF
     ……
```

#When the port tengigabitethernet0/1 receives ARP packets at a rate which is more than 30pps, the Device will discard the packets that exceed the rate and output the following prompt messages.

```
Jan  1 02:21:06: The rate on interface tengigabitethernet0/1 too fast ,the arp packet drop!
```

#When the port tengigabitethernet0/1 receives ARP packets at a rate which is more than 30pps for 20 seconds, the Device will close this port and output the following prompt messages.

```
Jan  1 02:21:26: %LINK-INTERFACE_DOWN-4: interface tengigabitethernet0/1, changed state to down
Jan  1 02:21:26: The rate of arp packet is too fast,dynamic arp inspection shut down the tengigabitethernet0/1 !
```

#Whe the ARP packets received by the port tengigabitethernet0/1 are inconsistent with the binding entries, the Device records the illegal information in the following format in the DAI log and output it periodically.

Jan 1 07:19:49: SEC-7-DARPLOG: sender IP address: 192.168.1.3 sender MAC address:0011.0100.0001 target IP address: 0.0.0.0 target MAC address:0000.0000.0000 vlan ID:2 interface ID: tengigabitethernet0/1 record packet :32 packet(s)

#View DAI log.

```
Device#show ip arp inspection log-information
LogCountInBuffer:1

SEC-7-DARPLOG: sender IP address: 192.168.1.3 sender MAC address:0011.0100.0001 target IP address: 0.0.0.0 target MAC address:0000.0000.0000 vlan ID:2 interface ID: tengigabitethernet0/1 record packet :0 packet(s)
```

66.3.2 Combination of DAI with DHCP Snooping

Network Requirements

- PC1 and PC2 access the IP Network through Device1, with PC2 being a DHCP client and Device2 being a DHCP relay.
- On Device1, configure DHCP Snooping and port DAI function so that PC2 instead of PC1 can normally access the IP Network.

Network Topology

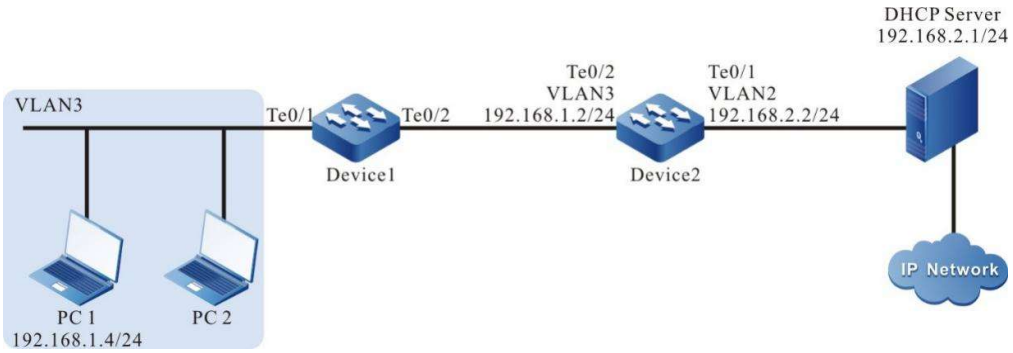


Figure 1 Network Topology for Combination of DAI and DHCP Snooping

Configuration Steps

Step 1: Configure VLAN and port link type on Device1.

#Create VLAN3.

```
Device1#configure terminal
Device1(config)#vlan 3
Device1(config-vlan3)#exit
```

#Configure the link type of both tengigabitethernet0/1 and tengigabitethernet0/2 as Access, permitting the services of VLAN3 to pass.

```
Device1(config)#interface tengigabitethernet 0/1-0/2
Device1(config-if-range)#switchport access vlan 3
Device1(config-if-range)#exit
```

Step 2: Configure VLAN and port link type on Device2.

#Create VLAN2 and VLAN3.

```
Device2#configure terminal
Device2(config)#vlan 2-3
```

#Configure the link type of port tengigabitethernet0/1 and tengigabitethernet0/2 as Access. Port tengigabitethernet0/1 allows the services of VLAN2 to pass and tengigabitethernet0/2 allows the services of VLAN3 to pass.

```
Device2(config)#interface tengigabitethernet 0/1
Device2(config-if-tengigabitethernet0/1)#switchport mode access
Device2(config-if-tengigabitethernet0/1)#switchport access vlan 2
Device2(config-if-tengigabitethernet0/1)#exit
Device2(config)#interface tengigabitethernet 0/2
Device2(config-if-tengigabitethernet0/2)#switchport mode access
Device2(config-if-tengigabitethernet0/2)#switchport access vlan 3
Device2(config-if-tengigabitethernet0/2)#exit
```

Step 3: Configure corresponding VLAN interface and IP address on Device1 and Device2. (Omitted)

Step 4: Configure DHCP Snooping function on Device1.

#Enable the DHCP Snooping function and configure gigabitethernet0/2 as a trusted port.

```
Device1(config)#dhcp-snooping
Device1(config)#interface tengigabitethernet 0/2
Device1(config-if-tengigabitethernet0/2)#dhcp-snooping trust
Device1(config-if-tengigabitethernet0/2)#exit
```

Step 5: Configure port DAI function on Device1.

#On the port tengigabitethernet0/1, enable the port DAI function.

```
Device1(config)#interface tengigabitethernet 0/1
Device1(config-if-tengigabitethernet0/1)#ip arp inspection
Device1(config-if-tengigabitethernet0/1)#exit
```

Step 6: Configure the IP address of DHCP relay server on Device2.

#Configure the IP address of DHCP relay server as 198.168.2.1.

```
Device2(config-if-vlan3)ip dhcp relay
Device2(config-if-vlan3)ip dhcp relay server-address 192.168.2.1
```

Step 7: Check the result.

#After PC2 successfully obtains the address, view the dynamic entries of DHCP Snooping on Device1.

```
Device1#show dhcp-snooping database
    dhcp-snooping database:
    database entries count:1
    database entries delete time :300
          ---------------------------------
    macAddr        ipAddr       transtion-id  vlan  interface   leaseTime(s)  status
  0013.0100.0001  192.168.1.100     2          2     te0/1          107990      active
    ------
```

#PC2 instead of PC1 can normally access the IP Network.

67 Host Guard

67.1 Overview

Host Guard is mainly used for the device in the access layer to prevent the ARP (Address Resolution Protocol) packets counterfeited by the attacker from damaging the ARP table on the terminal device. The host IP address protected by Host Guard generally corresponds to the IP address of the gateway device and important server in the network.

For the Host Guard function, there are two concepts:

- Host protection group: It is composed of a series of host protection group rules, i.e. the set of protected host IP address;
- Host protection group rule: A protected host IP address.

The working principle of Host Guard function is shown below:

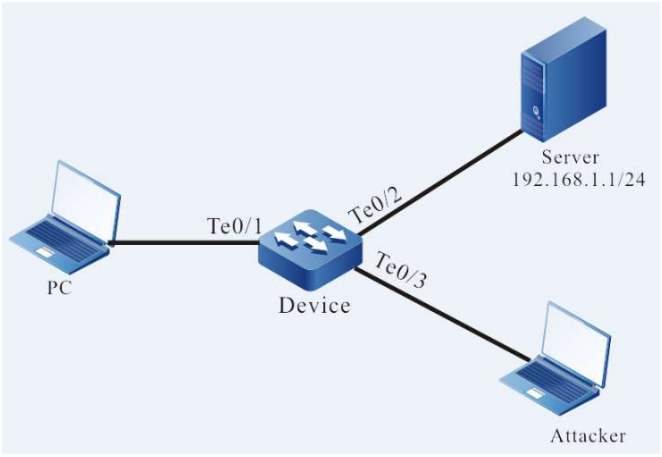


Figure 67 Functions of Host Guard

As shown in the figure above, the Attacker can use the IP address 192.168.1.1 of the Server to counterfeit ARP packets that will be forwarded to PC through the Device and damage the ARP table on the PC so that it cannot normally access the Server.

On the Device, after applying the IP address 192.168.1.1 of the Server to the port te0/2 as a host protection group rule, when among the ARP packets received by the Device, the IP address at the sending end is the same as that in the Server, if the receiving port is te0/2, the packets can be processed with normal methods; if not, they will be discarded. That is to say, the ARP packets sent by the Server can be forwarded through the port te0/2 only, and those counterfeited by the Attacker will be discarded.

67.2 Host Guard Function Configuration

Table 67 Host Guard Function Configuration List

Configuration Task	
Configure Host Guard Function	Configure Host Protection Group
	Configure Application of Host Protection Group

67.2.1 Configure Host Guard Function

Configuration Condition

None

Configure Host Protection Group

The host protection group is composed of a series of host protection group rules. The IP address of gateway and important server in the network can be configured as a rule in the host protection group.

Table 67 Configuring Host Protection Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create host protection group	**host-guard group** *group-name*	Mandatory By default, no host protection group is created.
Configure host protection group rules	**permit host** *ip-address*	Mandatory

Step	Command	Description
		By default, the host protection group rules are not configured.

Note

- Each host protection can support 128 rules at most.

Configure Application of Host Protection Group

Apply the host protection group to the port to monitor the ARP packets received and protect the ARP table.

Table 67 Configuring Application of Host Protection Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	
Configure Application of Host Protection Group	**host-guard binding** *group-name*	Mandatory By default, there is no host protection group applied on the port or aggregation group.

67.2.2 Host Guard Monitoring and Maintaining

Table 67 Host Guard Monitoring and Maintaining

Command	Description
show host-guard binding [**interface** *interface-id* | **link-aggregation** *link-aggregation-id*]	Show the application information of host protection group
show host-guard group [*group-name*]	Show the configuration information of host protection group and its rules

68 AAA

68.1 Overview

AAA means Authentication, Authorization, and Accounting. Since the birth of network, Authentication, Authorization and Accounting system has become the foundation of its operation. The use of various resources in the network needs to be managed by Authentication, Authorization and Accounting. Generally, AAA adopts the client/server structure. The client is running on NAS (Network Access Server), and the server is used for centralized management of user information. NAS is a server for users and a client for the server.

In particular, Authentication means to confirm the identity of users when they use the resources in the network system. During this process, the identity information obtained through interaction with users is submitted to the authentication server; the latter checks the identity information with the user information in the database, and then confirm whether users' identities are correct according to the processing result. Authorization means the network system authorizes users to use its resources in a specific way. This process specifies the services and permissions that the authenticated user can use and own after accessing the network, such as the IP address assigned. Accounting means the network system collects and records users' use of the network resources so as to charge fees from users for their use of the resources or use it for the purpose of auditing.

RADIUS (Remote Authentication Dial-In User Service) is a C/S-structured protocol. Its client was a NAS server at the beginning. RADIUS protocol authentication mechanism is flexible. It can use PAP, CHAP or Unix login. RADIUS is an extensible protocol, and all of its work is based on the vector of Attribute-Length-Value. The basic working principle of RADIUS is as follows: after users access the NAS, the NAS submits user information to the RADIUS server using data packet Access-Require, including user name, password and other related information. In particular, the user password is MD5 encrypted. The two parties use a shared key which is not propagated through network. The RADIUS server checks the legality of the user name and password, and when necessary, it can put forward a challenge to request further user authentication or similar authentication for the NAS. If it is legal, return the data packet Access-Accept to the NAS, allowing the user to proceed to the next step. Otherwise, it will return the data packet Access-Reject and deny user access. If the access is allowed, the NAS will request Account-Require to the RADIUS server which will give a response of Account-Accept prior to user statistics. At the same time, users can perform their own operations.

TACACS (Terminal Access Controller Access Control System) is an old authentication protocol for Unix network. It allows remote access server to send user login password to the authentication server which

determines whether the user can log in to the system. As an encryption protocol, TACACS has a lower security than the later TACACS+ and RADIUS. In fact, TACACS+ is a new protocol. It has superseded previous protocols with RADIUS in existing network. TACACS+ uses Transmission Control Protocol (TCP), and RADIUS applies User Datagram Protocol (UDP). RADIUS combines authentication and authorization from the perspective of users, while TACACS+ separates them.

68.2 AAA Function Configuration

Table 68 AAA Function Configuration List

Configuration Task	
Configure AAA Domain	Configure ISP Domain
Configure Authentication Function under AAA Domain	Configure default, login, dot1x and portal Authentication Method under ISP Domain
Configure Authorization Function under AAA Domain	Configure Default, Login and Commands Authorization Method under ISP Domain
Configure Accounting Function under AAA Domain	Configure Default, Login, Dot1x, Portal and Commands Accounting Method under ISP Domain
Configure Authentication Method of Entering Privileged Mode	Configure Authentication Method of Entering Privileged Mode
Configure to Enable Command Line Authorization	Configure to Use Command Line Authorization
	Configure to Use Console Authorization
Configure System Accounting Function	Configure System Event Accounting Method
Configure Statistics-related Properties	Configure to Close Accounting of Empty User Name
	Configure Sending of Accounting Update Packet
	Configure Method of Sending Accounting Failure for Processing
Configure RADIUS Program	Configure RADIUS Server
	Configure RADIUS-related Properties
	Configure to Send Source Address of RADIUS Packet

Configuration Task	
Configure TACACS Program	Configure TACACS Server
	Configure to Send Source Address of TACACS Packet

68.2.1 Configure AAA Domain

Domain: NAS manages users based on ISP (Internet Service Provider) domain. Each user belongs to an ISP domain. Generally, the ISP domain to which the user belongs is determined by the user name provided by the user at the time of login. By default, the system has a system domain. You can configure the authentication, authorization and charging method of each type of access user under the domain.

The solution for user and AAA management based on domain is described as follows:

NAS device manages users based on ISP domain. Generally, the ISP domain to which the user belongs is determined by the user name provided by the user at the time of login.

"User name input by user" = "user name understood by user" + "domain name"

During user authentication, the device identifies its domain by the following order, and then performs the AAA policy in the domain:

1) [Optional] Log in/access the authentication domain specified by module configuration;

2) ISP domain specified in the user name;

3) Default ISP domain of the system.

Configuration Condition

None

Configure ISP Domain

Table 68 Configuring AAA Domain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the view of ISP domain	**domain** *isp-name*	Optional.

Step	Command	Description
		By default, the system has an ISP domain named system.
Exit the global configuration mode	**exit**	-
Configure the default ISP domain	**domain default enable** *isp-name*	Optional. By default, the default ISP domain of the system is system domain.

68.2.2 Configure Authentication Function Under AAA Domain

AAA provides a series of authentication method to guarantee the security of device and network service. For example, prohibit illegal users from operating the device by authenticating user login; authenticate users' entering into the privileged mode and limit users' permission of using the device; authenticate PPP session connection and limit the establishment of illegal connection.

Configuration Condition

None

Configure the Authentication Method Under ISP Domain

When a user try to log in to a specific ISP domain, AAA can authenticate this user and prohibit the user from logging in to the ISP domain if it fails to pass the authentication.

Table 68 Configuring List of Authentication Methods under ISP Domain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the view of ISP domain	**domain** *isp-name*	Mandatory. By default, the system has an ISP domain named system.

Step	Command	Description
Configure the default authentication method under ISP domain	**aaa authentication default** { **none** / **local** / **radius-group** *group-name* / **tacacs-group** *group-name* }	Optional. By default, the default authentication method under ISP domain is local.
Configure the user login authentication method under ISP domain	**aaa authentication login** { **none** / **enable** / **local** / **radius-group** *group-name* / **tacacs-group** *group-name* }	Optional. By default, the login authentication method is not configured. The default authentication method under the domain is used.
Configure the portal|dot1x authentication method under ISP domain	**aaa authentication {portal | dot1x}{ none / local /radius-group** *group-name* / **tacacs -group** *group-name* }	Optional. By default, the portal and dot1x authentication methods are not configured. The default authentication method under the domain is used.

68.2.3 Configure Authorization Function Under AAA Domain

After the successful authentication, the authorization function of AAA can control the administrator's permission of using device resources and the access of users to network resources, limit the administrator's execution of unauthorized command, and limit the access of users to unauthorized network resources.

Configuration Condition

For the command line authorization under the configuration domain, please enable command line authorization first to enable that configured under the domain to take effect.

Configure the Authorization Method Under ISP Domain

When a user executes an authorized item under a specific ISP domain, AAA can authorize this user, grant permissions to it, and prohibit it from executing the authorized item under the domain if it fails to pass the authorization.

Table 68 Configuring List of Authorization Methods under ISP Domain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the view of ISP domain	**domain** *isp-name*	Mandatory. By default, the system has an ISP domain named system.
Configure the default authorization method under ISP domain	**aaa authorization default** { **if-authenticated** / **local** / **none** / **radius-group** *group-name* / **tacacs-group** *group-name* }	Optional. By default, the authorization method under ISP domain is none.
Configure the authorization method of commands under ISP domain	**aaa authorization commands** *cmd-lvl* { **if-authenticated** / **none** / **radius-group** *group-name* / **tacacs-group** *group-name* }	Optional. By default, the authorization method of commands under ISP domain is not configured. The authorization method under the domain is none. To enable this configuration to take effect, you must enable the command authorization function.
Configure the user login authorization method under ISP domain	**aaa authorization login** { **if-authenticated** / **local** / **none** / **radius-group** *group-name* / **tacacs-group** *group-name* }	Optional. By default, the login authorization method under ISP domain is not configured. The default authorization method under the domain is used.

Note

- **aaa authorization commands** and **aaa authorization config-commands** can be configured in any order.

68.2.4 Configure Accounting Function Under AAA Domain

Users' use of commands on the device, login of sessions, network service conditions and system events can be summarized with the user-defined method. The result provides a basis for charging users.

Configuration Condition

None

Configure the Accounting Method Under ISP Domain

When a user successfully logs in to a certain ISP domain, AAA can account for this user, including start login time, end login time, and the commands input.

Table 68 Configuring Accounting Methods under ISP Domain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the view of ISP domain	**domain** *isp-name*	Mandatory. By default, the system has an ISP domain named system.
Configure the accounting method of command lines under ISP domain	**aaa accounting commands** *cmd-lvl* { [**broadcast**] **tacacs-group** *group-name* }	Optional. By default, the command accounting method is not configured, and command accounting is not conducted.

Step	Command	Description
Configure the default accounting method under ISP domain	**aaa accounting default** { **none** | { **start-stop** | **stop-only** | **wait-start** [**broadcast**] { **radius-group** *group-name* / **tacacs-group** *group-name* }}}	Optional. By default, the accounting method under ISP domain is none.
Configure the user login accounting method under ISP domain	**aaa accounting login**{ **none** | { **start-stop** | **stop-only** | **wait-start** [**broadcast**] { **radius-group** *group-name* / **tacacs-group** *group-name* } } }	Optional. By default, the login accounting method under ISP domain is not configured. The default accounting method under ISP domain is used.
Configure the portal|dot1x accounting method under ISP domain	**aaa accounting** { **portal | dot1x }** { **none** | { **start-stop** | **stop-only** | **wait-start** [**broadcast**] { **radius-group** *group-name* / **tacacs-group** *group-name* } } }	Optional. By default, the portal and dot1x accounting methods under ISP domain are not configured. The default accounting method under ISP domain is used.

68.2.5 Configure the Authentication Method of Entering Privileged Mode

After the user successfully logs in to the device, AAA can input enable command for the user to enter the privileged mode for authentication and prohibit the user who fails to pass the authentication from entering the privileged mode.

Configuration Condition

None

Configure the Privileged Mode Authentication Method

Table 68 Configuring Privileged Mode Authentication Method

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the privileged mode authentication method	**aaa authentication enable-method** { **none** / **enable** / **radius-group** *group-name* / **tacacs-group** *group-name* }	Optional. By default, the privileged mode authentication method is enable.

Note

- When using the **RADIUS** authentication method, the password of the user name in the format of **$enabLEVEL$** is used as the authentication password. In particular, **LEVEL** means the user level entered by current user. Its value ranges from **0 to 15**, with level **15** being the highest.

68.2.6 Configure to Enable Command Line Authorization

Configuration Condition

None

Configure to Use Command Line Authorization

The device has commands with levels from 0 to 15. Command authorization is used to determine the level of command used by the user through the authorization method, and restrict the user from using the command higher than current level.

Table 68 Enabling Command Authorization in Global Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable command line authorization	**aaa authorization config-commands**	Mandatory. By default, the command line

Step	Command	Description
		authorization function is closed.

Configure to Use CONSOLE Authorization

To restrict access to the CONSOLE port, you can enable CONSOLE port authorization and activate the command authorization function. After that, the device will authorize the commands executed by the CONSOLE port.

Table 68 Configuring to Use Console Authorization

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to Use Console Authorization	**aaa authorization console**	Mandatory. By default, the Console authorization is disabled.

68.2.7 Configure the System Event Accounting Function

Users may send the events like system start and restart to the server for accounting by configuring the system event accounting method.

Configuration Condition

None

Configure System Event Accounting Method

Table 68 Configuring List of System Event Accounting Methods

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure System Event Accounting Method	**aaa accounting system** { **none** | { **start-stop** [**broadcast**] { **tacacs-group** *group-name* } } }	Mandatory By default, the accounting of system event is not conducted.

Note

- System event account supports **TACACS** protocol instead of **RADIUS** protocol.

68.2.8 Configure Statistics-related Properties

Configuration Condition

None

Configure to Close Accounting of Empty User Name

Users may close the AAA's accounting of empty user names by configuring the command **aaa accounting suppress null-username**. By default, AAA's accounting of empty user names is enabled.

Table 1 Configuring to Close Accounting of Empty User Names

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to Close Accounting of Empty User Name	**aaa accounting suppress null-username**	Mandatory. By default, the accounting of empty user names is enabled.

Configure Sending of Accounting Update Packet

Users can configure the method of sending accounting update packets, including real-time sending and periodic sending.

Table 2 Configuring Sending of Accounting Update Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Sending of Accounting Update Packet	**aaa accounting update periodic** *interval*	Mandatory. By default, the accounting update packets are not sent.

Configure Method of Sending Accounting Failure for Processing

Table 68 Configuring Method of Sending Accounting Failure for Processing

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the method of sending accounting failure for processing	**aaa accounting start-fail {online | offline}**	Optional. By default, users who fail to start the accounting cannot go online.

68.2.9 Configure RADIUS Program

To configure RADIUS program, you must first configure key parameters of the server.

Configuration Condition

None

Configure RADIUS Server

If AAA needs to use RADIUS for authentication, authorization and accounting, you are required to configure RADIUS server-related parameters, including server IP address, authentication/authorization port, accounting port, and shared key.

Before entering the RADIUS server, you need to configure a RADIUS server group. When quoting the server group name to configure the method list, you can use the RADIUS server group for authentication, authorization and accounting of users.

Table 3 Configuring RADIUS Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the RADIUS server group name (this command can also lead to the RADIUS server group configuration mode)	**aaa server group radius** *group-name*	Mandatory. By default, the RADIUS server group name is not configured.
Configure RADIUS Server	**server {***ip-address*|*ipv6 ip-address***} [acc-port** *acc-port-num* **] [auth-port** *auth-port-num* **] [priority** *priority* **] { key [0 | 7]** *key* **}**	Mandatory. By default, the RADIUS server is not configured.
Configure quiet period of RADIUS	**dead-time** *dead-time*	Optional. By default, the quiet period of RADIUS server is 0, i.e. no quiet period.
Configure the maximum times of RADIUS retransmission	**retransmit** *retries*	Optional. By default, the maximum times of retransmission by RADIUS server are 3.
Configure the response timeout	**timeout** *timeout*	Optional.

Step	Command	Description
time of RADIUS server		By default, the timeout time of waiting for the RADIUS server to respond is 5 seconds.
Configure not to check the TAG tag when resolving the tunnel attributes issued by the RADIUS server	**tunnel without-tag**	Optional. By default, TAG tag is required when resolving the tunnel attributes issued by the RADIUS server
Configure the VRF to which the RADIUS server group belgongs	**ip vrf forwarding** *vrf-name*	Optional. By default, the RADIUS server group belongs to the global VRF.

Note

- The device selects the order of using the **RADIUS** server according to the **priority** value configured.
- Quiet period means that the device marks the **RADIUS** servers which give no response to the authentication request unavailable, and no longer gives request to these servers during the **dead time**.
- The shared keys configured on the device and the **RADIUS** server must be consistent.

Configure RADIUS-related Properties

Table 4 Configuring Relevant Attributes of RADIUS

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the value of service-type in the RADIUS packets for login authentication	**radius login service-type** *attr-value*	Optional By default, the value of service-type in RADIUS packet is 7.
Configure the maximum number of concurrent packets of NAS device and RADIUS server	**radius control-speed** *pck-num*	Optional By default, the maximum number of concurrent packets of NAS device and RADIUS server is 100.

Configure to Send Source Address of RADIUS Packet

Table 5 Configuring Source Address of Sending RADIUS Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the interface selected by the RADIUS source address	**ip radius source-interface** *interface-name* [**vrf** *vrf-name*]	Optional By default, the device automatically selects source interface.

Configure the Accounting-on Function Which Can Send RADIUS

The accounting-on function is mainly used to make all the online users on the specified RADIUS server offline when the AAA process is pulled up for the first time. By default, the accounting-on function is disabled; when the account-on function is enabled, the default retransmission interval is 6 seconds, and the maximum times of retransmission are 50; since the SPU of high-end device starts slow, it is recommended that the retransmission times and interval be no less than the default values.

Table 68 Configuring Accounting-on Function of RADIUS

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the RADIUS server group mode	**aaa server group radius** *group-name*	-
Configure the accounting-on function of RADIUS	**accounting-on enable [interval** *seconds* **| send** *send-times***]**	Optional. By default, the accounting-on function is disabled.

68.2.10Configure TACACS Program

To configure TACACS program, you must first configure key parameters of the server.

Configuration Condition

None

Configure TACACS Server

After the TACACS server is configured, if AAA needs to use TACACS for authentication, authorization and accounting, you are required to configure TACACS server-related parameters, including server IP address, shared key, and server port number.

When quoting the server group name to configure the method, you can use the TACACS server group for authentication, authorization and accounting of users.

Table 6 Configuring TACACS Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the TACACS server group name (this command can also lead to the TACACS	**aaa server group tacacs** *group-name*	Mandatory. By default, the TACACS server group name is not configured.

Step	Command	Description
server group configuration mode)		
Configure TACACS Server	**server {***ip-address*|**ipv6** *ip-address*} [**port** *port-num*] [**priority** *priority*] { **key** [**0** | **7**] *key*}	Mandatory. By default, the member server of TACACS server group is not configured.
Configure the response timeout time of TACACS server	**timeout** *timeout*	Optional. By default, the timeout time of waiting for the TACACS server to respond is 5 seconds.
Configure the VRF attribute of TACACS server group	**ip vrf forwarding** *vrf-name*	Optional. By default, the TACACS server group belongs to the global VRF.

Note

- You can execute **server** {*ip-address*|**ipv6** *ip-address*} [**port** *port-num*] [**priority** *priority*] {**key** [**0** | **7**] key} multiple times to configure the multiple **TACACS** servers under the **TACACS** server group. The device will select servers by the configuring order for authentication. When a server fails, the device will automatically select the next one.
- The shared keys configured on the device and the **TACACS** server must be consistent.

Configure to Send Source Address of TACACS Packet

Table 7 Configuring Source Address of Sending TACACS Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure the interface selected by the TACACS source address	**ip tacacs source-interface** *interface-name* [**vrf** *vrf-name*]	Optional. By default, the device automatically selects source interface.

68.2.11AAA Monitoring and Maintaining

Table 8 AAA Monitoring and Maintaining

Command	Description
debug aaa { **authentication** | **authorization** | **accounting** | **event** | **error** | **all** }	Turn on the AAA debugging information switch
debug radius [details]	Turn on the TACACS debugging information switch
debug tacacs	Turn on the TACACS debugging information switch
show aaa configuration	Show the information of AAA configuration
show aaa module [dot1x | shell | shell-cmd | shell-web]	Show the function module of AAA and the result of operating AAA last time by this module
show aaa server [radius | tacacs]	Show the RADIUS/TACACS server configuration and status of AAA
show aaa session [dot1x | portal | shell | shell-web]	Show AAA statistics session
show aaa source-address	Show the source address used by AAA

68.3 Typical Configuration Example of AAA

68.3.1 Configure Telnet User Login for Local Authentication

Network Requirements

- Enable the Device to conduct local authentication for Telnet user login

Network Topology

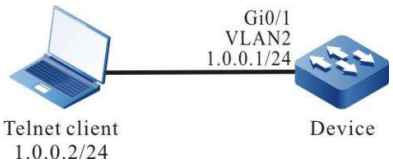


Figure 68 Network Topology for Configuring Local Authentication for Telnet User Login

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure the Device.

#Configure both user name and password as admin1.

```
Device#configure terminal
Device(config)#local-user admin1 class manager
Device(config-user-manager-admin1)#service-type telnet
Device(config-user-manager-admin1)#password 0 admin1
Device(config-user-manager-admin1)#exit
```

#Configure the AAA authentication mode to local authentication.

```
Device(config)#domain system
Device(config-isp-system)#aaa authentication login local
Device(config-isp-system)#exit
```

#Configure Telnet session and enable AAA local authentication.

```
Device(config)#line vty 0 15
Device(config-line)#login aaa
Device(config-line)#exit
```

Step 4: Check the result.

When the client logs in to the Device through telnet, it can successfully go to the Shell user interface of the Device by inputting user name and password admin1.

68.3.2 Configure Telnet User Login for RADIUS Authentication, Authorization and Accounting

Network Requirements

- The Device is connected to the Telnet client and RADIUS server, and the IP route is reachable.
- The IP address of the RADIUS server is 2.0.0.2/24; the authentication and authorization port is 1812; the accounting port is 1813; the shared key is admin.
- When the Telnet user logs in to the Device, it needs to perform authentication, authorization, and accounting through the RADIUS server.
- When the RADIUS server fails, local authentication and authorization apply.

Network Topology

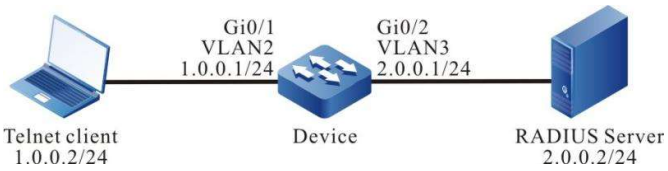


Figure 68 Network Topology for Configuring RADIUS Authentication, Authorization and Accounting for Telnet User Login

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure the Device.

#Configure AAA to use RADIUS authentication/authorization and accounting.

Note

- For authentication and authorization, first use the first method in the list of methods, and use the second method when the server fails.

```
Device#configure terminal
Device(config)#domain system
Device(config-isp-system)#aaa authentication login radius-group radius-group local
Device(config-isp-system)#aaa authorization login radius-group radius-group local
```

```
Device(config-isp-system)#aaa accounting login start-stop radius-group radius-group
Device(config-isp-system)#exit
```

#Configure the RADIUS server: the authentication port is 1812; the accounting port is 1813; the shared key is admin.

```
Device(config)#aaa server group radius radius-group
Device(config-sg-radius-radius-group)#server 2.0.0.2 auth-port 1812 acct-port 1813 key admin
Device(config-sg-radius-radius-group)#exit
```

#Configure Telnet session and enable RADIUS authentication, authorization and accounting.

```
Device(config)#line vty 0 15
Device(config-line)#login aaa
Device(config-line)#exit
```

Step 4: Configure the RADIUS server.

For the interface setting of RADIUS server, please see the help document of the server. The specific steps are shown below.

#Add user admin on the RADIUS server, set the password as admin, and configure the user level as 15.

#Set the IP address of the server as 2.0.0.2, shared key as admin, authentication port as 1812, and accounting port as 1813.

#Set the IP address of the client as 2.0.0.1 and shared key as admin.

Step 5: #Check the result, and verify authentication, authorization and accounting.

#After the Telnet user logs into the Device for successful authorization, show privilege to view the user priority, i.e. 15.

#Check the login and disconnection information on the RADIUS server.

68.3.3 Configure Telnet User Level Switch for RADIUS Authentication

Network Requirements

- The Device is connected to the Telnet client and RADIUS server, and the IP route is reachable.
- The IP address of the RADIUS server is 2.0.0.2/24; the authentication/authorization port is 1812; the shared key is admin.
- When the Telnet user logs in to the Device and the user level switches to 3 from 1, it needs to perform authentication through the RADIUS server.

Network Topology

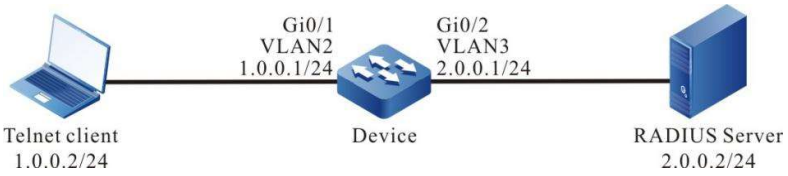


Figure 68 Network Topology for Configuring RADIUS Authentication for Telnet User Level Switch

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure the Device.

#Configure user level switch for RADIUS authentication.

```
Device#configure terminal
Device(config)#aaa authentication enable-method radius-group radius-group
Device(config)#domain system
Device(config-isp-system)#aaa authentication login radius-group radius-group local
Device(config-isp-system)#exit
```

#Configure the RADIUS server: the authentication port is 1812; the shared key is admin.

```
Device(config)#aaa server group radius radius-group
Device(config-sg-radius-radius-group)#server 2.0.0.2 auth-port 1812 acct-port 1813 key admin
Device(config-sg-radius-radius-group)#exit
Device(config)#line vty 0 15
Device(config-line)#login aaa
Device(config-line)#exit
```

Step 4: Configure the RADIUS server.

For the interface setting of RADIUS server, please see the help document of the server. The specific steps are shown below.

#Add user name $enab3$ (user level 3), and set the password as admin.

Note

- User level switch uses the user name authentication in the format of $enabLEVEL$. In particular, the uppercase LEVEL is the level to which the user intends to switch.
- No authentication is required when the user level decreases.

Step 5: Check the result.

Telnet users input user name and password according to the prompt. After login, the user level is 1 by default. After executing the command enable 3, input the password admin. After successful authentication by the RADIUS server, the user level switches to 3.

68.3.4 Configure TACACS Authorization and Accounting of SHELL Command

Network Requirements

- Device and TACACS server are interconnected, and the route is reachable.
- The IP address of the TACACS server is 2.0.0.2/24; the service port is 49; the shared key is admin.
- After the Telnet client logs in to the Device, the SHELL command with a user level of 15 is required to be authorized by the TACACS server and recorded on the TACACS server.

Network Topology

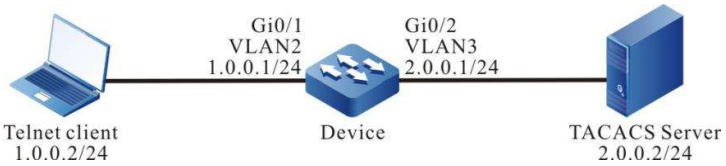


Figure 68 Network Topology for Configuring TACACS Authorization and Accounting for SHELL Command

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure the Device.

#Configure authorization and accounting of TACACS command.

Note

- The authentication must succeed prior to authorization and accounting.

```
Device#configure terminal
Device(config)#domain system
Device(config-isp-system)#aaa authentication login tacacs-group tacacs-group local
Device(config-isp-system)#aaa authorization commands 15 tacacs-group tacacs-group
Device(config-isp-system)#aaa accounting commands 15 tacacs-group tacacs-group
Device(config-isp-system)#exit
Device(config)#aaa authorization config-commands
```

#Configure the TACACS server: the service port is 49; the shared key is admin.

```
Device(config)#aaa server group tacacs tacacs-group
Device(config-sg-tacacs-tacacs-group)#server 2.0.0.2 port 49  key admin
Device(config-sg-tacacs-tacacs-group)#exit
```

#Configure Telnet session and enable TACACS authorization and accounting.

```
Device(config)#line vty 0 15
Device(config-line)#login aaa
Device(config-line)#exit
```

Step 4: Configure TACACS server.

For the interface setting of TACACS server, please see the help document of the server. The specific steps are shown below.

#Add the client 2.0.0.1 on the server; the shared key is admin; select "TACACS+(Cisco IOS)" authentication.

#Set SHELL command authorization for the admin of Telnet user. Permit commands configure terminal, router ospf and router rip, and deny other commands.

Step 5: Check the result.

#After logging in to the Device, the Telnet user can execute corresponding SHELL command. The command which is successfully authorized can be successfully executed, while the command which fails to be authorized cannot be executed.

```
Device#configure terminal
% Enter configuration commands, one per line.  End with CNTL+Z.
Device(config)#router ospf 100
Device(config-ospf)#exit
Device(config)#router rip
Device(config-rip)#exit
Device(config)#interface gigabitethernet 0/1
Command authorization failed
Device(config)#router bgp 100
Command authorization failed
```

#View the statistics of SHELL command.

#Check the statistics of SHELL command on the TACACS server.

69 802.1X

69.1 Overview

69.1.1 802.1X

802.1X is a broadband access authentication program proposed by IEEE in June 2001. It defines a Port-Based Network Access Control protocol. By utilizing the physical access features of IEEE 802 architecture LAN, 802.1X provides the method of connecting the device on LAN port in point-to-point mode for authentication, charging and authorization.

802.1X system is a typical client/server structure, as shown in the figure below. It includes three entities, i.e. Supplicant system, Authentication system, and Authentication server system.

Figure 69 802.1X System Structure

- Install software that supports 802.1X authentication on the client and sends an authentication request to the authentication device. After the authentication succeeds, it can normally access the network.
- Located between the client and the authentication server, the authentication device controls network access of the client through server interaction.
- Generally, the authentication server is RADIUS (Remote Authentication Dial-In User

Service) server. It is used to verify the legality of the client and notify the authentication result to the authentication device which controls network access of the client according to the authentication result.

The EAP (Extensible Authentication Protocol) used in 802.1X authentication is a general protocol for PPP authentication. It is used to realize the interaction of authentication information between the client, authentication device, and authentication server. The 802.1X protocol uses the EAPOL (EAP Over LAN) frame encapsulation format to encapsulate EAP packets to realize the interaction between client and authentication device. Depending on the application scenarios, the 802.1X protocol will encapsulate EAP packets in different frame formats to realize the interaction between authentication device and authentication server. In relay authentication, the EAP packets are encapsulated in EAPOR (EAP Over RADIUS) frame format; in termination authentication, EAP packets are encapsulated in standard RADIUS frame format.

802.1X authentication has two types, i.e. relay and termination.

The following figure shows relay authentication mode:

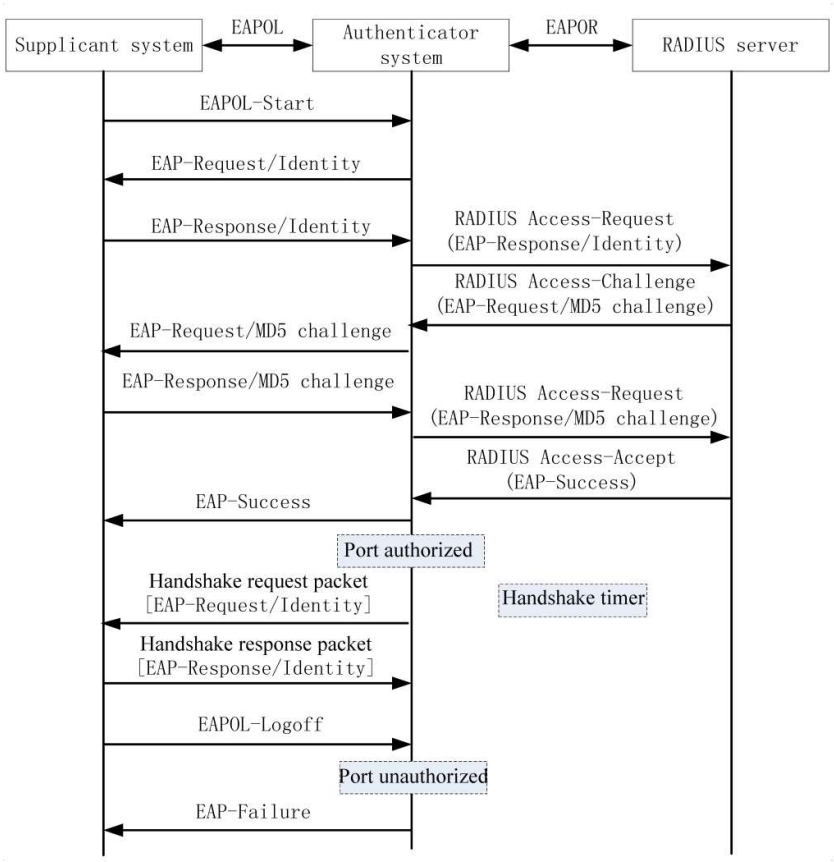


Figure 69 802.1X Relay Authentication Process

The relay authentication process is as follows:

- When the users intend to access the network, they can open the program on the 802.1X client, input the legal user name registered on the authentication server and password,

and initiate an authentication request (EAPOL-Start packet). At this time, the client program will send the packet requesting authentication to the authentication device, and start an authentication process;

- After the authentication device receives the data frame of requesting authentication, it will send a user name which the request frame (EAP-Request/Identity packet) requires the client program of the user to send;
- The client program responds to the request sent by the authentication device and sends the user name to the authentication device through a data frame (EAP-Response/Identity packet). The authentication device encapsulates the data frame sent by the client in a packet (RADIUS Access-Request packet) and sends it to the authentication server for processing;
- After the RADIUS server receives the user name forwarded by the authentication device, it compares the information with the user name table in the database, finds the password corresponding to the user name, encrypts it with an encrypted character randomly generated, and sends this character through the RADIUS Access-Challenge packet to the authentication device which then forwards it to the client program;
- After the client program receives the encrypted character (EAP-Request/MD5 Challenge packet) from the authentication device, it uses the encrypted character to encrypt the password part (this kind of encryption algorithm is usually irreversible, and it will generate EAP-Response/MD5 Challenge packet), and passes it to the authentication server through the authentication device;
- The RADIUS authentication server compares the encrypted password received (RADIUS Access-Request packet) with the local password after encryption operation. If they are the same, it is believed that this user is legal and it will give the message that authentication succeeds (RADIUS Access-Accept packet and EAP-Success packet);
- The authentication device changes the port to authorized after receiving the message that authentication succeeds, allowing the user to access the network through the port;
- The client can also send an EAPOL-Logoff packet to the authentication device to request to go offline. The authentication device changes the port status from authorized to unauthorized, and sends an EAP-Failure packet to the client.

This requires both the authentication device and the authentication server support EAP.

The following figure shows termination authentication mode:

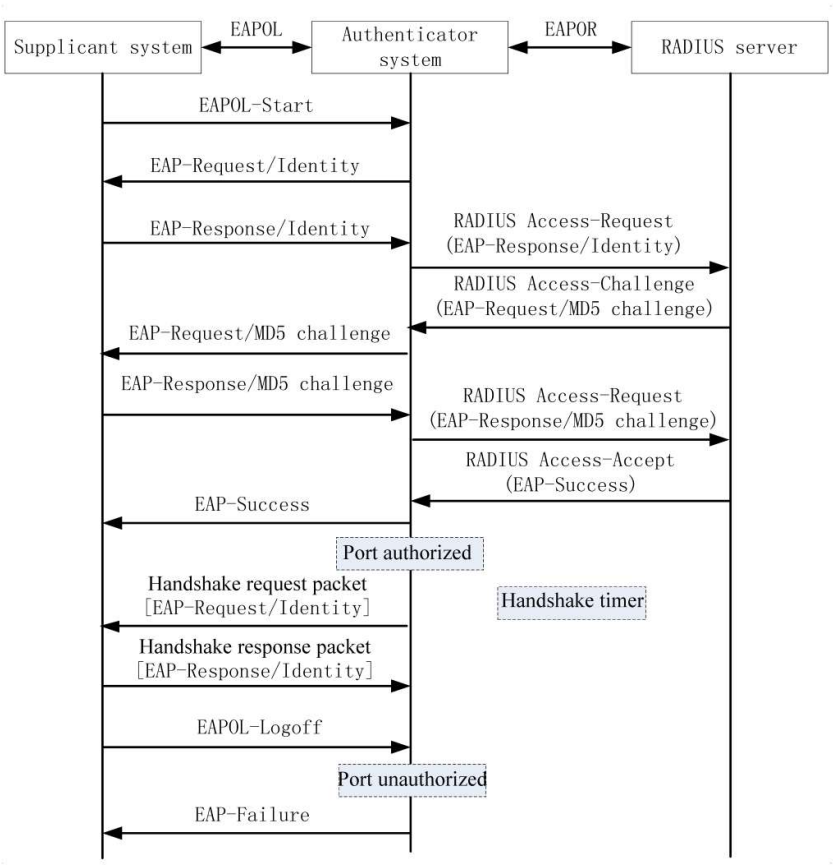


Figure 69 802.1X Termination Authentication Process

- The process of termination authentication is different from that of relay authentication in that the randomly encrypted character for encryption of user password is generated by the authentication device which then sends the user name, randomly encrypted character and client encryption password to the RADIUS server for relevant authentication processing.

Termination authentication is used for the authentication server which is deployed earlier and doesn't support EAP protocol.

The authentication device supports two types of access control:

- Port-based access control: After the first user under the port is successfully authenticated, other users can access the network without authentication. But when the first user goes offline, other users are not allowed to access the network;
- Macbased access control: All access users under the port need to be individually authenticated. After a user goes offline, it cannot access the network any longer. Yet this does not affect other users' access to the network.

Sometimes Auto VLAN is also called Assigned VLAN. When the client passes the server authentication, the server will send the authorized VLAN information to the authentication device. If this VLAN exists and is legal in the authentication device, the authentication port will be added to it. After the client goes offline,

the port becomes unauthenticated again and is deleted from this Auto VLAN, and the default VLAN of the port recovers to the previous one.

When the Guest VLAN function is enabled, the user can only access the resources in the VLAN without authentication; after the successful user authentication, the port leaves the Guest VLAN and the user can access other network resources. Generally, the user can obtain 802.1X client software from the Guest VLAN to upgrade the client, or execute other application (e.g. anti-virus software and OS patches) upgrading. After enabling 802.1X authentication and correctly configuring the Guest VLAN, the port will be added to the Guest VLAN in Untagged mode. At this time, the user under the port in the Guest VLAN initiates authentication. If the authentication fails, the port is still in the Guest VLAN; if it succeeds, one of the following two circumstances applies:

- If the authentication server issues a VLAN, the port moves from the Guest VLAN to the issued VLAN. After the user goes offline, the port will go back to the Guest VLAN;
- If the authentication server does not issue any VLAN, the port moves from the Guest VLAN to the Config VLAN that has been configured in the authentication device. After the user goes offline, the port will go back to the Guest VLAN.

69.1.2 Secure Channel Authentication

The secure channel authentication function is based on the 802.1X authentication function. In addition to 802.1X authentication, it can open a secure channel for specific terminal users so that they can access the resources in the specified network when they are not authenticated, or specify specific terminal users to access network resources without authentication.

69.1.3 MAC Address Authentication

In the actual network, in addition to plenty of terminal users, there may be some network terminals (e.g. network printers). These terminals do not have their own or cannot be installed with 802.1X authentication client software. In this case, you can access the network without client authentication. With this authentication method, users don't have to install any 802.1X authentication client software. After detecting the MAC address of the user for the first time, the authentication device sends the configured user name and password or the MAC address of the user as user name and password to the authentication server for authentication.

Generally, the MAC address uses the following two formats of user name and password:

MAC address: Use the MAC address of the authenticated user as user name and password;

Fixed user name and password: Use the user name and password that have been configured on the authentication device.

69.2 802.1X Function Configuration

Table 69-1 802.1X Function Configuration List

Configuration Task	
Configure 802.1X Authentication	Enable 802.1X Authentication
Configure Secure Channel Authentication	Enable Secure Channel Authentication Function
	Configure and Apply Secure Channel
Configure 802.1X Authentication and Secure Channel Authentication Attributes	Configure Port Authentication Method
	Configure Multicast Trigger
	Configure Reauthentication Function
	Configure the Maximum Number of Port Authentication Failures
	Configure Function of Omitting IP Field in User Name
	Configure Function of Transparent Transmission of Packets
	Configure Keepalive Function
	Configure Function of Not Waiting for Response of Server
Configure MAC Address Authentication	Enable MAC Address Authentication Function
	Configure MAC Address Authentication User Name Format
	Configure Domain Name Used in Global MAC Authentication
Configure Common Attributes	Configure Control Direction
	Configure Authenticable Host List
	Configure IP Authorization Function

Configuration Task	
	Configure the Maximum Times of Transmitting Authentication Request Packets
	Configure the Maximum Times of Transmitting Authentication Packets
	Configure Function of Data Logging
	Configure ARP Keepalive Function
	Configure the Maximum Number of Users on Port
	Configure IP ACL Prefix Name
	Configure Default Valid VLAN
	Configure Function of Permitting Unauthenticated Users to Communicate in the VLAN of PVID
	Configure Port Access Control Method
	Configure Guest VLAN
	Configure Guest ACL
	Configure Critical VLAN
	Configure User Authentication Migration Function
	Configure Timer Parameters
	Restore Default Configurations of Port
	Configure Step Size of Log Record

69.2.1 Configure 802.1X Authentication Function

Permit to configure both 802.1X authentication and MAC address authentication under the same port.

- When MAC address authentication is first conducted for terminal users, if the authentication succeeds, the 802.1X authentication initiated by these terminal users will not be processed. Otherwise, the 802.1X authentication initiated by these terminal users

will be processed.

- If 802.1X authentication is first conducted for the terminal users, no MAC address authentication is required.

Configuration Condition

None

Enable 802.1X Authentication

To enable the 802.1X authentication function, the terminal user has to install the client software with 802.1X authentication.

Table 69-2 Enabling 802.1X

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable global 802.1X authentication	**dot1x { enable | disable }**	Optional By default, the global 802.1X authentication function is enabled.
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable 802.1X Authentication	**dot1x port-control** { **enable** | **disable** }	Mandatory By default, the 802.1X authentication function under the port is disabled.

Note

- The 802.1X authentication and secure channel authentication functions cannot be both enabled under the same port.
- The 802.1X authentication and port security functions can be both enabled under the same port, but port security IP rules and MAX rules are not allowed to configure.
- When both 802.1X authentication and port security functions are used, if the port security is configured with relevant MAC rules, 802.1X doesn't process the sending packets and authentication request of this terminal. Instead, they will be processed by port security.

Configure the Function of Triggering the Generation of 802.1X Users Through ARP/IP Packets

After the 802.1X authentication function is enabled under the port, if the terminal user intends to view its information on the authentication device when it does not initiate authentication, you need to configure function of triggering the generation of 802.1X users through ARP/IP packets.

If the functions of 802.1X authentication and triggering the generation of 802.1X users through ARP/IP packets are both enabled under the same port, when the authentication device receives the ARP or IP packets of the terminal user under the port, 802.1X user can be generated.

Table 69-3 Enabling Function of Triggering Generation of 802.1X Users Through ARP/IP Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure the function of triggering the generation of 802.1X users through ARP/IP packets	**dot1x arp-ip-auth** { **enable** | **disable** }	Mandatory By default, the function of triggering the generation of 802.1X users through ARP/IP packets under the port is disabled.
Configure the timeout value of triggering the generation of 802.1X users through ARP/IP packets	**dot1x arp-ip-auth timeout** *timeout-value*	Optional By default, the timeout value of triggering the generation of 802.1X users through ARP/IP packets under the port is 5 minutes.

69.2.2 Configure Secure Channel Authentication

Configuration Condition

None

Enable Secure Channel Authentication

The secure channel authentication function is based on the 802.1X authentication function. In addition to 802.1X authentication, it can open a secure channel for specific terminal users so that they can access the resources in the specified network when they are not authenticated, or specify specific terminal users to access network resources without authentication.

Table 69-4 Enabling Secure Channel Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enable secure channel authentication	**dot1x free-ip**	Mandatory By default, the secure channel authentication function under the port is disabled.

Note

The secure channel authentication and port security functions cannot be both enabled under the same port.

The 802.1X authentication and secure channel authentication functions cannot be both enabled under the same port.

The MAC address authentication and secure channel authentication functions cannot be both enabled under the same port.

When the secure channel authentication function is enabled under the port, yet no secure channel is applied or no secure channel rule is configured, the secure channel authentication function is the same as 802.1X authentication function.

In case of secure channel authentication, after the user passes the authentication, it will occupy chip resources. Insufficient chip resources will lead to failure of user authentication.

Configure and Apply Secure Channel

After enabling the secure channel authentication function under the port, to permit terminal users to access the resources in the specified network when they are not authenticated, or specify specific terminal users to access network resources without authentication, you need to configure and apply secure channel.

Secure channel rules can be configured as follows.

- Permit terminal users to access specified network resources.
- Permit specified terminal users to access network resources.

Table 69 Applying Secure Channel

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure secure channel	**hybrid access-list advanced** { *access-list-number* | *access-list-name* }	Mandatory By default, no secure channel is configured in the device.
Configure secure channel rules	[*sequence*] **permit [ether-ipv6]** *protocol* { **any** | *source-ip-addr source-wildcard* | **host** *source-ip-addr* } { **any** | *source-mac-addr source-wildcard* | **host** *source-mac-addr* } { **any** | *destination-ip-addr destination-wildcard* | **host** *destination-ip-addr* } { **any** | *destination-mac-addr destination-wildcard* | **host** *destination-mac-addr* }	Mandatory By default, there are no secure channel rules under the secure channel.
Apply secure channel	**global security access-group** { *access-group-number* | *access-group-name* }	Mandatory By default, no secure channel is applied in the system.

Note

A device can be configured with multiple secure channels, and a secure channel may have multiple secure channel rules.

The type of secure channel can be mixed advanced ACL only, and only one secure channel can be applied in the device.

Configure the Function of URL Redirection

When URL redirection is configured on the authentication device, the authentication device will redirect the URL address the user visits to the configured redirected URL address when the user accesses a non-authentication-free network segment where it is

not authenticated or fails to pass the authentication. In the specified URL page, users can download/upgrade the authentication client, or update software.

Table 69 Configuring URL Redirection Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure secure channel	**hybrid access-list advanced** { *access-list-number* | *access-list-name* }	Mandatory By default, no secure channel is configured in the device.
Configure secure channel rules	[*sequence*] **permit [ether-ipv6]** *protocol* { **any** | *source-ip-addr source-wildcard* | **host** *source-ip-addr* } { **any** | *source-mac-addr source-wildcard* | **host** *source-mac-addr* } { **any** | *destination-ip-addr destination-wildcard* | **host** *destination-ip-addr* } { **any** | *destination-mac-addr destination-wildcard* | **host** *destination-mac-addr* }	Mandatory By default, there are no secure channel rules under the secure channel.
Apply secure channel	**global security access-group** { *access-group-number* | *access-group-name* }	Mandatory By default, no secure channel is applied in the system.
Configure the function of URL redirection	**dot1x url** *url-redirect-string*	Mandatory By default, redirected URL address is not configured on the device.

Note

The authentication-free network segment should have the IP address of DNS server and the IP address of redirected URL link.

The client is required to apply for an address from the DHCP server. When the authentication device itself is not a DHCP server, the DHCP RELAY function should be enabled to ensure that the client can normally obtain IP address.

69.2.3 Configure 802.1X Authentication and Secure Channel Authentication Attributes

If the 802.1X authentication function or secure channel authentication function is not enabled under the port, relevant attributes configured cannot take effect.

Configuration Condition

None

Configure Port Authentication Method

802.1X authentication has two types, i.e. relay and termination.

The 802.1X authentication is composed of three parts, i.e. client, authentication device, and authentication server. According to the standard 802.1X protocol, the client interacts with the authentication server through EAP packets. The authentication device, as a "relay" in the interaction, encapsulates the EAP data sent by the client in other protocols, e.g. RADIUS protocol, and sends them to the authentication server. Likewise, the authentication device encapsulates the EAP data sent by the authentication server in an EAPOL packet and forwards them to the client. This way of interaction is called relay authentication. It requires the authentication server to support EAP protocol. The specific authentication mechanism supported by EAP relay authentication depends on the client and the authentication server.

The authentication server deployed earlier may not support EAP protocol. It needs to be configured with termination authentication. The EAP packets of the client will not be directly sent to the authentication server. Instead, the authentication device will complete the EAP packet interaction with the client. After the authentication device obtains enough information about user authentication, the authentication information is sent to the authentication server for authentication.

EAP termination authentication supports PAP (Password Authentication Protocol) authentication and CHAP (Challenge Handshake Authentication Protocol) authentication.

Table 69 Configuring Port Authentication Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure port authentication mode	**dot1x eap-relay** { **enable** | **disable** }	Mandatory By default, the port authentication mode is termination authentication.

Note

Configure termination authentication. Currently, only the EAP authentication based on MD5 (Message Digest Algorithm Version 5) is supported. The 802.1X authentication and secure channel authentication functions support both relay and termination authentication.

When the client uses certificate authentication, the authentication port needs to be configured as relay authentication.

MAC address authentication supports termination authentication only.

Configure Multicast Trigger

Some terminals have 802.1X authentication client, but the client cannot initiate authentication. The authentication process can only be triggered by the authentication device. The authentication device will periodically send a multicast packet requesting user name to the port configured with multicast trigger. After receiving this packet, the client responds to the authentication request of the authentication device and begins the authentication process.

Table 69 Configuring Multicast Trigger

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable multicast trigger	**dot1x multicast-trigger**	Mandatory By default, the multicast trigger under the port is disabled.
Configure multicast trigger period	**dot1x multicast-period** *multicast-period-value*	Optional By default, the multicast trigger time under the port is 15 seconds.

Note

If the client doesn't support multicast trigger, its network card may display abnormally and cause failure of reauthentication.

Configure Reauthentication Function

In order to detect whether the client is online, prevent abnormal client crashes from affecting the accuracy of charging, and prevent the client from being illegally used by others, the authentication device will

periodically initiate a reauthentication request to the client. During this process, users are not required to input user name and password again.

Table 69 Configuring Reauthentication Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Reauthentication Function	**dot1x reauthentication**	Mandatory By default, the reauthentication function is enabled under the port.

Configure the Maximum Number of Authentication Failures

When the number of authentication failures on the client reaches the upper limit, the client becomes quiet, during which period, the authentication device gives no response to the authentication request initiated by this client.

Table 69 Configuring Maximum Number of Authentication Failures

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the upper limit of the maximum number of port authentication failures	**dot1x max-authfail** *max-authfail-value*	Mandatory By default, the maximum number of authentication failures under the port is 1.

Configure Function of Transparent Transmission of Packets

In the actual application environment, there may be intermediate devices between the terminal to be authenticated and the authentication device. If these intermediate devices cannot transparently transmit EAPOL packets, a normal authentication process is impossible. In order to enable a normal authentication process, you are required to enable the transparent transmission of EAPOL packet on the port of the intermediate device which receives EAPOL packet, and configure an uplink port for this port. If the port where the function of EAPOL packet transparent transmission is enabled receives an EAPOL packet, it will send it out from the configured uplink port. If the device directly connected to the uplink port is an authentication device, the authentication device will process the EAPOL packet after receiving it.

Table 1 Configuring Function of Packet Transparent Transmission

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure Function of Transparent Transmission of Packets	**dot1x eapol-relay** { **enable** | **disble** }	Mandatory By default, the function of packet transparent transmission under the port is disabled.
Configure uplink port for packet transparent transmission	**dot1x eapol-relay uplink** { **interface** *interface-name* | **link-aggregation** *link-aggregation-id* }	Mandatory By default, uplink port is not configured under the port.

Configure Keepalive Function

In order to check whether the client is online, the authentication device will periodically send EAP-Request/Identity packet to the client. After receiving the EAP-Response/Identity packet from the client, it will send EAP-Request/MD5 Challenge packet to the client. If the authentication system receives the EAP-Response/MD5 Challenge packet, it confirms that the client is online normally, and sends an EAP-Success packet to notify the client of the successful keepalive.

Table 2 Configuring Keepalive Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure Keepalive Function	**dot1x keepalive** { **enable** | **disable** }	Mandatory By default, the keepalive function under the port is disabled.
Configure keepalive time	**dot1x keepalive period** *period-value*	Optional By default, the keepalive period under the port is 60 seconds.
Configure the times of keepalive packets retransmission	**dot1x keepalive retries** *retries-value*	Optional By default, the maximum keepalive times is 3.
Configure keepalive type	**dot1x keepalive type { request-identity | request-md5}**	Optional By default, the keepalive type under the port is standard keepalive.

Note

The keepalive function needs the support of 802.1X authentication client software (the TC client of our company). If the client doesn't support this function, the keepalive will fail and the user will go offline.

Configure Function of Not Waiting for Response of Server

Under relay authentication, the client may send some packets to which the server will not respond. These packets will make the session channels of authentication device and authentication server occupied so that subsequent client authentication fails. To avoid this, you can enable the function of not waiting for response of server under the port.

Table 3 Configuring Function of not Waiting for Response of Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Function of Not Waiting for Response of Server	**dot1x nowait-result**	Mandatory By default, the function of not waiting for response of server under the port is disabled.

69.2.4 Configure MAC Address Authentication

Permit to configure both 802.1X authentication and MAC address authentication under the same port.

- When MAC address authentication is first conducted for terminal users, if the authentication succeeds, the 802.1X authentication initiated by these terminal users will not be processed. Otherwise, the 802.1X authentication initiated by these terminal users will be processed.
- If 802.1X authentication is first conducted for the terminal users, no MAC address authentication is required.

Configuration Condition

None

Enable MAC Address Authentication Function

MAC address authentication is also called client-free authentication. This authentication method applies to both the terminals where client software cannot be installed for authentication, and the terminal users who do not have client software and can authenticate without inputting user name and password.

When configuring the parameters related to MAC address authentication under the port of authentication device, if the MAC address authentication function is not enabled on the port, relevant functions configured cannot take effect.

Table 69 Enabling MAC Address Authentication Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable MAC Address Authentication Function	**dot1x mac-authentication** { **enable** | **disable** }	Mandatory By default, the MAC address authentication function under the port is disabled.

Note

The MAC address authentication and port security functions can be both enabled under the same port, but port security IP rules and MAX rules are not allowed to configure.

The MAC address authentication and secure channel authentication functions cannot be both enabled under the same port.

Configure MAC Address Authentication User Name Format

There are two types of user name and password formats for MAC address authentication: fixed and MAC address.

Fixed user name and password: When the authentication device receives the data packet of the terminal user, it will send the user name and password configured to the authentication server for authentication.

MAC address user name and password: The authentication will use the MAC address of the terminal user as user name and password. The MAC address format may either contain hyphen (e.g. 00-01-7a-00-00-01) or not contain hyphen (e.g. 00017a000001).

Table 4 Configuring Format of User Name for MAC Address Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure MAC Address Authentication User Name Format	**dot1x mac-authentication user-name-format** { **fixed account** *account-value* **password** *password-value* |	Mandatory By default, the MAC address with hyphen is used as user name and

Step	Command	Description
	mac-address [**with-hyphen** | **without-hyphen**] }	password for MAC address authentication.

Configure the Domain Name Used in Global MAC Authentication

This function can be enabled when the MAC authentication users connected to all ports on the device are required to be assigned to a specified domain for authentication.

By default, the domain name used in MAC authentication is not specified in the global mode. The domain used for user authentication should be the mandatory authentication domain configured on the port. If no such domain is configured on the port, use the domain contained in the user name. If the user name does not contain any domain, use the default domain of the aaa module.

After configuring on the port, the priority of the domain used by users who access mac authentication under the port is as follows: mandatory authentication domain configured on the port > domain contained in the fixed user name configured on the port > domain globally specified to be used for mac authentication > default domain of aaa module; the priority of the domain used by the 1x authentication users accessed under the port is as follows: mandatory authentication domain configured on the port > domain contained in the user name > default domain of the aaa module.

Table 69-16 Configuring Domain Name Used in Global MAC Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the domain name used in global MAC authentication	**dot1x mac-authentication domain** *domain-name*	Mandatory By default, the domain name used in global MAC authentication is not configured under the port.

Configure Domain Name Separator

The authentication device can manage users based on domains. If the authentication user name contains a domain name, the device uses the server in the corresponding AAA server group to authenticate, authorize and charge the user. If the authentication user name does not contain any domain name, it will use the default authentication server in the system for authentication. Therefore, the authentication device should be able to accurately resolve the user name and domain name in the user name. This is very critical in providing authentication services for users. Different clients support different user name and domain name

separators. In order to better manage and control the user access with different user name formats, it is required to specify the supported domain name separators on the authentication device.

At present, the domain name separators supported include @, \, and /.

When the domain name separator is '@', the format of authentication user name is username@domain.

When the domain name separator is '/', the format of authentication user name is username/domain.

When the domain name separator is '\', the format of authentication user name is domain\username.

In particular, username means a pure user name, and domain denotes a domain name. If the user name contains multiple domain name separators, the authentication device will identify the first one as the actual domain name separator, and all others will be considered as part of the domain name.

Table 5 Configuring Domain Name Separator

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure domain name separator	**dot1x domain-delimiter** *domain-delimiter-type*	Mandatory By default, the domain name separator under the port is '@'.

Note

When using the user name with a domain name for authentication, corresponding authentication server group needs to be configured on the authentication device.

Configure the Format of Authentication User Name

The authentication user is named in the format of 'username@domain', and the content following the separator '@' is a domain name. The authentication device determines which authentication server group is used to authenticate the user by resolving the domain name. Some earlier servers cannot accept user names that contain domain names. In this case, the authentication device needs to remove the domain names from the user names and only send the authentication user names to the server. Whether the authentication user name sent to the authentication device contains a domain name can be selected by configuring the format of authentication user name.

At present, the domain name separators supported include @, \, and /.

Table 69-18 Configuring Format of Authentication User Name

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the format of authentication user name	**dot1x user-name-format** { with-domain | without-domain }	Mandatory By default, the authentication user name with domain name is sent to the authentication server.

Note

Configure the port that sends the authentication user name without domain name to the authentication server. Certificate authentication is not supported.

Configure Authentication Packet Interaction Mode

In actual application scenarios, after most clients initiate authentication, the unicast/multicast authentication interaction mode is supported between the authentication device and the client. However, some authentication clients only recognize multicast authentication packets, i.e. those with a destination MAC address of 0180.C200.0003. In this case, the multicast authentication interaction mode can be configured under the port.

For most authentication clients, after the authentication device receives the EAP packet from the server for the first time, subsequent interactions with the client and the authentication server are all subject to the identifier contained in the server packet. Very few authentication clients are subject to the identifier generated by the authentication device during authentication. In this case, it is required to configure the function of caring about the identifier in EAP authentication packet under the port.

Table 69-19 Configuring Authentication Packet Interaction Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure authentication interaction mode	**dot1x auth-mac** { **multicast** | **unicast** }	Mandatory By default, the unicast authentication packet interaction mode is used under the port.
Function of caring about the identifier in EAP authentication packet	**dot1x identifier** { **match** | **ignore** }	Optional By default, the identifier in EAP authentication packet is not cared about.

Note

Very few clients need to care about the identifier in EAP authentication interaction packet. Unless explicitly required, do not configure this function as far as possible.

69.2.5 Configure Common Attributes

When configuring the parameters of common attributes, if the 802.1X authentication function, secure channel authentication function or MAC address authentication function is not enabled on the port, relevant functions configured cannot take effect.

Configuration Condition

When configuring the IP authorization function under the port, you are also required to configure the ARP keepalive function.

Configure Control Direction

Port control direction has two types, i.e. two-way control and one-way control.

- Two-way control means the port cannot receive or forward packets.
- One-way control means the port cannot receive the packets from the client, though it can forward packets to the client.

It is used with the WOL (Wake On Lan) function. For some terminals, although they are dormant, their network card can process some special packets, such as WOL packets. After receiving the WOL packet, the network card will start the terminal device and begin working.

When the authentication function is enabled on the access port of the dormant terminal, you can configure the port as one-way control to ensure that WOL packets can be forwarded to the terminal normally. After the terminal is started, authentication activity can be initiated. It can normally access network resources after passing the authentication.

When sending WOL packets across network segments, it is required to configure ARP forwarding entries on the authentication device.

Table 69-20 Configuring Control Direction

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure Control Direction	**dot1x control-direction** { **both** | **in** }	Mandatory By default, the port is controlled in both directions.

Configure Authenticable Host List

After the function of authenticable host list is enabled, only the user whose MAC address is in the authenticable host list is permitted to conduct authentication activity. The authentications initiated by other users will be denied.

Table 69-21 Configure Authenticable Host List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Authenticable Host List	**dot1x auth-address** { **enable | disable |** *mac-address* }	Mandatory By default, the authenticable host list under the port is disabled.

Configure IP Authorization Function

Enable the IP authorization function under the port. If any change of the IP address of the authentication user is detected, the user will become offline. There are several modes:

disable: Disable mode. Under this mode, the IP address of user is not detected.

dhcp-server: DHCP Server mode. When configuring this mode, you are required to configure the DHCP Snooping function on the device. After the authentication user obtains IP address from the DHCP server, the device will record the binding relationship between authentication user and IP address. If any change of the IP address of the authentication user is detected, the user will become offline.

radius-server: RADIUS Server mode. RADIUS Server encapsulates in the RADIUS packet the IP address that the authentication user should use in the Frame-IP-Address field. The authentication device records the

binding relationship between the user and this IP address. If it finds that the IP address of the user has changed, the user will become offline.

Supplicant: client mode. After the user passes the authentication for the first time, the binding relationship between the authentication user and the IP address is recorded on the device. If any change of the IP address of the user is detected, the user will become offline.

bind-mac-ip: MAC+IP binding mode. After the user passes the authentication for the first time, MAC+IP binding entries will be generated and saved. Then, only the IP address in the binding entries generated by the first authentication is permitted to access the network.

Table 69-22 Configuring IP Authorization Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure IP Authorization Function	**dot1x authorization ip-auth-mode { disable | dhcp-server | radius-server | supplicant | bind-mac-ip }**	Mandatory By default, the IP authorization function under the port is disabled.

Configure the Maximum Times of Transmitting Authentication Request Packets

After receiving the EAPOL-Start packet sent by the client, the authentication device will send an authentication request EAP-Request/Identity packet to the client. If the authentication device fails to receive the response packet, the packet will be retransmited. This function is used to configure the maximum times of sending EAP-Request/Identity packets. If the times of sending exceed the configured

upper limit, the authentication device will consider the client has disconnected and end the authentication activity.

For the process of retransmitting EAP-Request/Identity packet, see the figure below:

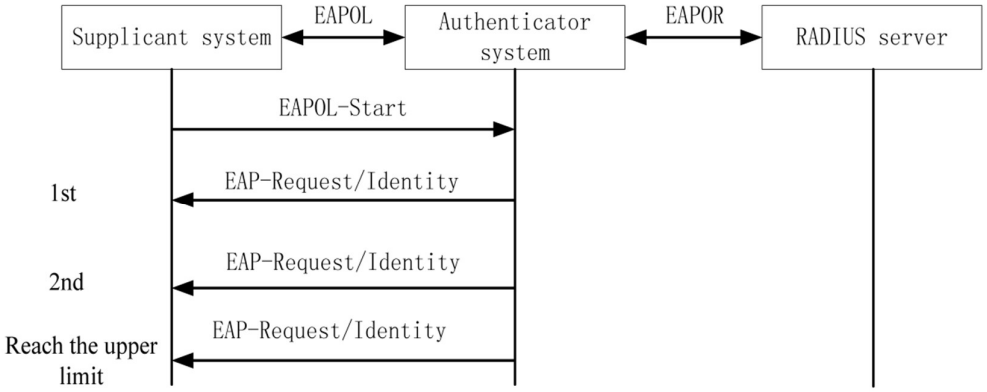


Figure 69 Retransmission of EAP-Request/Identity Packet

Table 69-23 Configuring the Maximum Times of Transmitting Authentication Request Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the Maximum Times of Transmitting	**dot1x max-reauth** *count*	Mandatory

Step	Command	Description
Authentication Request Packets		By default, the maximum times of transmitting authentication request packets under the port are 3.

Configure the Maximum Times of Transmitting Authentication Packets

During the process of authentication, the authentication device sends other EAP-Request packets than EAP-Request/Identity packet to the client, such as EAP-Request/MD5 challenge packet. If the authentication device fails to receive the response packet, the packet will be retransmited. This function is used to configure the maximum times of sending these packets. If the times of sending exceed the configured upper limit, the authentication device will consider the client authentication fails.

For the process of retransmitting EAP-Request packet, see the figure below:

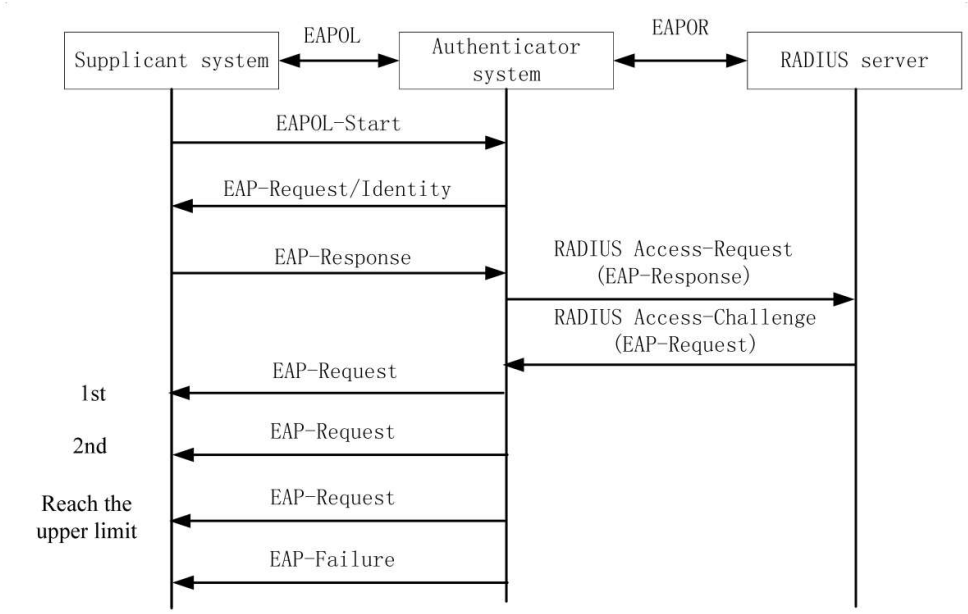


Figure 69 Retransmission of EAP-Request Packet

Table 69-24 Configuring the Maximum Times of Transmitting Authentication Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the Maximum Times of Transmitting Authentication Packets	**dot1x max-req** *count*	Mandatory By default, the maximum times of transmitting authentication packets under the port are 2.

Configure Function of Data Logging

After the data logging function is enabled, the authentication device will record the information about the user's going online and offline and the change of user information for the convenience of troubleshooting.

Table 69-25 Configuring Data Logging Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure Function of Data Logging	**dot1x logging security-data** {**abnormal-logoff** | **failed-login** | **normal-logoff** | **successful-login** | **information**}*	Mandatory By default, the data logging function is not enabled under the port.

Configure ARP Keepalive Function

After the terminal user authentication succeeds, to check whether the user is online, the authentication device can send ARP request packet to the authenticated user. It identifies whether the user is online through the ARP response packet it can receive or not from the user.

Table 69-26 Configuring ARP Keepalive Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration

Step	Command	Description
		takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure ARP Keepalive Function	**dot1x client-probe** { **enable** | **disable** }	Mandatory By default, the ARP keepalive function under the port is disabled.

Note

To normally trigger the ARP keep-alive function, the authentication device has to obtain the IP address of the authenticated user. If the ARP response packet fails to be received from the authentication device during the protection period, the user will become offline.

Configure the Maximum Number of Users on Port

After the number of users authenticated under the port reaches the upper limit configured, the authentication system no longer responds to the authentication request initiated by the new user.

Table 69-27 Configuring Maximum Number of Users on Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		subsequent configuration takes effect only within the aggregation group.
Configure the Maximum Number of Users on Port	**authentication max-user-num** *max-uer-num-value*	Mandatory By default, at most 256 users are permitted to access under the port.

Note

Under the port, configure as Macbased access control. Otherwise, the configured number of users permitted to access cannot take effect.

Configure IP ACL Prefix Name

After the terminal user authentication succeeds, when the number of the IP ACL issued by the server is greater than 2000, the IP ACL named "IP ACL prefix name" + "ACL number" needs to be configured in the device. For example, if the server issues ACL 2001, the IP ACL named "assignacl-2001" should be configured on the device.

Table 69-28 Configuring IP ACL Prefix Name

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure IP ACL Prefix Name	**dot1x number-acl-prefix** *number-acl-prefix-name*	Mandatory By default, the IP ACL prefix name is "assignacl-".

Note

When the access control method is configured as portbased host-mode multi-hosts, the function of issuing ACL is not valid.

Configure Default Valid VLAN

When the server issues no VLAN (Auto VLAN), to make the users who pass authentication communicate within the specified VLAN, you can use this configuration to specify a VLAN.

Table 69-29 Configuring Default Valid VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Default Valid VLAN	**dot1x default-active-vlan** *default-active-vlan-id*	Mandatory By default, no default valid VLAN is configured under the port.

Note

After the user authentication succeeds, the priority of binding with VLAN is as follows: VLAN issued by the server, default valid VLAN, and VLAN to which the port PVID belongs.

When Macbased access control is configured under the port, the default valid VLAN will take effect only when the port meets the following conditions: VLAN mode is hybrid and MAC VLAN is enabled.

Configure Function of Permitting Unauthenticated Users to Communicate in the VLAN of PVID

When multiple terminals access the port, each of them should have access control. This command can be enabled for the network resources which some terminals intend to access even if they cannot initiate 802.1X authentication. After this function is enabled, the unauthenticated terminal user can normally communicate in the VLAN of PVID.

This function can be normally used only when it meets the following conditions:

- 802.1X authentication or MAC address authentication is enabled on the port.
- The port access control is Macbased.
- The port VLAN mode is Hybrid.
- The function of receiving Untag packets only is enabled under the port.

Table 69-30 Configuring Function of Permitting Unauthenticated Users to Communicate in the VLAN of PVID

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Function of Permitting Unauthenticated Users to Communicate in the VLAN of PVID	**dot1x native-vlan-free**	Mandatory By default, the function of permitting unauthenticated users to communicate in the VLAN of PVID is disabled under the port.

Note

After this function is enabled on the port, the function of receiving Untag packets only should also be enabled (configure the following command under the port: switchport accept frame-type untag) to guarantee the packets sent by the users who fail to pass the authentication are forwarded within the VLAN of PVID only.

It is recommended that this function be used with the VLAN issued by the server or the default valid VLAN configured.

This function does not support secure channel authentication.

Configure Port Access Control Method

There are two types of port access control: Portbased and Macbased.

Portbased access control: Only one user is permitted to pass authentication under the port.

Macbased access control: Multiple users are permitted to pass authentication under the port. They cannot access the network without passing authentication.

The Portbased access control also has two modes: Multi-hosts and Single-host.

Multi-hosts: After one user passes authentication, other users under the port can access the network without authentication.

Single-host: Under the port, only one user is permitted to pass authentication and access the network. Other users cannot access the network or pass authentication.

Table 69-31 Configuring Port Access Control Method

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure access control method	**authentication port-method** { **macbased** | **portbased** }	Mandatory By default, user authentication method is enabled under the port.
Portbased access control method	**authentication port-method portbased host-mode** { **multi-hosts** | **single-host** }	Optional By default, Multi-hosts authentication is enabled under the port.

Note

When configuring the host mode under portbased access control, you should guarantee that the access control method has been configured as Portbased.

Configure Guest VLAN

The user can obtain 802.1X client software from the Guest VLAN to upgrade the client, or execute other application (e.g. anti-virus software and OS patches) upgrading.

Table 69-32 Configuring Guest VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Guest VLAN	**authentication guest-vlan** *guest-vlan-id*	Mandatory By default, no Guest VLAN is configured under the port, and the value range is 1~4094.

Note

The Guest VLAN of the port cannot be applied to the dynamic VLAN. If the VLAN ID specified by the Guest VLAN is automatically created by GVRP, then the Guest VLAN can be successfully configured, but it will not take effect.

To ensure various functions can be normally used, please assign different VLAN IDs to Voice VLAN, Private VLAN and Guest VLAN.

Configure Guest ACL

If the user fails to pass authentication, you can restrict it from accessing resources in the Guest VLAN by configuring Guest ACL under the port.

Table 69-33 Configuring Guest ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Guest ACL	**authentication guest-acl** *guest-acl-name*	Mandatory By default, Guest ACL rules are not configured under the port.

Note

If no Guest VLAN is configured under the port, the configuration of Guest ACL will not take effect.

Guest ACL only takes effect under the Macbased port access control method.

Corresponding ACL rules have been configured in the authentication device.

Configure Critical VLAN

When the user uses RADIUS authentication, if the authentication fails due to the unreachable authentication server, this user can access resources in the specified VLAN. This VLAN is called a Critical VLAN.

When the port is configured with portbased access control method, and there is user authentication on the port, yet all authentication servers are unreachable, the port will be added to the Critical VLAN, and all users under the port can access resources in the Critical VLAN.

When the port is configured with Macbased access control method, and there is user authentication on the port, yet all authentication servers are unreachable, the user can only access resources in the Critical VLAN.

When the port is configured with Macbased access control method, it can be normally used only when it meets the following conditions:

- The port VLAN mode is Hybrid.
- Enable the MAC VLAN function on the port. When the user in the Critical VLAN initiates an authentication activity, if the authentication server is still unreachable, the user maintains in the Critical VLAN. If the authentication server is reachable, the user exits the Critical VLAN with the authentication result.

After the port is added to the critical VLAN and the authentication device is configured with the AAA detection function, when the authentication server is found reachable, if the critical-vlan recovery reinitialize function is configured, then:

- If the port is configured with Macbased access control method, the port added to the Critical VLAN will actively send unicast packets to all users in the Critical VLAN, triggering user reauthentication.
- If the port is configured with Portbased access control method, the port added to the Critical VLAN will actively send multicast packets to trigger user reauthentication.

Table 6 Configuring Critical VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure Critical VLAN	**authentication critical-vlan** *critical-vlan-id*	Mandatory By default, no Critical VLAN is configured under the port, and the value range is 1~4094.
Configure port recovery and trigger authentication	**authentication critical-vlan recovery-action reinitialize**	Optional By default, after the authentication server is found reachable, the port leaves the Critical VLAN only.

Note

- This function supports RADIUS authentication only.
- If the device is configured with radius and escape functions, i.e., aaa authentication dot1x radius none and critical vlan, when the user is authenticated and the authentication server is unreachable, the user will not enter the critical VLAN but escape directly; if only the escape function, i.e. aaa authentication dot1x none, and critical vlan are configured, when the user is authenticated, the escape function takes effect.
- When only Guest VLAN is configured under the port, the users who fail to pass the authentication are within the Guest VLAN. When both Guest VLAN and Critical VLAN functions are configured under the port, the user will enter the Critical VLAN if the authentication fails due to the unreachable authentication server, or the Guest VLAN if the authentication fails due to other reasons.
- For details of the AAA detection function, see the AAA configuration-related section.

Configure User Authentication Migration Function

The user authentication migration function applies to the scenarios where the same user (depending on the terminal MAC address) migrates from one authentication port to another in the same device. When the user authentication migration function is disabled, after a user is authenticated on one port of the device, it is not permitted to initiate authentication on another authentication port of the device; when the user authentication migration function is enabled, after the user is authenticated on one port, and the device finds that the user has migrated to another authentication port, the device deletes the authentication

information on the original port and then permits the user to initiate authentication on a new authentication port.

No matter whether the user authentication migration function is enabled, the device will record a log once it finds user migration between authentication ports.

Table 7 Configuring User Authentication Migration Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure User Authentication Migration Function	**authentication station-move { enable | disable }**	Mandatory By default, the user authentication migration function is disabled.

Configure Timer Parameters

The timer parameters under the port include re-authperiod, quiet-period, server-timeout, supp-timeout, and MAC address authentication user offline-detect.

Re-authperiod: After the reauthentication function is configured under the port, the authentication device periodically initiates reauthentication requests to the client, which applies to 802.1X authentication.

Quiet-period: When the client reaches the maximum number of authentication failures, the authentication device will respond to the authentication request from the client again after the quiet period expires. This applies to 802.1X authentication and MAC address authentication.

Server-timeout: If the authentication device fails to receive the server response packet within the specified time, it is considered that it has disconnected with the server. This applies to 802.1X authentication and MAC address authentication.

Supp-timeout: If the authentication device fails to receive response packet from the 802.1X client within the specified time, it is considered that it has disconnected with the user. This applies to 802.1X authentication.

MAC address authentication user offline-detect: After MAC address authentication is enabled, the port periodically checks whether the user is online. This applies to MAC address authentication.

Table 69-36 Configuring Timer Parameters

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Timer Parameters	**dot1x timeout** { **re-authperiod** *re-authperiod-value* | **quiet-period** *quiet-period-value* | **server-timeout** *server-timeout-value* | **supp-timeout** *supp-timeout-value* | **offline-detect** *offline-detect-value* }	Mandatory By default, the reauthentication time under the port is 3600 seconds, and the value range is 5~65535; the quiet period is 60 seconds, and the value range is 1~65535; the timeout time of the server is 30 seconds, and the value range is 5~3600;

Step	Command	Description
		the timeout time of the client is 30 seconds, and the value range is 5~3600; the client offline detection time is 300 seconds, and the value range is 5~3600.

Configure MAB Function

After the terminal passes the MAC address authentication, when it's necessary to use higher access rights through client authentication, you can enable this function.

Table 69-37 Enabling MAB Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable 802.1X Authentication	**dot1x port-control** { **enable** | **disable** }	Mandatory By default, the 802.1X authentication function under the port is disabled.
Enable MAC Address Authentication Function	**dot1x mac-authentication** { **enable** | **disable** }	Mandatory By default, the MAC address authentication

Step	Command	Description
		function under the port is disabled.
Enable MAB function	**dot1x after-mac-auth** { **enable** | **disable** }	Mandatory By default, the MAB function under the port is disabled.

Restore Default Configurations of Port

Recover the default configuration of 802.1X authentication and MAC address authentication under the port.

Table 69-38 Recovering Default Configuration of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Restore Default Configurations of Port	**dot1x default**	Mandatory The 802.1X authentication and MAC address authentication functions under the port are disabled, related configuration parameters are recovered to default values, and the

Step	Command	Description
		default configuration parameters do not take effect.

Note

The command show dot1x is used to view detailed default authentication configuration parameters.

Configure Mandatory Authentication Domain for Port

This function can be enabled when the users to be authenticated on the port are required to be assigned to a specified domain for authentication.

By default, no mandatory authentication domain is configured for the port. The domain used for user authentication should be that carried by the user. If there is no domain in the user name, use the default domain of the aaa module.

After configuration on the port, the user can use the domains by the following priority: domain configured under the port > domain carried by the user > default domain of aaa module.

Table 69-39 Enabling Mandatory Authentication Domain Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Enable 802.1X mandatory authentication domain function	**dot1x authentication domain** *domain-name*	Mandatory By default, no mandatory authentication domain is configured under the port.

69.2.6 802.1X Monitoring and Maintaining

Table 69-40 802.1X Monitoring and Maintaining

Command	Description
clear dot1x statistic [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* | **mac** { *mac-address* | **all** }]	Clear authentication statistics
clear dot1x auth-fail-user history [**mac** *mac-address*]	Clear record of failed authentication
show authentication user [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* | **mac** *mac-address* | **summary**]	Show the information of authentication management users
show authentication intf-status [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Show the information of authentication status
show dot1x	Show default configurations of authentication
show dot1x auth-fail-user history [**recent** | **mac** *mac-address*]	Show the information of authentication failure
show dot1x auth-address [*mac-address* | **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Show the information of authenticable host list
show dot1x config [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Show configurations of authentication

Command	Description
show dot1x free-ip	Show configuration information of secure channel.
show dot1x global config	Show the information of global configuration
show dot1x statistic [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* | **mac {** *mac-address* | **all** }]	Show authentication statistics
show dot1x user [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* | **summary**]	Show user information

69.3 Typical Example of Configuration OF 802.1X Function

69.3.1 Configure Portbased Authentication of 802.1X

Network Requirements

- PC1 and PC2 on the same LAN access the IP network through the Device where 802.1X access control is enabled;
- RADIUS authentication is used as an authentication method;
- Users can access the Update Server only when they fail to pass authentication. They are permitted to access the IP Network once it passes the authentication;
- After one user on the LAN passes authentication, other users on this LAN can access the IP Network without authentication.

Network Topology

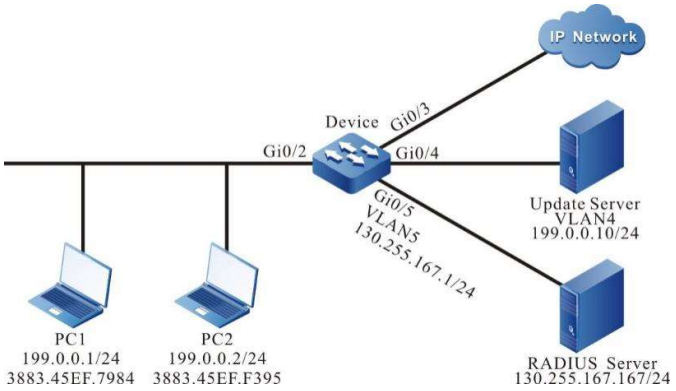


Figure 69 Network Topology for Configuring Portbased Authentication of 802.1X

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN2~VLAN5 on the Device.

```
Device#configure terminal
Device(config)# vlan 2-5
Device(config)#exit
```

#Configure the link type of port gigabitethernet0/2 to Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode access
Device(config-if-gigabitethernet0/2)#switchport access vlan 2
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the link type of the ports gigabitethernet 0/3~gigabitethernet 0/5 on the Device as Access, allowing the services of VLAN3~VLAN5 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN5 as 130.255.167.1/24.

```
Device(config)#interface vlan 5
Device(config-if-vlan5)#ip address 130.255.167.1 255.255.255.0
Device(config-if-vlan5)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA on the Device and use RADIUS authentication. The server key is admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
Device(config-isp-system)# aaa authentication dot1x radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

#On the AAA server, configure three attributes for the Auto VLAN issued by RADIUS: 64 as VLAN, 65 as 802, and 81 as VLAN3. (Omitted)

Step 5: Configure 802.1X authentication for the port.

#Enable 802.1X authentication on the port and configure Portbased mode.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x port-control enable
Device(config-if-gigabitethernet0/2)#authentication port-method portbased
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the Guest VLAN of the port as VLAN4.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#authentication guest-vlan 4
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Check the result.

#Before passing authentication, gigabitethernet0/2 is added to the Guest VLAN. At this moment, both PC1 and PC2 users are within VLAN4 and permitted to access the Update Server.

```
Device#show vlan 4
---- ---- -------------------------------- ------- --------- -------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- -------------------------------
1    4    VLAN0004                         static  Untagged  gi0/2  gi0/4
```

#Verify that PC1 can pass the authentication, and the authentication server issues VLAN3. At this moment, both PC1 and PC2 users are within VLAN3 and can access the IP Network.

```
Device#show dot1x user
-------------------
NO 1   : MAC_ADDRESS= 3883.45ef.7984  STATUS=     Authorized      USER_NAME=   admin
      VLAN=      3            INTERFACE=   gi0/2          USER_TYPE=   DOT1X
      AUTH_STATE=  AUTHENTICATED   BACK_STATE=  IDLE          IP_ADDRESS=  Unknown
      IPV6_ADDRESS= Unknown

      Online time: 0 week 0 day 0 hours 0 minute 51 seconds

 Total: 1    Authorized: 1  GetIP: 0  Unauthorized/guest/critical: 0/0/0   Unknown: 0
```

69.3.2 Configure Macbased Authentication of 802.1X

Network Requirements

- Both PC1 and PC2 access the IP network through the Device which uses 802.1X access

control;

- RADIUS authentication is used as an authentication method;
- PC can access the Update Server only when it fails to pass authentication. It permitted to access the IP Network once it passes the authentication;
- After one user on the LAN passes authentication, other users on this LAN still need to pass the authentication prior to accessing the IP Network.

Network Topology

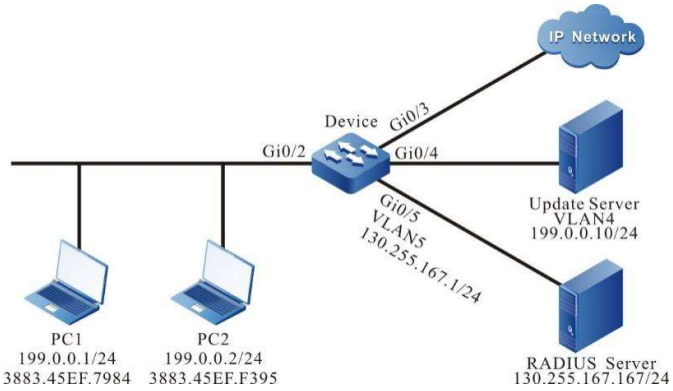


Figure 69 Network Topology for Configuring Macbased Authentication of 802.1X

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN2~VLAN5 on the Device.

```
Device#configure terminal
Device(config)#vlan 2-5
Device(config)#exit
```

#Configure the link type of port gigabitethernet 0/2 to Hybrid to allow services of VLAN2 to pass, and configure PVID to 2.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport hybrid untagged vlan 2
Device(config-if-gigabitethernet0/2)#switchport hybrid pvid vlan 2

Device(config-if-gigabitethernet0/2)#exit
```

#Configure the link type of the ports gigabitethernet 0/3~gigabitethernet 0/5 on the Device as Access, allowing the services of VLAN3~VLAN5 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN5 as 130.255.167.1/24.

```
Device(config)#interface vlan 5
Device(config-if-vlan5)#ip address 130.255.167.1 255.255.255.0
Device(config-if-vlan5)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
Device(config-isp-system)# aaa authentication dot1x radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key    admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

#On the AAA server, configure three attributes for the Auto VLAN issued by RADIUS: 64 as VLAN, 65 as 802, and 81 as VLAN3. (Omitted)

Step 5: Configure 802.1X authentication.

#Enable 802.1X authentication on the port and configure the authentication mode as Macbased.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x port-control enable
Device(config-if-gigabitethernet0/2)#authentication port-method macbased
Device(config-if-gigabitethernet0/2)#exit
```

#Enable the MAC VLAN of gigabitethernet0/2.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#mac-vlan enable
Device(config-if-gigabitethernet0/2)exit
```

#Configure the Guest VLAN of the port as VLAN4.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#authentication guest-vlan 4
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Check the result.

#Before passing authentication, gigabitethernet0/2 is added to the Guest VLAN. At this moment, both PC1 and PC2 users are within VLAN4 and can access the Update Server.

```
Device#show vlan 4
---- ---- -------------------------------- ------- --------- ------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Interface
---- ---- -------------------------------- ------- --------- ------------------------------
1    4    VLAN0004                         static  Untagged  gi0/2  gi0/4
```

#After PC1 users initiate authentication and successfully pass the authentication, they are within Auto VLAN3 and can access the IP Network. At this moment, PC2 still needs to pass the authentication prior to accessing the IP Network.

```
Device#show dot1x user
-------------------
NO 1  : MAC_ADDRESS= 3883.45ef.7984  STATUS=     Authorized      USER_NAME=   admin
      VLAN=      3            INTERFACE=   gi0/2          USER_TYPE=   DOT1X
      AUTH_STATE=  AUTHENTICATED   BACK_STATE=  IDLE          IP_ADDRESS=  Unknown
      IPV6_ADDRESS= Unknown

      Online time: 0 week 0 day 0 hours 0 minute 51 seconds

 Total: 1    Authorized: 1  GetIP: 0  Unauthorized/guest/critical: 0/0/0   Unknown: 0
```

#After PC2 users input incorrect user name or password authentication fails, PC2 users are within Guest VLAN4 and can access the Update Server.

```
Device#show dot1x user
-------------------
NO 1  : MAC_ADDRESS= 3883.45ef.f395   STATUS=     Unauth(guest)     USER_NAME=   admin
     VLAN=      4            INTERFACE=   gi0/2          USER_TYPE=   DOT1X
     AUTH_STATE=  GUEST_HELD      BACK_STATE=  IDLE          IP_ADDRESS=  Unknown
     IPV6_ADDRESS= Unknown

Total:1     Authorized: 0   Unauthorized/guest/critical: 0/1/0   Unknown: 0
```

69.3.3 Configure Transparent Transmission Mode of 802.1X

Network Requirements

- PC connects to Device2 where 802.1X access control is enabled through Device1 to access the IP Network.
- Device1 enables the function of transparent transmission, and Device 2 uses RADIUS authentication.
- PC can access the IP Network once it passes authentication.

Network Topology

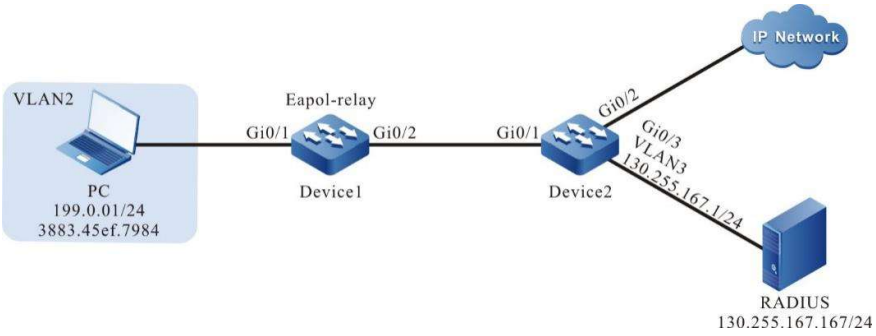


Figure 69 Network Topology for Configuring Transparent Transmission Mode of 802.1X

Configuration Steps

Step 1: Configure VLAN and port link type on Device2.

#Create VLAN2-VLAN3 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2-3
Device2(config)#exit
```

#Configure the link type of port gigabitethernet 0/1 to Access to allow services of VLAN 2 to pass.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode access
Device2(config-if-gigabitethernet0/1)#switchport access vlan 2
Device2(config-if-gigabitethernet0/1)#exit
```

#Configure the link type of the ports gigabitethernet 0/2~ gigabitethernet 0/3 on Device2 as Access, allowing the services of VLAN2~VLAN3 to pass. (Omitted)

Step 2: Configure the interface IP address of Device2.

#Configure the IP address of VLAN3 as 130.255.167.1/24.

```
Device2(config)#interface vlan 3
Device2(config-if-vlan3)#ip address 130.255.167.1 255.255.255.0
Device2(config-if-vlan3)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on Device2, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
Device(config-isp-system)# aaa authentication dot1x radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin (omitted).

Step 5: Configure the port VLAN of Device1.

#Configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 on Device1 as Access, allowing the services of VLAN2 to pass. (Omitted)

Step 6: On Device1, enable the function of 802.1X transparent transmission.

#Configure 802.1X transparent transmission mode on the port gigabitethernet0/1 of Device1, with the uplink port being gigabitethernet0/2.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#dot1x eapol-relay enable
Device1(config-if-gigabitethernet0/1)#dot1x eapol-relay uplink interface gigabitethernet 0/2
Device1(config-if-gigabitethernet0/1)#exit
```

Step 7: Configure 802.1X authentication mode on Device2.

#Enable 802.1X authentication on gigabitethernet0/1 and configure the port authentication mode as Portbased.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#dot1x port-control enable
Device2(config-if-gigabitethernet0/1)#authentication port-method portbased
Device2(config-if-gigabitethernet0/1)#exit
```

Step 8: Check the result.

#PC users can successfully pass the authentication and access the IP Network.

```
Device2#show dot1x user

---------------------

NO 1   : MAC_ADDRESS= 3883.45ef.7984  STATUS=     Authorized      USER_NAME=   admin
      VLAN=      2            INTERFACE=   gi0/1          USER_TYPE=   DOT1X
      AUTH_STATE=  AUTHENTICATED   BACK_STATE=  IDLE          IP_ADDRESS=  Unknown
      IPV6_ADDRESS= Unknown

      Online time: 0 week 0 day 0 hours 0 minute 51 seconds

 Total: 1    Authorized: 1  GetIP: 0  Unauthorized/guest/critical: 0/0/0   Unknown: 0
```

69.3.4 Configure 802.1X Free-Client Authentication

Network Requirements

- The network printer accesses IP network through the Device which uses 802.1X access control.
- The Device periodically conducts offline detection over the network printer.
- Use RADIUS authentication.
- After passing authentication, the network printer can perform the printing tasks from IP network.

Network Topology

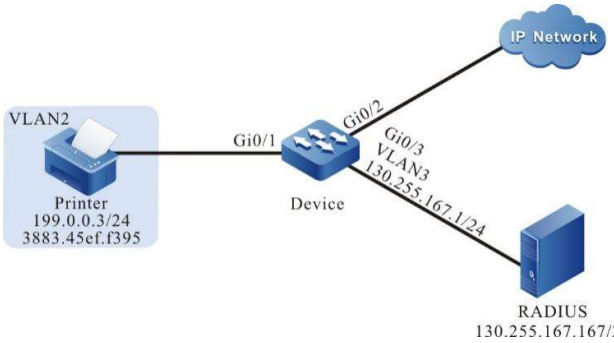


Figure 69 Network Topology for Configuring 802.1X Free-client Authentication

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN2-VLAN3 on the Device.

```
Device#configure terminal
Device(config)#vlan 2-3
Device(config)#exit
```

#Configure the link type of port as Access on gigabitethernet 0/1, permitting the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the link type of port as Access on gigabitethernet 0/2~ gigabitethernet 0/3 of the Device, allowing the services of VLAN2~VLAN3 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN3 as 130.255.167.1/24.

```
Device(config)#interface vlan 3
Device(config-if-vlan3)#ip address 130.255.167.1 255.255.255.0
Device(config-if-vlan3)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
Device(config-isp-system)# aaa authentication dot1x radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure 802.1X authentication.

#Configure 802.1X free-client authentication mode, and use the MAC address of the network printer as user name and password.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#dot1x mac-authentication enable
Device(config-if-gigabitethernet0/1)#exit
```

#Configure the Device to periodically conduct offline detection over the printer every 120 seconds.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#dot1x timeout offline-detect 120
Device(config-if-gigabitethernet0/1)#exit
```

Step 6: Check the result.

#The network printer can pass authentication and perform the printing tasks from IP network.

```
Device#show dot1x user
--------------------
NO 1   : MAC_ADDRESS= 3883.45ef.f395  STATUS=  Authorized    USER_NAME=   38-83-45-ef-f3-95
      VLAN=      2              INTERFACE=   gi0/1            USER_TYPE=   DOT1X
      AUTH_STATE=  AUTHENTICATED   BACK_STATE=  IDLE          IP_ADDRESS=  199.0.0.3
      IPV6_ADDRESS= Unknown

      Online time: 0 week 0 day 0  hours 1  minutes 6 seconds
Total: 1     Authorized: 1  GetIP: 0  Unauthorized/guest/critical: 0/0/0   Unknown: 0
```

69.3.5 Configure Secure Channel

Network Requirements

- PC1 and PC2 on the same LAN access the IP network through the Device where secure channel access control is enabled;
- RADIUS authentication is used as an authentication method;
- PC1 can access the Update Server prior to passing authentication. It is permitted to access the Update Server once it passes the authentication;
- PC2 can access the Update Server and IP Network without authentication.

Network Topology

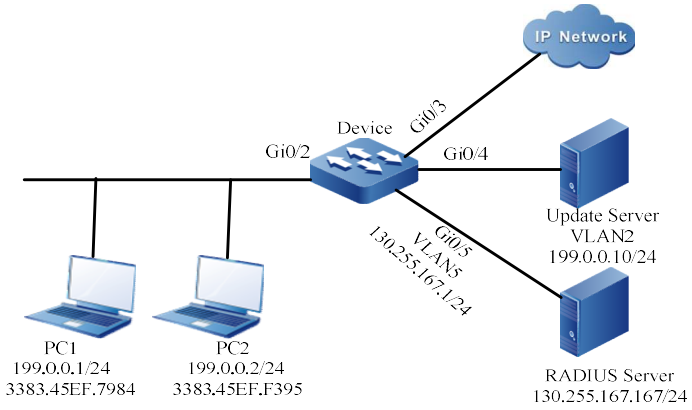


Figure 1 Network Topology for Configuring Secure Channel

Configuration Steps

Step 1: Configure VLAN and link type on the port.

#Create VLAN2 and VLAN5 on the Device.

```
Device#configure terminal
Device(config)#vlan 2,5
Device(config)#exit
```

#Configure the link type of gigabitethernet0/2 to Access to allow services of VLAN 2 to pass.

```
Device#configure terminal
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)# switchport mode access
Device(config-if-gigabitethernet0/2)# switchport access vlan 2
Device(config-if-gigabitethernet0/2)#end
```

#Configure the link type of port as Access on gigabitethernet 0/3~gigabitethernet 0/4 of the Device to allow services of VLAN 2 to pass, and as Trunk on gigabitethernet 0/5 to allow services of VLAN5 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN5 as 130.255.167.1/24.

```
Device#configure terminal
Device(config)#interface vlan 5
Device(config-if-vlan5)#ip address 130.255.167.1 255.255.255.0
Device(config-if-vlan5)#end
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
Device(config-isp-system)# aaa authentication dot1x radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure secure channel.

#Enable secure channel access control on the port gigabitethernet 0/2.

```
Device#configure terminal
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x free-ip
Device(config-if-gigabitethernet0/2)#exit
```

#Configure a secure channel named channel, and configure to permit PC1 to access the Update Server, and PC2 to access both Update Server and IP Network.

```
Device#configure terminal
Device(config)#hybrid access-list advanced channel
Device (config-adv-hybrid-nacl)#permit ip any any host 199.0.0.10 any
Device(config-adv-hybrid-nacl)#permit ip host 199.0.0.2 any any any
```

#Apply the secure channel named channel.

```
Device#configure terminal
Device(config)#global security access-group channel
Device(config)#exit
```

Step 6: Check the result.

#View the configuration information of secure channel

```
Device#show dot1x free-ip
802.1X free-ip Enable Interface (num:1): gi0/2
global security access-group channel
Total free-ip user number    : 0


Device#show hybrid access-list channel
hybrid access-list advanced channel
```

```
10 permit ip any any host 199.0.0.10 any
20 permit ip host 199.0.0.2 any any any
```

It is indicated that secure channel is enabled on gigabitethernet 0/2, and the secure channel rules of channel are bound.

#Before passing authentication, PC1 can access the Update Server instead of other network resources.

#After PC1 users initiate authentication and the authentication succeeds, view the information of user authentication.

Device#show dot1x user

```
---------------------
NO 1   : MAC_ADDRESS= 3883.45ef.7984  STATUS=     Authorized     USER_NAME=   admin
      VLAN=       2             INTERFACE=   gi0/2         USER_TYPE=   DOT1X
      AUTH_STATE=  AUTHENTICATED   BACK_STATE=  IDLE          IP_ADDRESS=  199.0.0.1
      IPV6_ADDRESS= Unknown

      Online time: 0 week 0 day 0 hours 0 minute 51 seconds

 Total: 1    Authorized: 1  GetIP: 0  Unauthorized/guest/critical: 0/0/0   Unknown: 0
```

It is indicated that the PC1 user has passed authentication and can access the Update Server and IP Network.

#PC2 can access the Update Server and IP Network without authentication.

69.3.6 Configure IP Authorization as DHCP Server Mode

Network Requirements

- PC accesses IP network through the Device which enables 802.1X access control;
- RADIUS authentication is used as an authentication method;
- PC1 can access the IP Network after obtaining IP address through the specified DHCP Server;
- PC2 cannot access the IP Networ after being configured with static IP address authentication.

Network Topology

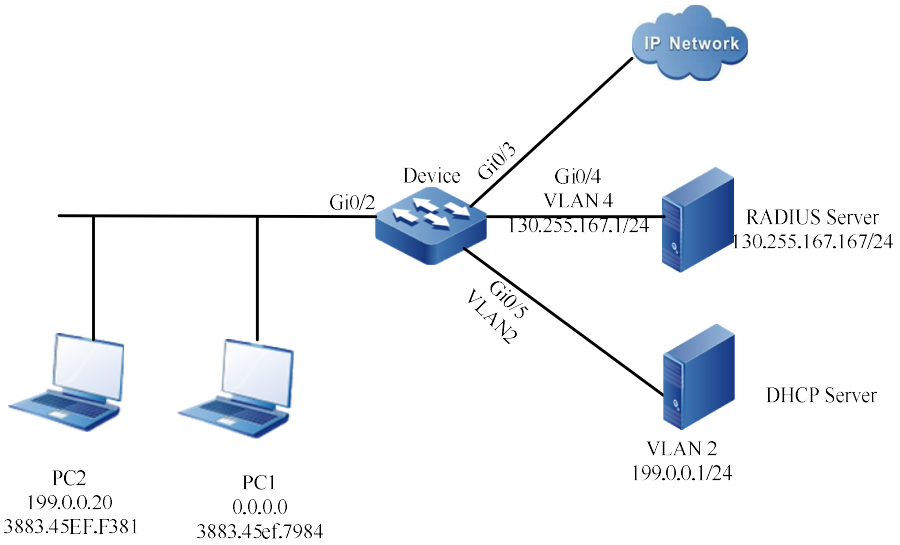


Figure 69 Network Topology for Configuring 802.1X IP Authorization as DHCP Server Mode

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#On the Device, create VLAN2 and VLAN4, configure the link type of port as Hybrid on gigabitethernet0/2, permitting the services of VLAN2 to pass, and configure PVID as 2.

```
Device#configure terminal
Device(config)#vlan 2,4
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode hybrid
Device(config-if-gigabitethernet0/2)#switchport hybrid untagged vlan 2
Device(config-if-gigabitethernet0/2)#switchport hybrid pvid vlan 2
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the link type of port as Access on gigabitethernet0/5 of the Device, allowing the services of VLAN2 to pass. (Omitted)

#Configure the link type of port as Access on gigabitethernet0/4 of the Device, allowing the services of VLAN4 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN4 as 130.255.167.1/24.

```
Device(config)#intergice vlan 4
Device(config-if-vlan4)#ip address 130.255.167.1 255.255.255.0
Device(config-if-vlan4)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
```

```
Device(config-isp-system)# aaa authentication dot1x radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure the DHCP server.

#Configure the segment of assigning IP address on the DHCP server as 199.0.0.2-199.0.0.10, and the subnet mask as 255.255.255.0. (omitted)

Step 6: On the Device, enable the DHCP Snooping function and configure gigabitethernet0/5 as a trusted port.

```
Device(config)#dhcp-snooping
Device(config)#intergice gigabitethernet 0/5
Device(config-if-gigabitethernet0/5)#dhcp-snooping trust
Device(config-if-gigabitethernet0/5)#exit
```

Step 7: Configure 802.1X authentication on the Device.

#Enable 802.1X authentication of gigabitethernet0/2.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x port-control enable
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the IP authorization of gigabitethernet0/2 as DHCP Server mode.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x authorization ip-auth-mode dhcp-server
Device(config-if-gigabitethernet0/2)#exit
```

#Enable the ARP keepalive of gigabitethernet0/2.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x client-probe enable
Device(config-if-gigabitethernet0/2)#exit
```

Step 8: Check the result.

#PC1 users can successfully pass the authentication and obtain IP address from DHCP server and access the IP Network.

```
Device#show dot1x user
--------------------
NO 1   : MAC_ADDRESS= 3883.45ef.7984  STATUS=     Authorized     USER_NAME=   admin
      VLAN=       2             INTERFACE=   gi0/2         USER_TYPE=   DOT1X
      AUTH_STATE=  AUTHENTICATED   BACK_STATE=  IDLE          IP_ADDRESS=  199.0.0.3
      IPV6_ADDRESS= Unknown
```

Online time: 0 week 0 day 0 hours 0 minutes 36 seconds

Total: 1 Authorized: 1 GetIP: 0 Unauthorized/guest/critical: 0/0/0 Unknown: 0

#PC2 users are under GET-IP status after authentication. They cannot obtain IP address.

NO 1 : MAC_ADDRESS= 3883.45ef.f381 STATUS= Unauthorized USER_NAME= admin
VLAN= 2 INTERFACE= gi0/2 USER_TYPE= DOT1X
AUTH_STATE= GET_IP BACK_STATE= IDLE IP_ADDRESS= Unknown
IPV6_ADDRESS= Unknown

Online time: 0 week 0 day 0 hour 0 minute 34 seconds

Total: 1 Authorized: 0 GetIP: 0 Unauthorized/guest/critical: 1/0/0 Unknown: 0

#PC2 cannot access the IP Network even if it has passed authentication.

69.3.7 Configure 802.1X Critical VLAN

Network Requirements

- PC accesses IP network through the Device which enables 802.1X access control;
- RADIUS authentication is used as an authentication method;
- PC2 can access the Update Server only when it fails to pass authentication due to the unreachable server.

Network Topology

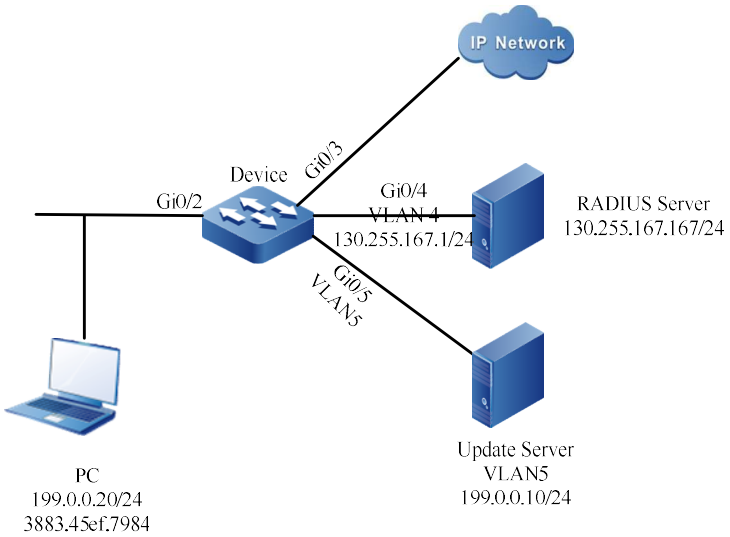


Figure 2 Network Topology for Configuring 802.1X Critical VLAN

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#On the Device, create VLAN2, VLAN4 and VLAN5, configure the link type of port as Hybrid on gigabitethernet0/2, permitting the services of VLAN2 to pass, and configure PVID as 2.

```
Device#configure terminal
Device(config)#vlan 2,4,5
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode hybrid
Device(config-if-gigabitethernet0/2)#switchport hybrid untagged vlan 2
Device(config-if-gigabitethernet0/2)#switchport hybrid pvid vlan 2
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the link type of port as Access on gigabitethernet0/5 of the Device, allowing the services of VLAN5 to pass. (Omitted)

#Configure the link type of port as Access on gigabitethernet0/4 of the Device, allowing the services of VLAN4 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN4 as 130.255.167.1/24.

```
Device(config)#intergice vlan 4
Device(config-if-vlan4)#ip address 130.255.167.1 255.255.255.0
Device(config-if-vlan4)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
Device(config-isp-system)# aaa authentication dot1x radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure 802.1X authentication on the Device.

#Enable 802.1X authentication of gigabitethernet 0/2.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x port-control enable
Device(config-if-gigabitethernet0/2)#exit
```

#Enable the MAC VLAN of gigabitethernet0/2.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#mac-vlan enable
Device(config-if-gigabitethernet0/2)exit
```

#Configure the Critical VLAN of the port as VLAN5.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#authentication critical-vlan 5
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Check the result.

#The Device cannot ping the server when the server is abnormal. As a result, the user fails to pass authentication due to the unreachable server. The PC user is in the Critical VLAN and can access the Update Server.

Device#show dot1x user

```
--------------------
NO 1   : MAC_ADDRESS= 3883.45ef.7984  STATUS=     Unauth(critical)  USER_NAME=   admin
       VLAN=       5              INTERFACE=   gi0/2            USER_TYPE=   DOT1X
       AUTH_STATE=  CRITICAL_HELD   BACK_STATE=  IDLE           IP_ADDRESS=  Unknown
       IPV6_ADDRESS= Unknown


 Total: 1   Authorized: 0  GetIP: 0  Unauthorized/guest/critical: 0/0/1 Unknown: 0
```

#At this time, the port gigabitethernet0/2 is added to the Critical VLAN.

```
Device#show vlan 5
---- ---- -------------------------------- ------- --------- -------------------------------
NO.  VID  VLAN-Name                        Owner   Mode      Intergice
---- ----- -------------------------------- ------- --------- -------------------------------
1    5 VLAN5                    static  Untagged  gi0/2   gi0/5
```

69.3.8 Configure Combined Use of 802.1x and Port Security

Network Requirements

- PC accesses IP network through the Device which enables 802.1X access control and port security;
- RADIUS authentication is used as an authentication method;
- Configure port security rules that fail to match the MAC address of PC1, and PC1 can access the IP Network through authentication;
- Configure port security deny rules that fail to match the MAC address of PC2, and PC2 cannot pass authentication.

Network Topology

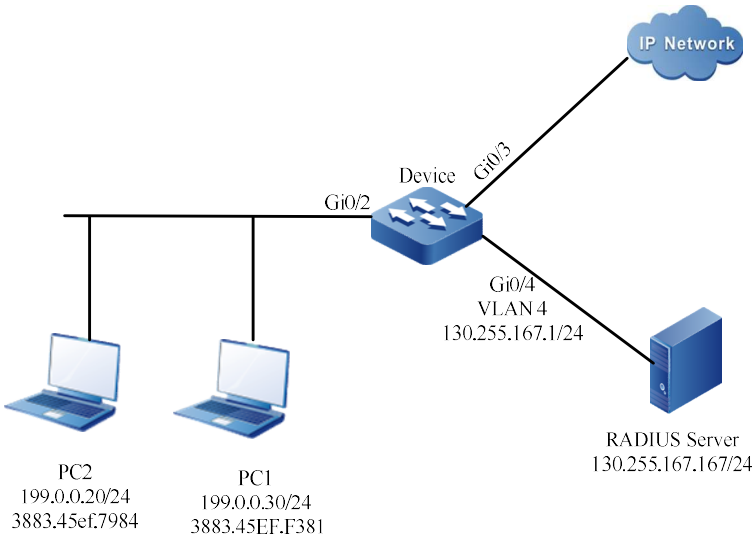


Figure 3 Network Topology for Configuring Combined Use of 802.1X and Port Security

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#On the Device, create VLAN2 and VLAN4, configure the link type of port as Hybrid on gigabitethernet0/2, permitting the services of VLAN2 to pass, and configure PVID as 2.

```
Device#configure terminal
Device(config)#vlan 2,4
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode hybrid
Device(config-if-gigabitethernet0/2)#switchport hybrid untagged vlan 2
Device(config-if-gigabitethernet0/2)#switchport hybrid pvid vlan 2
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the link type of port as Access on gigabitethernet0/4 of the Device, allowing the services of VLAN4 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN4 as 130.255.167.1/24.

```
Device(config)#intergice vlan 4
Device(config-if-vlan4)#ip address 130.255.167.1 255.255.255.0
Device(config-if-vlan4)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device(config)#domain system
Device(config-isp-system)# aaa authentication dot1x radius-group radius
Device(config-isp-system)#exit
```

```
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 130.255.167.167 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure 802.1X authentication on the Device.

#Enable 802.1X authentication of gigabitethernet0/2.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#dot1x port-control enable
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Configure port security on the Device.

#On port gigabitethernet0/2, enable port security.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#port-security enable
Device(config-if-gigabitethernet0/2)exit
```

#Configure port security rules on port gigabitethernet0/2.

```
Device(config)#intergice gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#port-security deny mac-address 3883.45EF.7984
Device(config-if-gigabitethernet0/2)exit
```

Step 7: Check the result.

#PC1 users can successfully pass the authentication and then access the IP Network.

```
Device#show dot1x user

---------------------

NO 1   : MAC_ADDRESS= 3883.45ef.f381  STATUS=     Authorized       USER_NAME=   admin
      VLAN=       2             INTERFACE=   gi0/2           USER_TYPE=   DOT1X
      AUTH_STATE=  AUTHENTICATED   BACK_STATE=  IDLE           IP_ADDRESS=  Unknown
      IPV6_ADDRESS= Unknown

      Online time: 0 week 0 day 0 hour 0 minute 1 second

 Total: 1   Authorized: 1  GetIP: 0  Unauthorized/guest/critical: 0/0/0 Unknown: 0
```

#PC2 users cannot successfully pass the authentication, so they cannot access the network.

70 PORTAL

70.1 Overview

70.1.1 Introduction

Portal authentication is often called Web authentication, i.e. accept the user name and password input by the user through Web pages to authenticate the user. Portal authentication technology offers a flexible access control method. It can realize access control in the access layer and key data entries that need to be protected without installing a client. Generally, Portal authentication website is called portal website.

When an unauthenticated user surfs on the Internet, the device forces the user to visit a specific site, i.e., the Portal server. The user can access the services therein for free without authentication, such as application (e.g. antivirus software and OS patches) upgrading. When the user needs to access other resources on the Internet, it must authenticate its identity on the Portal authentication page provided by the Portal server. It can access the network resources only when it passes authentication.

In addition to flexible authentication, Portal can provide convenient management function, and there is advertising, notification and other personalized services on the Portal authentication page.

70.1.2 System Composition of Portal

The typical networking method of Portal is shown in the figure below. It comprises four elements: Portal Client, Authentication Device, Portal Server and AAA Server (Authentication/Authorization/Accounting Server).

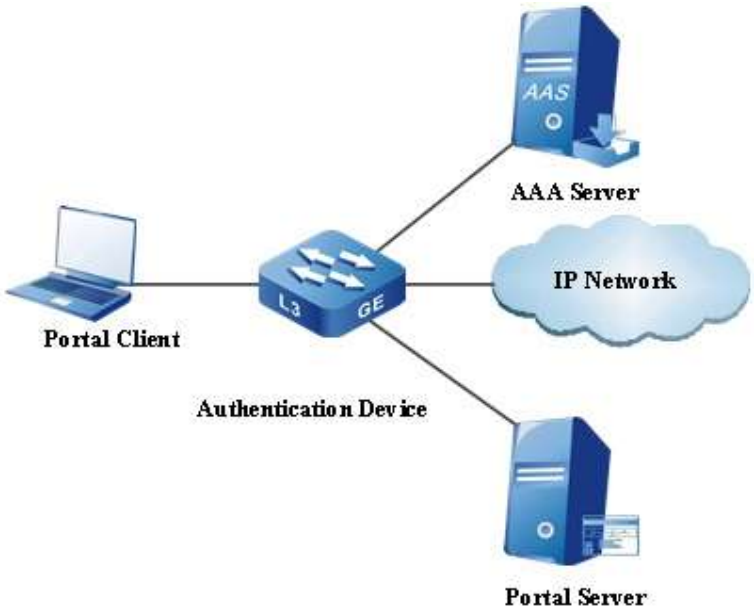


Figure 70 System Composition of Portal

- Portal Client: Generally the browser which runs HTTP or the proprietary Portal client software.
- Authentication Device: Located between the client and the authentication server, it controls network access of the client through interactions with Portal server and AAA server.
- Portal Server: The server system which receives authentication requests from the authentication client, and provides free portal service and Web authentication-based interface. After accepting the authentication requests from the authentication client and extracting authentication information therefrom, it interacts with the authentication device through the Portal protocol and notifies the authentication client of the authentication result.
- AAA Server: Generally, it is RADIUS (Remote Authentication Dial-In User Service) server. It is used to verify the legality of the client and notify the authentication result to the authentication device which controls network access of the client according to the authentication result.

70.1.3 Authentication Method of Portal

The Portal authentication method that can be used varies with networking mode. According to the network layer where Portal authentication is implemented in the network, Portal authentication method has two types, i.e. layer-2 authentication and layer-3 authentication.

1. Layer-2 authentication

Support enabling the Portal authentication function on the layer-2 interface through which the authentication device connects with the user. Before authentication, the user obtains an IP address

through manual configuration or DHCP, and can only access the Portal server; after passing the authentication, it can access network resources. Layer-2 authentication, based on source MAC control, permits the packets with legal source MAC address to pass after passing the authentication.

2. Layer-3 authentication

Support enabling the Portal authentication function on the layer-3 interface through which the authentication device connects with the user. Layer-3 authentication has two types, i.e. general layer-3 authentication and secondary address allocation authentication.

（1） General layer-3 authentication

Before authentication, the user obtains an IP address through manual configuration or DHCP, and can only access the Portal server and the free access address set; after passing the authentication, it can access network resources. General layer-3 authentication realizes control in two ways:

- Based on source IP control, permitting the packets with legal source IP to pass after passing the authentication.
- Based on source IP + source MAC control, permits the packets with legal source IP and source MAC address to pass after passing the authentication.

70.1.4 Authentication Process of Portal

There are two ways of authentication interaction between Portal server and authentication device:

- CHAP (Challenge Handshake Authentication Protocol): It is very secure as both user name and password are encrypted during transmission.
- PAP (Password Authentication Protocol): It has low security as both user name and password are transmitted in plaintext.

Portal server completes challenge handshake authentication through CHAP authentication interaction. Challenge is randomly generated by the authentication device when receiving Challenge request packets. With 16 bytes, it will be issued to the Portal server with Challenge response packets.

Layer-2 Portal authentication has the same process as general layer-3 Portal authentication.

1. Process of layer-2 Portal and general layer-3 Portal authentication

The flow chart is shown below:

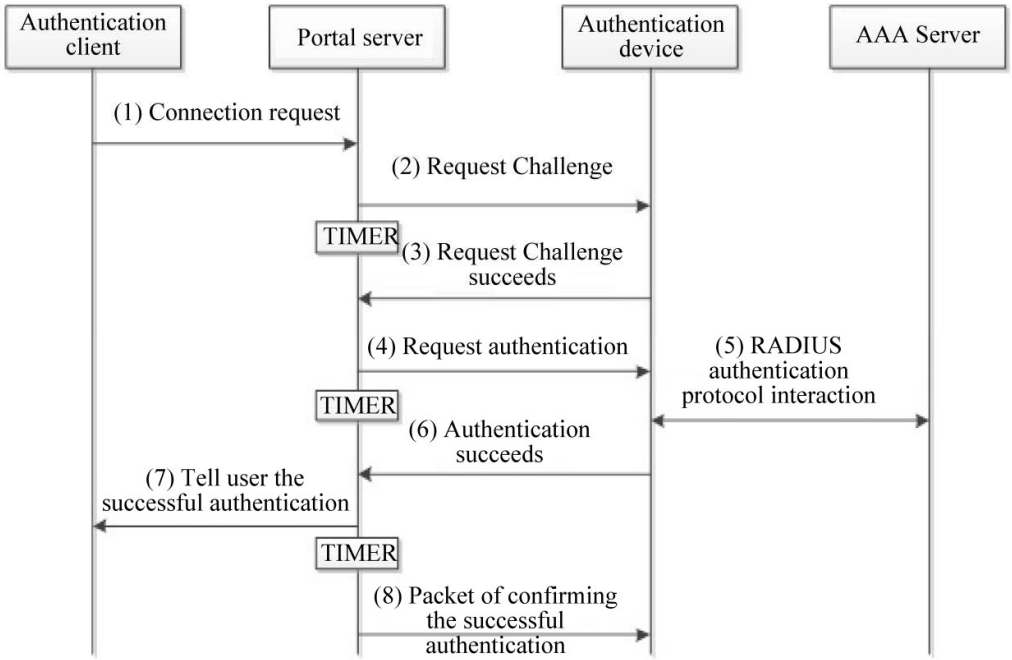


Figure 70 CHAP Flow Chart of Layer-2/General Layer-3 Portal Authentication

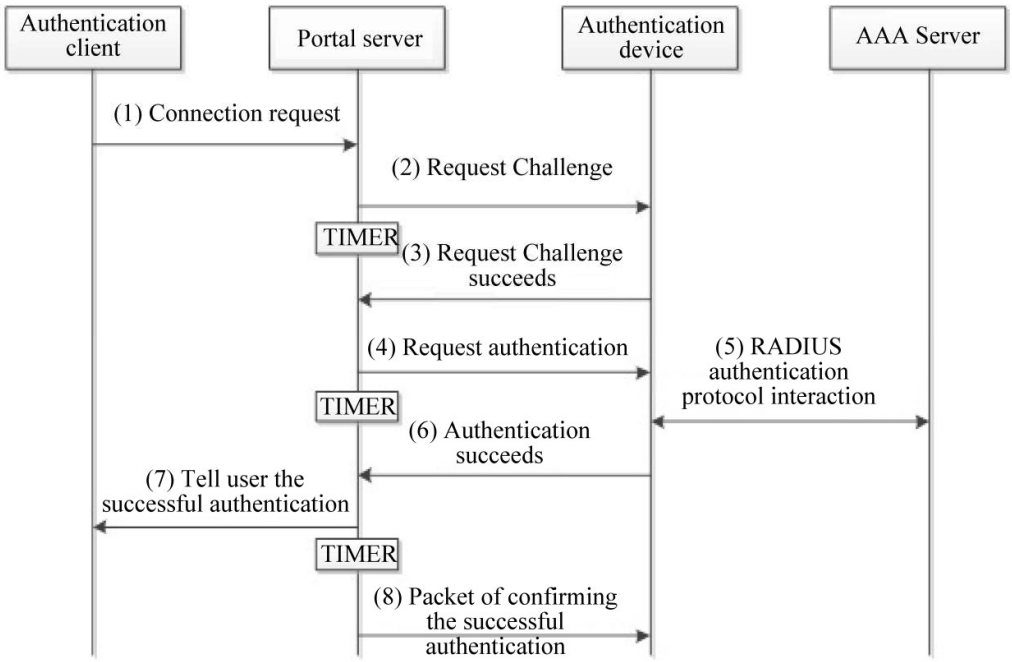


Figure 70 PAP Flow Chart of Layer-2/General Layer-3 Portal Authentication

Process of layer-2 Portal and general layer-3 Portal authentication:

2) Portal users have to initiate authentication requests when they need to access the network. When HTTP packets pass through the authentication device, the authentication device allows those accessing the Portal server or the free access

address set to pass, and intercepts and redirects those accessing other addresses to the Portal server. The Portal server begins an authentication process by providing a Web page for users to input the legal user name and password that have been registered on the authentication server.

3) The Portal server uses CHAP authentication interaction to perform challenge handshake authentication. It will send a Challenge request to the authentication device. Use PAP authentication interaction to go to step (4).

4) The authentication device randomly generates a Challenge when receiving a Challenge request packet, and sends a successful challenge request packet to issue the Challenge to the Portal server. Use PAP authentication interaction to go to step (4).

5) The Portal server packets the user name and password input by the user into an authentication request packet and then sends it to the authentication device for authentication. At the same time, it enables the timer to wait for the authentication response.

6) The interaction of RADIUS protocol packets is conducted between the authentication device and the RADIUS server.

7) The authentication device sends a packet of successful authentication to the Portal server.

8) The Portal server sends the packet of successful authentication to the authentication client to notify the user of the successful authentication.

9) The Portal server sends the packet of confirming successful authentication to the authentication device.

70.1.5 Support Issuing ACL

ACL (Access Control List) offers the function of controlling users' access to network resources and restricting users' access permission. When users go online, if an authorized ACL is configured on the server, the device will control the data flow of the port where the user is located according to the authorized ACL issued by the server; before configuring the authorized ACL on the server, it is required to configure corresponding rules on the device. Layer-2 Portal authentication supports issuing standard IP ACLs and extended IP ACLs; layer-3 Portal authentication supports issuing extended IP ACLs, and the matching items of the ACL rules configured support adding "source IP + source MAC".

70.2 Portal Function Configuration

Table 70 Portal Function Configuration List

Configuration Task	
Configure Portal Server and Attributes	Create Portal Server
	Configure Type of Portal Server
	Configure Detection Function for Portal Server
	Configure Source Interface for Sending Portal Packet
	Configure Destination UDP Port Number for Sending Packet of Forcing Users to Go Offline
Configure Layer-2 Portal Authentication Function	Enable Layer-2 Portal Authentication Function
Configure Layer-2 Portal Authentication Attributes	Configure Port Access Control Method
Configure Layer-3 Portal Authentication Function	Enable General Layer-3 Portal Authentication Function
	Configure and Apply Secure Channel
Configure Common Attributes	Configure the Maximum Number of Users on Interface
	Configure User Authentication Migration Function
	Configure the Function of Removing Domain Name
	Configure Timer Parameters
	Configure Authentication Method List
	Configure Accounting Method List

70.2.1 Configure Portal Server and Attributes

Configuration Condition

None

Create Portal Server

Create a Portal server and specify relevant parameters of the Portal server, including server IP address, shared encryption key, server port number, and server URL (authentication page address of the server).

Table 70 Creating Portal Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create Portal Server	**portal server** *server-name* **ip** *ip-address* **key** [**0** | **7**] *key-string* [**port** *udp-port-num* | **url** *url-string*]	Optional By default, the Portal server is not created.

Note

- Portal authentication supports IPV4 protocol only.
- At most 5 Portal servers can be created on the authentication device.
- The parameters of the Portal server configured can be deleted or modified only when this Portal server is not referenced by interface.
- The shared keys configured on the authentication device and Portal server must be consistent.

Configure Type of Portal Server

Configuring the type of Portal server is useful in two aspects:

- Different Portal servers extend the standard Portal protocol specifications.
- When no server URL is configured on the Portal server, it uses the default server URL of corresponding type for redirection.

The server types that can be specified include:

aas: AAS server, default server URL: http://IP-ADDRESS/portal/Login.do

imc: IMC server, default server URL: http://IP-ADDRES:8080/portal

user-defined: user-defined server, the default server URL format complies with the protocol specification "PORTAL Protocol Specification v2.0.2 for WLAN Service of China Mobile".

Table 70 Configuring Type of Portal Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Type of Portal Server	**portal server** *server-name* **type** { **aas** | **imc** | **user-defined** }	Optional By default, the server type is AAS.

Configure Detection Function for Portal Server

During the process of Portal authentication, if the communication between authentication device and Portal server is interrupted, new users cannot go online, and the Portal users who are already online cannot go offline normally. To solve this problem, the authentication device should be able to timely detect the changes of the reachable state of the Portal server, and trigger the performance of corresponding operation to respond to the influence of these changes. For example, when the specified Portal server is unreachable, all users who use the Portal server for authentication will be forced to pass the authentication to access network resources, i.e. the Portal escape function.

Configure detection function so that the authentication device can detect the reachable state of the Portal server. The specific configurations are shown below:

（1） Time interval of detecting reachability of server

（2） Action performed when the reachable state of server changes

- Log record: When the reachable state of Portal server changes, the log information is recorded.
- Enable user restriction: When the reachable state of the Portal server changes, the log information is recorded; when the specified Portal server is unreachable, all users who use the Portal server for authentication will be forced to pass the authentication; when the Portal server is reachable again, the users who use this Portal server for forced authentication will be forced to go offline.

Table 70 Configuring Detection Function for Portal Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the time interval of detecting Portal server	**portal server** *server-name* **detect-interval** *detect-interval-value*	Optional By default, the time interval of detecting Portal server is 60 seconds, and the value range is 20~600 seconds or 0; when it is configured as 0, the Portal server cannot be detected.
Configure the action performed when the reachable state of the Portal server changes	**portal server** *server-name* **failover** { **log** | **permit** }	Optional By default, when the reachable state of Portal server changes, the log information is recorded.

Configure Source Interface for Sending Portal Packet

Specify the source interface for sending Portal packet. The master IP address configured under the source interface is the source address used by the authentication device to send Portal packets to this Portal server. If there is no master IP address under the source interface, the communication will fail.

Table 70 Configuring Source Interface for Sending Portal Packet

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Source Interface for Sending Portal Packet	**portal server** *server-name* **source-interface** *interface-name*	Optional By default, the source interface for sending Portal packet is not specified, and the user access interface is the source interface for sending Portal packet.

Configure the destination UDP port number for sending packet of forcing users to go offline

The port number of some servers for receiving the packet of forcing users to go offline is the specific UDP port number. Therefore, it's necessary to configure the destination UDP port number for sending packet of forcing users to go offline.

Table 70 Configuring Destination UDP Port Number for Sending Packet of Forcing Users to Go Offline

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the destination UDP port number for sending packet of forcing users to go offline	**portal server** *server-name* **ntf-logout-port** *udp-port-num*	Optional By default, the destination UDP port number for sending packet of forcing users to go offline is not specified. Instead, the port number of server is used.

70.2.2 Configure Layer-2 Portal Authentication Function

Configuration Condition

To enable the layer-2 Portal authentication function, the following conditions should be met:

- This Portal server has been created on the authentication device

Enable Layer-2 Portal Authentication Function

Enable layer-2 Portal authentication on the port of the authentication device connecting the user. The layer-2 authentication, based on source MAC control, permits the packets with legal source MAC address to pass after passing the authentication.

Table 70 Enabling Layer-2 Portal Authentication Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only on the interface of current aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable Layer-2 Portal Authentication Function	**portal server** *server-name* **method layer2**	Mandatory By default, the layer-2 Portal authentication function under the port is disabled.

Note

- The layer-2 Portal authentication doesn't support the issuance of VLAN.
- Layer-2 Portal authentication and Free-IP of 802.1X cannot be both configured for the same port.
- When layer-2 Portal authentication is enabled on the port, layer-3 Portal authentication cannot be enabled on corresponding VLAN interface. Otherwise, the configuration will fail.
- When the port where layer-2 Portal authentication is enabled is added to the VLAN interface where layer-3 Portal authentication is enabled, the configuration related to layer-2 Portal authentication of the port will be automatically cleared, and the log automatically cleared will be recorded.

70.2.3 Configure Layer-2 Portal Authentication Attributes

Configuration Condition

None

Configure Port Access Control Method

There are two types of port access control: Portbased and Macbased.

Portbased access control: Only one user is permitted to pass authentication under the port.

Macbased access control: Multiple users are permitted to pass authentication under the port. They cannot access the network without passing authentication.

The Portbased access control also has two modes: Multi-hosts and Single-host.

Multi-hosts: After one user passes authentication, other users under the port can access the network without authentication.

Single-host: Under the port, only one user is permitted to pass authentication and access the network. Other users cannot access the network or pass authentication.

Table 70 Configuring Port Access Control Method

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only on the interface of current aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure access control method	**authentication port-method** { **macbased** | **portbased** }	Mandatory By default, user authentication method is enabled under the port.
Portbased access control method	**authentication port-method portbased host-**	Optional

Step	Command	Description
	mode { **multi-hosts** | **single-host** }	By default, Multi-hosts authentication is enabled under the port.

Note

- When configuring the host mode under portbased access control, you should guarantee that the access control method has been configured as Portbased.

70.2.4 Configure Layer-3 Portal Authentication Function

Configuration Condition

To enable the layer-3 Portal authentication function, the following conditions should be met:

- This Portal server has been created on the authentication device

Enable General Layer-3 Portal Authentication Function

Enable the general layer-3 Portal authentication function on the layer-3 interface of the authentication device connecting to the user. The general layer-3 authentication has two control methods:

- Based on source IP control, permitting the packets with legal source IP to pass after passing the authentication.
- Based on source IP + source MAC control, permits the packets with legal source IP and source MAC address to pass after passing the authentication.

Table 70 Enabling General Layer-3 Portal Authentication Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Enable General Layer-3 Portal Authentication Function	**portal server** *server-name* **method layer3** [**ip** | **ip-mac**]	Mandatory By default, the general layer-3 Portal

Step	Command	Description
		authentication function of the interface is disabled.

Note

- After the port under the general layer-3 Portal authentication interface is enabled, both 802.1X authentication and MAC authentication cannot be enabled.
- After the port under the general layer-3 Portal authentication interface is enabled, the layer-2 Portal authentication function cannot be enabled.
- When the port where layer-2 Portal authentication is enabled is added to the VLAN interface where the general layer-3 Portal authentication has been enabled, the enabling status of layer-2 Portal authentication is cleared.

Configure and Apply Secure Channel

After enabling the layer-3 authentication function under the layer-3 interface, to permit terminal users to access the resources in the specified network when they are not authenticated, or specify specific terminal users to access network resources without authentication, you need to configure and apply secure channel.

Secure channel rules can be configured as follows.

- Permit terminal users to access specified network resources.
- Permit specified terminal users to access network resources.

Table 1 Applying Secure Channel

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure secure channel	**hybrid access-list advanced** { *access-list-number* | *access-list-name* }	Mandatory By default, no secure channel is configured in the device.
Configure secure channel rules	[*sequence*] **permit** *protocol* { **any** | *source-ip-addr source-wildcard* | **host**	Mandatory

Step	Command	Description
	source-ip-addr } { **any** | *source-mac-addr source-wildcard* | **host** *source-mac-addr* } { **any** | *destination-ip-addr destination-wildcard* | **host** *destination-ip-addr* } { **any** | *destination-mac-addr destination-wildcard* | **host** *destination-mac-addr* }	By default, there are no secure channel rules under the secure channel.
Apply secure channel	**global security access-group** { *access-group-number* | *access-group-name* }	Mandatory By default, no secure channel is applied in the system.

Note

- A device can be configured with multiple secure channels, and a secure channel may have multiple secure channel rules.
- The type of secure channel can be mixed advanced ACL only, and only one secure channel can be applied in the device.

70.2.5 Configure Common Attributes

Configuration Condition

None

Configure the Maximum Number of Users on Interface

After the number of users authenticated under the interface reaches the upper limit configured, the authentication system no longer responds to the authentication request initiated by the new user.

The maximum number of users on layer-2 interface ranges from 1 to 4096, and that on layer-3 interface from 1 to 500.

Table 2 Configuring Maximum Number of Users on Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on current interface after you enter the layer-2 Ethernet interface configuration mode, only on the interface of current aggregation group after you enter the aggregation group configuration mode, and only on current interface after you enter the interface configuration mode
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enter the interface configuration mode	**interface** *interface-name*	
Configure the Maximum Number of Users on Interface	**authentication max-user-num** *max-user-num-value*	Mandatory By default, at most 256 users are permitted to access under the interface.

Note

- Under the layer-2 interface, configure as Macbased access control. Otherwise, the configured number of users permitted to access cannot take effect.

Configure User Authentication Migration Function

The user authentication migration function applies to the scenarios where the same user migrates from one authentication interface to another in the same device. When the user authentication migration function is disabled, after a user is authenticated on one interface of the device, it is not permitted to initiate authentication on another authentication interface of the device; when the user authentication migration function is enabled, after the user is authenticated on one interface, and the device finds that the user has migrated to another authentication interface, the device deletes the authentication information

on the original interface and then permits the user to initiate authentication on a new authentication interface.

No matter whether the user authentication migration function is enabled, the device will record a log once it finds user migration between authentication interfaces.

Table 3 Configuring User Authentication Migration Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on current interface after you enter the layer-2 Ethernet interface configuration mode, only on the interface of current aggregation group after you enter the aggregation group configuration mode, and only on current interface after you enter the interface configuration mode
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enter the interface configuration mode	**interface** *interface-name*	
Configure User Authentication Migration Function	**authentication station-move** { **enable** | **disable** }	Mandatory By default, the user authentication migration function is disabled.

Configure the Function of Removing Domain Name

In some scenarios, the username automatically contains the domain name when the client initiates authentication, and the user carrying the domain name cannot pass the authentication on the authentication server. In order to avoid this, whether the authenticated user name sent to the authentication device contains a domain name can be configured for the authentication device.

Table 4 Configuring Function of Removing Domain Name

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on current interface after you enter the layer-2 Ethernet interface configuration mode, only on the interface of aggregation group after you enter the aggregation group configuration mode, and only on current interface after you enter the interface configuration mode
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enter the interface configuration mode	**interface** *interface-name*	
Configure the Function of Removing Domain Name	**portal user-name-format** { **with-domain** | **without-domain** }	Mandatory By default, the function of removing domain name is not configured.

Configure Timer Parameters

The timer parameters under the interface include authenticating-period, authenticated-period, idle-period, and idle-period.

Authenticating-period: When any client packet is detected, the authenticating-period timer is enabled. After time-out of the timer, if no authentication result has been obtained, the client will be deleted.

Authenticated-period: After the client passes the authentication, this timer is enabled. After time-out of the timer, the information of the client which passes the authentication is deleted.

Idle-period: After the client passes the authentication, this timer is enabled. When the client is found offline, the information of the client which passes the authentication is deleted.

Quiet-period: When the client fails to pass the authentication, this timer is enabled. After time-out of the timer, the authentication device will respond to the authentication request from the client again.

The timer newly configure is valid for the authenticated users who later go online instead of those who have been online.

Table 5 Configuring Timer Parameters

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on current interface after you enter the layer-2 Ethernet interface configuration mode, only on the interface of current aggregation group after you enter the aggregation group configuration mode, and only on current interface after you enter the interface configuration mode
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enter the interface configuration mode	**interface** *interface-name*	
Configure Timer Parameters	**portal timeout** { **authenticating-period** *authenticating-period-value* | **authenticated-period** *authenticated-period-value* | **idle-period** *idle-period-value* | **quiet-period** *quiet-period-value* }	Mandatory By default, the authenticating-period is 120 seconds, and the value range is 15~300; the authenticated-period is 36000 seconds, and the value range is 0 or 300~ 864000; the idle-period is 300 seconds, and the value range is 0 or 180~1800; the quiet period is 60 seconds, and the value range is 15~3600.

Configure Authentication Method List

Configure the authentication method list used by Portal users. When the user name of a Portal user contains a domain name, the authentication method list specified by the domain name is used; when there is no domain name in the Portal user name, the authentication method list configured is used.

Table 6 Configuring Authentication Method List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to connect the authentication method list	**portal authentication method-list** { **default** | *list-name* }	Optional By default, the authentication method list of default is used.

Configure Accounting Method List

The accounting method list used by Portal users. When the user name of a Portal user contains a domain name, the accounting method list specified by the domain name is used; when there is no domain name in the Portal user name, the accounting method list configured is used.

Table 13-16 Configuring Accounting Method List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to connect the accounting method list	**portal accounting method-list** { **default** | *list-name* }	Optional By default, the accounting method list of default is used.

70.2.6 Portal Monitoring and Maintaining

Table 7 Portal Monitoring and Maintaining

Command	Description
clear portal user { **ip** *ip-address* **| mac** *mac-address* | **all** | **interface** *interface-*	Force the Portal user to go offline

Command	Description
name | **link-aggregation** *link-aggregation-id* }	
clear portal auth-fail-user history [**ip** *ip-address*]	Clear record of failed authentication
clear portal statistic [**interface** *interface-name* | **link-aggregation** *link-aggregation-id*]	Clear authentication statistics
show authentication user [**ip** *ip-address* **| mac** *mac-address* | **all | interface** *interface-name* **| link-aggregation** *link-aggregation-id* | **summary**]	Show the information of authentication management users
show authentication intf-status [**interface** *interface-name* | **link-aggregation** *link-aggregation-id*]	Show the information of authentication status
show portal	Show default configurations of authentication
show portal auth-fail-user history [**ip** *ip-address* | **recent]**	Show the information of authentication failure
show portal config [**interface** *interface-name* | **link-aggregation** *link-aggregation-id*]	Show configurations of authentication
show portal global config	Show the information of global configuration
show portal server	Show the information of Portal server
show portal statistic [**interface** *interface-name* | **link-aggregation** *link-aggregation-id*]	Show authentication statistics
show portal user [**ip** *ip-address* | **mac** *mac-address* | **interface** *interface-name* | **link-aggregation** *link-aggregation-id* | **summary**]	Show user information

70.3 Typical Configuration Example of Portal

70.3.1 Configure Portbased Layer-2 Portal Authentication

Network Requirements

- PC1 and PC2 on the same LAN access the IP network through the Device where the layer-2 Portal authentication function is enabled and configured as Portabased.
- RADIUS authentication is used as an authentication method.
- Users can access the Portal Server only when they fail to pass authentication. They are permitted to access the IP Network once it passes the authentication.
- After one user on the LAN passes authentication, other users on this LAN can access the IP Network without authentication.

Network Topology

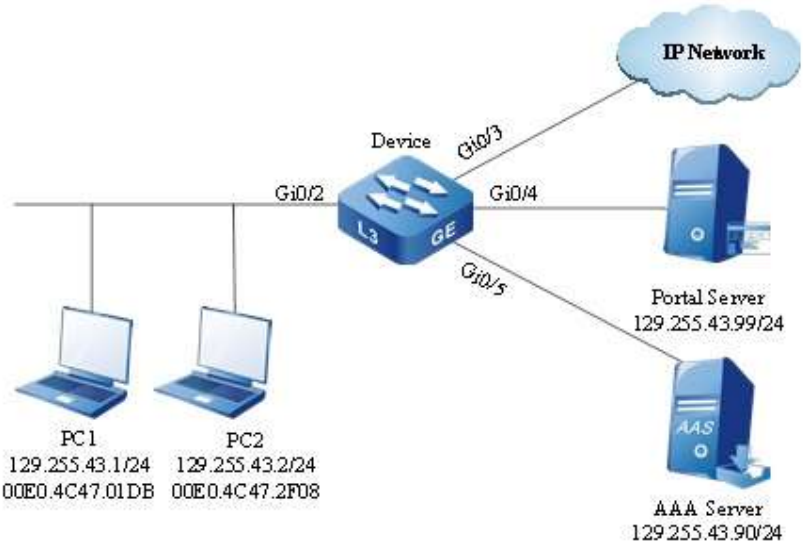


Figure 70 Network Topology for Configuring Portbased Layer-2 Portal Authentication

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN129 on the Device.

```
Device#configure terminal
Device(config)#vlan 129
Device(config)#exit
```

#Configure the link type of port gigabitethernet0/2 as Access, allowing the services of VLAN129 to pass.

```
Device(config)#interface gigabitethernet 0/2
```

```
Device(config-if-gigabitethernet0/2)#switchport mode access
Device(config-if-gigabitethernet0/2)#switchport access vlan 129
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the link type of the ports gigabitethernet 0/3~gigabitethernet 0/5 on the Device as Access, allowing the services of VLAN129 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN129 as 129.255.43.10/24.

```
Device(config)#interface vlan 129
Device(config-if-vlan129)#ip address 129.255.43.10 255.255.255.0
Device(config-if-vlan129)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, RADIUS server address 129.255.43.90/24, server key admin, and priority 1.

```
Device#configure terminal
Device(config)#domain system
Device(config-isp-system)# aaa authentication portal radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 129.255.43.90 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure layer-2 Portal authentication.

#On the Device, configure the Portal server of server1.

```
Device(config)# portal server server1 ip 129.255.43.99 key admin url http://129.255.43.99:8080/portal
```

#Enable layer-2 portal authentication on the Device and configure Portbased mode.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#portal server server1 method layer2
Device(config-if-gigabitethernet0/2)#authentication port-method portbased
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Configure Portal server.

#On Portal server, configure IP address of PC1, address of the Device and key value as admin. (Omitted)

Step 7: Check the result.

#Before passing the authentication, PC1 and PC2 can access the Portal Server only.

#Verify that PC1 can pass the authentication. At this moment, both PC1 and PC2 can access the IP Network.

```
Device#show portal user
--------------------
NO 1   : IP_ADDRESS= 129.255.43.1   STATUS= Authorized    USER_NAME=   admin
       INTERFACE=  gi0/2          CTRL_METHOD= L2_MAC   AUTH_STATE=  AUTHENTICATED
       BACK_STATE= AAA_SM_IDLE    VLAN= 129             MAC_ADDRESS= 00E0.4C47.01DB

 Total: 1    Authorized: 1    Unauthorized/Guest/Critical: 0/0/0
```

70.3.2 Configure Macbased Layer-2 Portal Authentication

Network Requirements

- PC1 and PC2 on the same LAN access the IP network through the Device where the layer-2 Portal authentication function is enabled and configured as Macbased.
- RADIUS authentication is used as an authentication method.
- Users can access the Portal Server only when they fail to pass authentication. They are permitted to access the IP Network once it passes the authentication.
- After one user on the LAN passes authentication, it can access the IP Network. Other users on this LAN can access the IP Network only when they pass authentication.

Network Topology

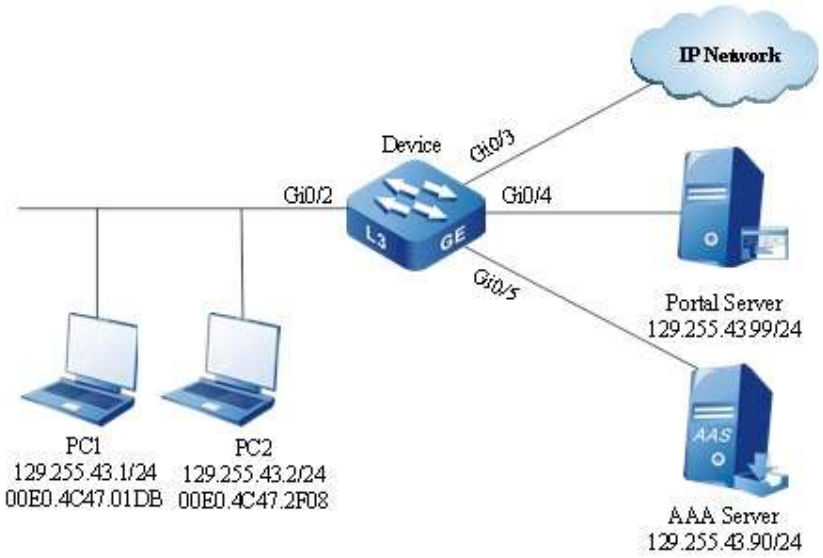


Figure 70 Network Topology for Configuring Macbased Layer-2 Portal Authentication

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN129 on the Device.

```
Device#configure terminal
Device(config)#vlan 129
Device(config)#exit
```

#Configure the link type of port gigabitethernet0/2 as Access, allowing the services of VLAN129 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode access
Device(config-if-gigabitethernet0/2)#switchport access vlan 129
Device(config-if-gigabitethernet0/2)#exit
```

#Configure the link type of the ports gigabitethernet 0/3~gigabitethernet 0/5 on the Device as Access, allowing the services of VLAN129 to pass. (Omitted)

Step 2: Configure interface IP address for the Device.

#Configure the IP address of VLAN129 as 129.255.43.10/24.

```
Device(config)#interface vlan 129
Device(config-if-vlan129)#ip address 129.255.43.10 255.255.255.0
Device(config-if-vlan129)#exit
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, RADIUS server address 129.255.43.90/24, server key admin, and priority 1.

```
Device#configure terminal
Device(config)#domain system
Device(config-isp-system)# aaa authentication portal radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 129.255.43.90 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure layer-2 Portal authentication.

#On the Device, configure the Portal server of server1.

```
Device(config)# portal server server1 ip 129.255.43.99 key admin url http://129.255.43.99:8080/portal
```

#Enable layer-2 portal authentication on the Device and configure Macbased mode.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#portal server server1 method layer2
Device(config-if-gigabitethernet0/2)#authentication port-method macbased
Device(config-if-gigabitethernet0/2)#exit
```

Step 6: Configure Portal server.

#On Portal server, configure IP address of PC1, address of the Device and key value as admin. (Omitted)

Step 7: Check the result.

#Before passing the authentication, PC1 and PC2 can access the Portal Server only.

#Verify that PC1 can pass the authentication. At this moment, PC1 instead of PC2 can access the IP Network.

```
Device#show portal user
--------------------
NO 1   : IP_ADDRESS= 129.255.43.1   STATUS= Authorized    USER_NAME=   admin
      INTERFACE=  gi0/2          CTRL_METHOD= L2_MAC   AUTH_STATE=  AUTHENTICATED
      BACK_STATE= AAA_SM_IDLE    VLAN= 129             MAC_ADDRESS= 00E0.4C47.01DB
 Total: 1    Authorized: 1    Unauthorized/Guest/Critical: 0/0/0
```

70.3.3 Configure General Layer-3 Portal Authentication

Network Requirements

- PC1 and PC2 on the same LAN access the IP network through the Device where the general layer-3 Portal authentication is enabled.
- RADIUS authentication is used as an authentication method.
- PC1 can access the Update Server only prior to passing authentication. It is permitted to access the IP Network once it passes the authentication.
- PC2 is permitted to access the Update Server.

Network Topology

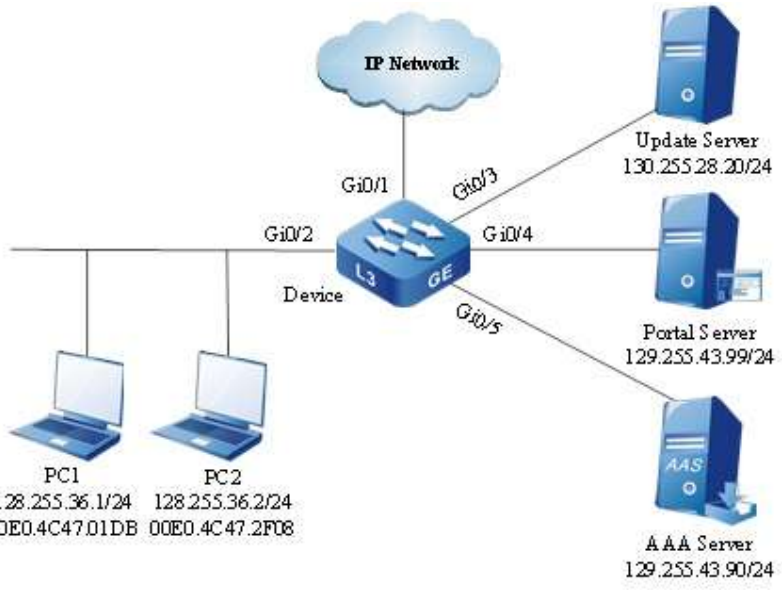


Figure 70 Network Topology for Configuring General Layer-3 Portal Authentication

Configuration Steps

Step 1: Configure VLAN and link type on the port.

#Create VLAN128, VLAN129, VLAN130 and VLAN131 on the Device.

```
Device#configure terminal
Device(config)#vlan 128,129,130,131
Device(config)#exit
```

#Configure the link type of gigabitethernet0/2 to Access to allow services of VLAN128 to pass.

```
Device#configure terminal
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode access
Device(config-if-gigabitethernet0/2)#switchport access vlan 128
Device(config-if-gigabitethernet0/2)#end
```

#Configure the link type of port as Access on gigabitethernet 0/1 of the Device, allowing the services of VLAN131 to pass. Configure the link type of port as Access on gigabitethernet 0/3 of the Device to allow services of VLAN130 to pass, and as Access on gigabitethernet 0/4~gigabitethernet 0/5 to allow services of VLAN129 to pass. (Omitted)

Step 2: Configure interface IP address of the Device so that network routes are reachable.

#Configure the IP address of VLAN128 as 128.255.36.10/24.

```
Device#configure terminal
Device(config)#interface vlan 128
Device(config-if-vlan128)#ip address 128.255.36.10 255.255.255.0
```

```
Device(config-if-vlan128)#end
```

#Configure the IP address of VLAN129 as 129.255.43.10/24.

```
Device#configure terminal
Device(config)#interface vlan 129
Device(config-if-vlan129)#ip address 129.255.43.10 255.255.255.0
Device(config-if-vlan129)#end
```

#Configure the IP address of VLAN130 as 130.255.28.10/24.

```
Device#configure terminal
Device(config)#interface vlan 130
Device(config-if-vlan130)#ip address 130.255.28.10 255.255.255.0
Device(config-if-vlan130)#end
```

#Configure the IP address of VLAN131 as 131.255.28.10/24.

```
Device#configure terminal
Device(config)#interface vlan 131
Device(config-if-vlan131)#ip address 131.255.28.10 255.255.255.0
Device(config-if-vlan131)#end
```

Step 3: Configure AAA authentication.

#Enable AAA authentication on the Device, authentication method RADIUS, RADIUS server address 129.255.43.90/24, server key admin, and priority 1.

```
Device#configure terminal
Device(config)#domain system
Device(config-isp-system)# aaa authentication portal radius-group radius
Device(config-isp-system)#exit
Device(config)#aaa server group radius radius
Device(config-sg-radius-radius)#server 129.255.43.90 priority 1 key admin
```

Step 4: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 5: Configure general layer-3 Portal authentication.

#On the Device, configure the Portal server of server1.

```
Device(config)# portal server server1 ip 129.255.43.99 key admin url http://129.255.43.99:8080/portal
```

#Enable layer-3 Portal authentication on the Device.

```
Device#configure terminal
Device(config)#interface vlan 128
Device(config-if-vlan128)#portal server server1 method layer3 ip
Device(config-if-vlan128)#exit
```

#Configure a secure channel named channel, and permit both PC1 and PC2 to access the Update Serve.

```
Device#configure terminal
Device(config)#hybrid access-list advanced channel
Device(config-adv-hybrid-nacl)#permit ip any any host 130.255.28.20 any
```

#Apply the secure channel named channel.

```
Device#configure terminal
Device(config)#global security access-group channel
Device(config)#exit
```

Step 6: Configure Portal server.

#On Portal server, configure IP address of PC1, address of the Device and key value as admin. (Omitted)

Step 7: Check the result.

#View the configuration information of secure channel

Device#show portal global config

```
portal global configuration information:
authentication method list   : default
accounting method list       : default

global security access-group : channel
```

#Before passing authentication, PC1 can access the Update Server instead of IP Network.

#Verify that PC1 can pass the authentication. At this moment, PC1 can access both Update Server and IP Network; PC2 can access the Update Server instead of IP Network.

```
Device#show portal user
--------------------
NO 1:IP_ADDRESS= 128.255.36.1   STATUS=     Authorized     USER_NAME=   admin
    INTERFACE=  vlan128       CTRL_METHOD= L3_IP         AUTH_STATE=  AUTHENTICATED
    BACK_STATE= AAA_SM_IDLE

 Total: 1    Authorized: 1    Unauthorized/Guest/Critical: 0/0/0
```

71 Trusted device access

71.1 Overview

In order to prevent unauthorized access to the core network, the edge devices of core network must have high security. Therefore, other network devices that access these edge devices must be trusted ones. The trusted device access function implements the scheme of prohibiting unauthorized devices from accessing the core network based on the mature 802.1X protocol. Its basic network topology is shown in Figure 7-1. It includes three entities, i.e. Access Device, Authentication System and Authentication Server System.

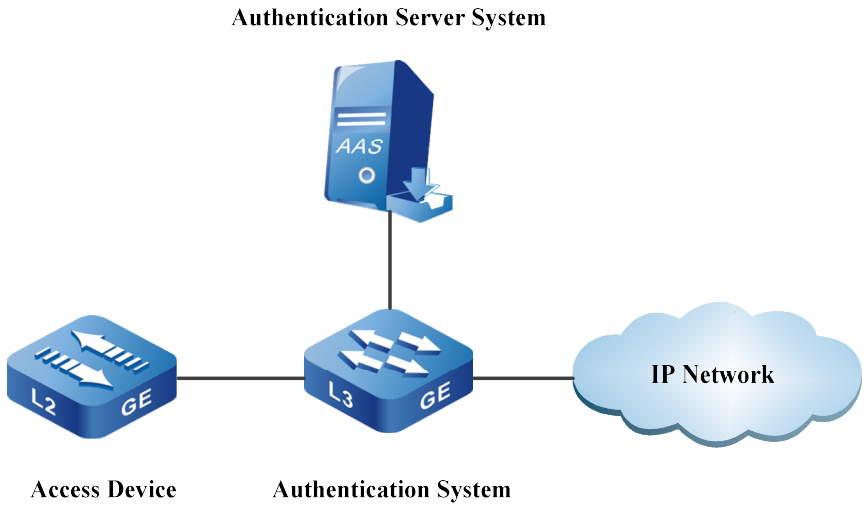


Figure 13-1 Topology for Trusted Device Access

The specific methods of accessing trusted device are shown below:

- Enable the trusted device access function on the access device, and configure the identity credential and relevant parameters required for device access on the access device and authentication server.
- Enable the authentication function of 802.1X device on the authentication device and make the port accessing to the access device become a controlled port for access of device.
- After the access device accesses the authentication device, it automatically initiates 802.1X authentication. After passing the 802.1X authentication, the authentication device turns on the controlled port to enable the access device to successfully access the network.
- The access device periodically conducts keepalive authentication according to the keepalive period set on the authentication device.

71.2 Configuration of trusted device access

Table 13-1 Trusted Device Access Function Configuration List

Configuration Task	
Configure Trusted Device Access	Configure User Name and Password of Trusted Device Access
	Configure the User Name Format of Trusted Device Access
	Configure Trigger Period of Trusted Device Access
	Enable Trusted Device Access
Configure 802.1X Device Authentication	Enable 802.1X Device Authentication Function
	Configure Authentication Keepalive Period of 802.1X Device

71.2.1 Configure Trusted Device Access

Configuration Condition

None

Configure User Name and Password of Trusted Device Access

To successfully make the access device access the network, you are required to configure the user name and password of trusted device access on the port connecting the authentication device. The user name and password configured will be sent as the authentication credential of the access device to the authentication device for authentication through 802.1X protocol (MD5-Challenge mode).

Table 13-2 Configuring User Name and Password of Trusted Device Access

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure User Name and Password of Trusted Device Access	**dot1x client user** *username* password 0 *password*	Mandatory By default, the user name and password of trusted device access are not configured under the port.

Note

- Only one user name and password for device access can be configured under one port. The newly configured user name and password under the same port will overwrite the original ones under this port.

Configure the User Name Format of Trusted Device Access

802.1X authentication identifies whether the peer end initiating authentication is device or terminal according to the device ID in the protocol packet EAP-Response/Identity. When the user name of the trusted device access under the port contains device ID, the authentication initiated by this port is 802.1X device authentication. When there is no device ID in the user name of the trusted device access under the port, the authentication initiated by this port is 802.1X terminal authentication.

Table 13-3 Configuring User Name Format of Trusted Device Access

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure the User Name Format of Trusted Device Access	**dot1x client user-name-format** { **with-dev-flag** | **without-dev-flag** }	Mandatory By default, the user name of trusted device access under the port contains device ID.

Configure Trigger Period of Trusted Device Access

Before the access device passes the authentication, it actively sends an EAPoL-Start packet for 802.1X device authentication according to the access trigger period configured to ensure that the access device can quickly access the network.

Table 13-4 Configuring Trigger Period of Trusted Device Access

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode,
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		the subsequent configuration takes effect only within the aggregation group.
Configure Trigger Period of Trusted Device Access	**dot1x client auth-interval** *interval-value*	Mandatory By default, the trigger period of trusted device access under the port is 15 seconds.

Enable Trusted Device Access

After the device access function is enabled, the access device will actively conduct 802.1X device authentication prior to passing authentication. After passing the 802.1X authentication, the authentication device turns on the controlled port to enable the access device to successfully access the network.

Table 13-5 Enabling Trusted Device Access

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable Trusted Device Access	**dot1x client** { **enable** | **disable** }	Mandatory

Step	Command	Description
		By default, the trusted device access function under the port is disabled.

Note

- The trusted device access and 802.1X authentication functions cannot be both enabled on the same port.
- The trusted device access and MAC address authentication functions cannot be both enabled on the same port.
- The trusted device access and secure channel authentication functions cannot be both enabled on the same port.

71.2.2 Configure 802.1X Device Authentication

Configuration Condition

None

Enable 802.1X Device Authentication Function

To enable the 802.1X device authentication function to take effect on the authentication device, you are required to enable both 802.1X authentication and 802.1X device authentication function. After the authentication device takes effect, the port connecting authentication device and access device becomes a controlled one; after passing the authentication, the authentication device turns on the controlled port to enable the access device to successfully access the network.

Table 13-6 Enabling 802.1X Device Authentication Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.

Step	Command	Description
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enable 802.1X Authentication	**dot1x port-control** { **enable** | **disable** }	Mandatory By default, the 802.1X authentication function under the port is disabled.
Enable 802.1X device authentication	**dot1x device-auth { enable | disable }**	Mandatory By default, the 802.1X device authentication function under the port is disabled.

Note

- The 802.1X device authentication and MAC address authentication functions cannot be both enabled on the same port.
- The 802.1X device authentication and secure channel authentication functions cannot be both enabled on the same port.

Configure Authentication Keepalive Period of 802.1X Device

In order to check whether the access device is online, after passing the authentication, the authentication device sends the 802.1X device authentication keepalive period configured to the access device which initiates keepalive authentication with this keepalive period. If the authentication device fails to receive the keepalive authentication from the access device during a period which is three times the keepalive period, the access device is considered offline, and the port status is changed to controlled.

Table 13-7 Configuring Keepalive Period of 802.1X Device Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure Authentication Keepalive Period of 802.1X Device	**dot1x device-auth keepalive** *period-value*	Mandatory By default, the keepalive period of 802.1X device authentication under the port is 600 seconds.

71.2.3 Trusted Device Access Monitoring and Maintaining

Table 13-8 Trusted Device Access Monitoring and Maintaining

Command	Description
show dot1x client config { interface *interface-name* | **link-aggregation** *link-aggregation-id* **}**	Show configuration information
show dot1x client user { interface *interface-name* | **link-aggregation** *link-aggregation-id* **}**	Shown access information
show dot1x user [*mac-address* | **auth-type {device** | **user }** | **interface** *interface-*	Show user information

Command	Description
name | **link-aggregation** *link-aggregation-id* | **summary**]	

71.3 Typical Example of Configuration of Trusted Device access

Network Requirements

- The access device Device1 accesses the IP Network through the authentication device Device2 which uses device authentication access control.
- Device1 periodically initiates keepalive authentication.
- Use RADIUS authentication.
- After the access device passes authentication, PC can access the network.

Network Topology

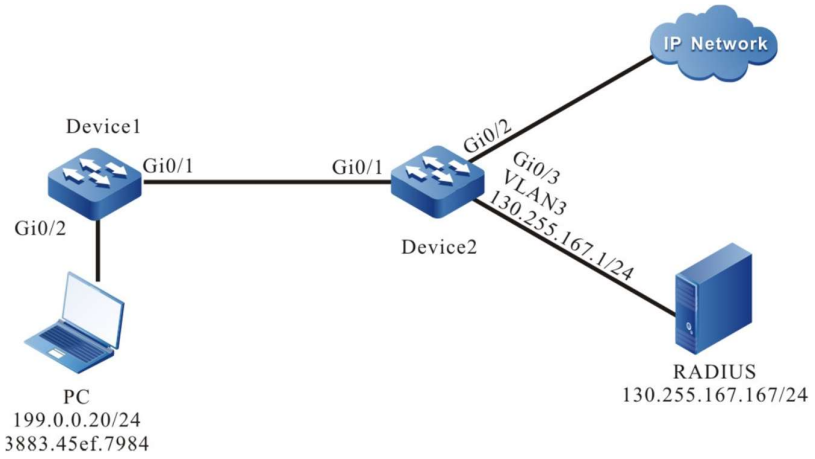


Figure 13-2 Network Topology for Configuring Trusted Device Access

Configuration Steps

Step 1: Configure VLAN and port link type on Device1.

#Configure the link type of port as Access on gigabitethernet 0/2 of Device1, allowing the services of VLAN2 to pass.

```
Device1(config)#interface gigabitethernet 0/2
Device1(config-if-range)#switchport mode access
Device1(config-if-range)#switchport access vlan 2
Device1(config-if-range)#exit
```

#Configure the link type of port as Hybrid on gigabitethernet 0/1 of Device1, and add the port to VLAN2 in Tagged mode.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-range)#switchport mode hybrid
Device1(config-if-range)#switchport hybrid tagged vlan 2
Device1(config-if-range)#exit
```

Step 2: Configure VLAN and port link type on Device2.

#Create VLAN2-VLAN3 on Device2.

```
Device2#configure terminal
Device2(config)#vlan 2-3
Device2(config)#exit
```

#Configure the link type of port as Hybrid on gigabitethernet 0/1 of Device2, and add the port to VLAN2 in Tagged mode.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-range)#switchport mode hybrid
Device2(config-if-range)# switchport hybrid tagged vlan 2
Device2(config-if-range)#exit
```

#Configure the link type of port as Access on gigabitethernet 0/2~ gigabitethernet 0/3 of the Device2, allowing the services of VLAN2~VLAN3 to pass. (Omitted)

Step 3: Configure the interface IP address of Device2.

#Configure the IP address of VLAN3 as 130.255.167.1/24 on Device2.

```
Device2(config)#interface vlan 3
Device2(config-if-vlan3)#ip address 130.255.167.1 255.255.255.0
Device2(config-if-vlan3)#exit
```

Step 4: Configure AAA authentication on Device2.

#Enable AAA authentication on Device2, authentication method RADIUS, server key admin, priority 1, and RADIUS server address 130.255.167.167/24.

```
Device2(config)#aaa new-model
Device2(config)#aaa authentication connection default radius
Device2(config)#radius-server host 130.255.167.167 priority 1 key admin
```

Step 5: Configure AAA server.

#On AAA server, configure user name, password and key value as admin. (Omitted)

Step 6: Configure trusted device access on Device1.

#On Device1, configure the user name and password for trusted device access authentication.

```
Device1(config)#interface gigabitethernet 0/1
```

```
Device1(config-if-gigabitethernet0/1)#dot1x client user admin password 0 admin
Device1(config-if-gigabitethernet0/1)#exit
```

#Configure to initiate eapol-start packet for 802.1X device authentication every 10 seconds.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#dot1x client auth-interval 10
Device1(config-if-gigabitethernet0/1)#exit
```

#On Device1, enable the trusted device access function

```
Device1(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#dot1x client enable
Device2(config-if-gigabitethernet0/1)#exit
```

Step 7: Configure 802.1X device authentication on Device2.

#Enable 802.1X authentication on Device2.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#dot1x port-control enable
Device2(config-if-gigabitethernet0/1)#exit
```

#Enable 802.1X device authentication on Device2

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#dot1x device-auth enable
Device2(config-if-gigabitethernet0/1)#exit
```

#On Device2, configure the keepalive period of 802.1X device authentication as 120 seconds.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#dot1x device-auth keepalive 120
Device2(config-if-gigabitethernet0/1)#exit
```

Step 8: Check the result.

#Before the access device passes the authentication, PC cannot access the network. After passing authentication, PC can normally access the network.

```
Device1#show dot1x client user
 Interface          : gi0/1
 Status             : Authorized
 State Machine State : AUTHENTICATED
 Keep Alive Interval : 120 sec (802.1X Server)
```

```
Device2#show dot1x user auth-type device
---------------------
NO 1   : MAC_ADDRESS= 3883.45ef.7984      STATUS=      Authorized     USER_NAME=   admin
       VLAN=       2               INTERFACE=   gi0/1         USER_TYPE=   DOT1X
       AUTH_STATE=  AUTHENTICATED     BACK_STATE=  IDLE          IP_ADDRESS=  Unknown
       Online time: 0 week 0 day 0 hour 0 minute 53 seconds

 Total: 1   Authorized: 1   Unauthorized/guest/critical: 0/0/0 Unknown: 0
```

72 ACL Configuration

72.1 Overview

72.1.1 Overview

ACL (Access Control List) is composed of a series of rules. Each rule is a statement of permit, deny or comment, stating corresponding matching conditions and behaviors. ACL rules filter packets by matching some fields in the packets.

ACL can be composed of multiple rules. The matching content specified by each rule is not completely the same, and they may overlap or conflict. ACL rules match by numbers from small to large, and those will a small sequence number takes effect first. Sequence means the sequence number of rules in the entire ACL.

Following the last ACL rule, there is a rule which denies all packets. Its sequence is larger than all the other rules. With invisible rule, it will discard the packet which doesn't match all the prior rules. That is to say, when the packet doesn't match all the previous rules, the default rules will be matched and the packet will be discarded.

Depending on the application purpose, ACL can be divided into seven types, standard IP ACL, extended IP ACL, standard MAC ACL, extended MAC ACL, extended Hybrid ACL, standard IPv6 ACL, and extended IPv6 ACL. ACL name comprises figures or user-defined character strings. When figures are used as ACL name, corresponding ACL category and value range are shown below:

- Standard IP ACL: 1 ~ 1000;
- Extended IP ACL: 1001 ~ 2000;
- Standard MAC ACL: 2001 ~ 3000;
- Extended MAC ACL: 3001 ~ 4000;
- Extended hybrid ACL: 5001 ~ 6000;
- Standard IPv6 ACL: 6001 ~ 7000;
- Extended IPv6 ACL: 7001 ~ 8000;

When user-defined character strings are used as ACL name, all ALCs share the same space. That is to say, if standard IP ACL uses a certain name, other types of ACL cannot use this name again.

ACL can also perform corresponding action group according to the matching result. For details, see the QOS configuration-related chapter in the User Manual.

72.1.2 Time Domain

Time domain is a set of time periods. A time domain can contain multiple time periods, and the time scope of time domain is the union of all time periods.

Time period has two types:

- Periodic time period means one or several days from Monday to Sunday and the period from start time to end time are selected as time periods, which can repeatedly take effect per week;
- Absolute time period takes effect in the specified date and time scope.

Users often have the following requirements:

The PC in a certain network segment can access the server during the office hours of working days (except for all holidays); all PCs are permitted to communicate with external networks on Saturday afternoon;

These time-based communication control requirements can be satisfied by binding time domains in ACL or ACL rules.

72.2 ACL Function Configuration

Table 72 ACL Function Configuration List

Configuration Task	
Configure Standard IP ACL	Configure Standard IP ACL
	Configure Standard IP ACL Named with Figures
Configure Extended IP ACL	Configure Extended IP ACL
	Configure Extended IP ACL Named with Figures
Configure Standard MAC ACL	Configure Standard MAC ACL
	Configure Standard MAC ACL Named with Figures
Configure Extended MAC ACL	Configure Extended MAC ACL

Configuration Task	
	Configure Extended MAC ACL Named with Figures
Configure Extended Hybrid ACL	Configure Extended Hybrid ACL
	Configure Extended Hybrid ACL Named with Figures
Configure Standard IPv6 ACL	Configure Standard IPv6 ACL
	Configure Standard IPv6 ACL Named with Figures
Configure Extended IPv6 ACL	Configure Extended IPv6 ACL
	Configure Extended IPv6 ACL Named with Figures
Configure Limit of ACL Rule Entries	Configure Limit of ACL Rule Entries
Configure Time Domain	Configure Time Domain
	Configure Periodic Time Period
	Configure Absolute Time Period
	Configure Refresh Period
	Configure the Maximum Time Deviation
	Configure Binding of Time Domain to ACL Rules
	Configure Binding of Time Domain to ACL
Configure ACL Application	Configure Application of IP ACL to Port
	Configure Application of MAC ACL to Port
	Configure Application of IP ACL to VLAN
	Configure Application of IP ACL to Global
	Configure Global Application of Hybrid ACL
	Configure Application of IP ACL to Interface
	Configure Application of MAC ACL to Interface

Configuration Task	
	Configure Application of IPv6 ACL to Port
	Configure Application of IPv6 ACL to Interface

72.2.1 Configure Standard IP ACL

The standard IP ACL only filters packets according to the rules set by source IP address.

Configuration Condition

None

Configure Standard IP ACL

The standard IP ACL name comprises figures or user-defined character strings. When figures are used as standard IP ACL name, the maximum number of ACLs can be enabled; if user-defined character strings are used as standard IP ACL name, the maximum number of ACLs can be disabled. Users can choose an appropriate ACL name according to the actual situation.

Table 72 Configuring Standard IP ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Standard IP ACL	**ip access-list standard** { *access-list-number* | *access-list-name* }	Mandatory By default, no standard IP ACL is configured. Value range of standard IP ACL: 1 ~ 1000
Configure ACL permit rules	[*sequence*] **permit** { **any** | *source-addr source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] **[log]** [**pbr-action-group** *pbr-action-group-name*]	Optional By default, no ACL permit rule is configured.

Step	Command	Description
	[**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	
Configure ACL deny rules	[*sequence*] **deny** { **any** | *source-addr source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] **[log]** [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Optional By default, no ACL deny rule is configured.
Configure ACL comment	[*sequence*] **remark** *comment*	Optional By default, no comment of ACL rules is configured.

Note

- To create standard IP ACL with the command ip access-list standard, rules must be configured under the standard IP ACL configuration mode.
- Sequence means the sequence number of rules in the entire ACL. ACLs match and filter packets by numbers from small to large, and those will a small sequence number takes effect first. When the packet doesn't match any of the rules, the default discarding action will be performed, i.e. all the packets that have not been permitted to pass will be discarded.

Configure Standard IP ACL Named with Figures

The standard IP ACL rules named with figures allow users to quickly identify the type of ACL. But they have some limitations, such as limited number of access lists and complicated process for users to identify ACL rules.

Table 72 Configuring Standard IP ACL Named with Figures

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Standard IP ACL Named with Figures	**access-list** *access-list-number* { **permit** | **deny** } { **any** | *source-addr source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] **[log]** [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Mandatory By default, no standard IP ACL named with figures is configured. Value range of standard IP ACL: 1 ~ 1000
Configure comment for standard IP ACL named with figures	**access-list** *access-list-number* **remark** *comment*	Optional By default, no comment for standard IP ACL rules named with figures is configured.

Note

- If the ACL with a specified number doesn't exist, create a new ACL and add new rules. If the ACL with a specified number exists, add new rules only.

72.2.2 Configure Extended IP ACL

The extended IP ACL can set classification rules according to IP protocol number, source IP address, destination IP address, source TCP/UDP port number, destination TCP/UDP port number, packet priority, TCP flag, and fragment flag to filter the packets.

Configuration Condition

None

Configure Extended IP ACL

The extended ACL name comprises figures or user-defined character strings. When figures are used as extended IP ACL name, the maximum number of ACLs can be enabled; if user-defined character strings are used as extended IP ACL name, the maximum number of ACLs can be disabled. Users can choose an appropriate ACL name according to the actual situation. The extended IP ACL has more abundant, accurate and flexible content than standard IP ACL.

Table 72 Configuring Extended IP ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Extended IP ACL	**ip access-list extended** { *access-list-number* | *access-list-name* }	Mandatory By default, no extended IP ACL is configured. Value range of extended IP ACL: 1001 ~ 2000
Configure ACL permit rules	[*sequence*] **permit** *protocol* { **any** | *source-addr source-wildcard* | **host** *source-addr* } [*operator source-port*] { **any** | *destination-addr destination-wildcard* | **host** *destination-addr* } [*operator destination-port*] [**ack** | **fin** | **psh** | **rst** | **syn** | **urg**] [**precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] **[log]** [**time-range** *time-range-name*] [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Optional By default, no ACL permit rule is configured.

Step	Command	Description
Configure ACL deny rules	[*sequence*] **deny** *protocol* { **any** | *source-addr source-wildcard* | **host** *source-addr* } [*operator source-port*] { **any** | *destination-addr destination-wildcard* | **host** *destination-addr* } [*operator destination-port*] [**ack** | **fin** | **psh** | **rst** | **syn** | **urg**] [**precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] **[log]** [**time-range** *time-range-name*] [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Optional By default, no ACL deny rule is configured.
Configure ACL comment	[*sequence*] **remark** *comment*	Optional By default, no comment of ACL rules is configured.

Note

- To create extended IP ACL with the command **ip access-list extended**, rules must be configured under the extended IP ACL configuration mode.
- Sequence means the sequence number of rules in the entire ACL. ACLs match and filter packets by numbers from small to large, and those will a small sequence number takes effect first. When the packet doesn't match any of the rules, the default discarding action will be performed, i.e. all the packets that have not been permitted to pass will be denied.

Configure Extended IP ACL Named with Figures

The extended IP ACL rules named with figures allow users to quickly identify the type of ACL. But they have some limitations, such as limited number of access lists and complicated process for users to identify ACL rules. The extended IP ACL has more abundant, accurate and flexible content than standard IP ACL.

Table 72 Configuring Extended IP ACL Named with Figures

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Extended IP ACL Named with Figures	**access-list** *access-list-number* { **permit** | **deny** } *protocol* { **any** | *source-addr source-wildcard* | **host** *source-addr* } [*operator source-port*] { **any** | *destination-addr destination-wildcard* | **host** *destination-addr* } [*operator destination-port*] [**ack** | **fin** | **psh** | **rst** | **syn** | **urg**] [**precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] **[log]** [**time-range** *time-range-name*] [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Mandatory By default, no extended IP ACL named with figures is configured. Value range of extended IP ACL: 1001 ~ 2000
Configure comment for extended IP ACL named with figures	**access-list** *access-list-number* **remark** *comment*	Optional By default, no comment for extended IP ACL rules named with figures is configured.

Note

- If the ACL with a specified number doesn't exist, create a new ACL and add new rules. If the ACL with a specified number exists, add new rules only.

72.2.3 Configure Standard MAC ACL

The standard MAC ACL only filters packets according to the rules set by source MAC address.

Configuration Condition

None

Configure Standard MAC ACL

The standard MAC ACL name comprises figures or user-defined character strings. When figures are used as standard MAC ACL name, the maximum number of ACLs can be enabled; if user-defined character strings are used as standard MAC ACL name, the maximum number of ACLs can be disabled. Users can choose an appropriate ACL name according to the actual situation.

Table 72 Configuring Standard MAC ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Standard MAC ACL	**mac access-list standard** { *access-list-number* | *access-list-name* }	Mandatory By default, no standard MAC ACL is configured. Value range of standard MAC ACL: 2001 ~ 3000
Configure ACL permit rules	[*sequence*] **permit** { **any** | *source-addr source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] **[log]** [**l2-action-group** *l2-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Optional By default, no ACL permit rule is configured.
Configure ACL deny rules	[*sequence*] **deny** { **any** | *source-addr source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] [log] [**l2-action-group** *l2-action-group-name*] [**egr-action-**	Optional By default, no ACL deny rule is configured.

Step	Command	Description
	group *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	
Configure ACL comment	[*sequence*] **remark** *comment*	Optional By default, no comment of ACL rules is configured.

Note

- To create standard MAC ACL with the command **mac access-list standard**, rules must be configured under the standard MAC ACL configuration mode.
- Sequence means the sequence number of rules in the entire ACL. ACLs match and filter packets by numbers from small to large, and those will a small sequence number takes effect first. When the packet doesn't match any of the rules, the default discarding action will be performed, i.e. all the packets that have not been permitted to pass will be discarded.

Configure Standard MAC ACL Named with Figures

The standard MAC ACL rules named with figures allow users to quickly identify the type of ACL. But they have some limitations, such as limited number of access lists and complicated process for users to identify ACL rules.

Table 72 Configuring Standard MAC ACL Named with Figures

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Standard MAC ACL Named with Figures	**access-list** *access-list-number* { **permit** | **deny** } { **any** | *source-addr source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] **[log]** [**l2-action-group** *l2-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Mandatory By default, no standard MAC ACL named with figures is configured. Value range of standard MAC ACL: 2001 ~ 3000

Step	Command	Description
Configure comment for standard MAC ACL named with figures	**access-list** *access-list-number* **remark** *comment*	Optional By default, no comment for standard MAC ACL rules named with figures is configured.

Note

- If the ACL with a specified number doesn't exist, create a new ACL and add new rules. If the ACL with a specified number exists, add new rules only.

72.2.4 Configure Extended MAC ACL

The extended MAC ACL can set classification rules according to Ethernet protocol type, source MAC address, destination MAC address, VLAN ID, and 802.1p priority to filter the packets.

Configuration Condition

None

Configure Extended MAC ACL

The extended MAC ACL name comprises figures or user-defined character strings. When figures are used as extended MAC ACL name, the maximum number of ACLs can be enabled; if user-defined character strings are used as extended MAC ACL name, the maximum number of ACLs can be disabled. Users can choose an appropriate ACL name according to the actual situation. The extended MAC ACL has more abundant, accurate and flexible content than standard MAC ACL.

Table 15-8 Configuring Extended MAC ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Extended MAC ACL	**mac access-list extended** { *access-list-number* | *access-list-name* }	Mandatory

Step	Command	Description
		By default, no extended MAC ACL is configured. Value range of extended MAC ACL: 3001 ~ 4000
Configure ACL permit rules	[*sequence*] **permit** { **any** | *source-addr source-wildcard* | **host** *source-addr* } { **any** | *destination-addr destination-wildcard* | **host** *destination-addr* } [**ether-type** *type*] [**cos** *cos*] [**vlan-id** *vlan*] [**time-range** *time-range-name*] **[log]** [**l2-action-group** *l2-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Optional By default, no ACL permit rule is configured.
Configure ACL deny rules	[*sequence*] **deny** { **any** | *source-addr source-wildcard* | **host** *source-addr* } { **any** | *destination-addr destination-wildcard* | **host** *destination-addr* } [**ether-type** *type*] [**cos** *cos*] [**vlan-id** *vlan*] [**time-range** *time-range-name*] [log] [**l2-action-group** *l2-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Optional By default, no ACL deny rule is configured.
Configure ACL comment	[*sequence*] **remark** *comment*	Optional By default, no comment of ACL rules is configured.

Note

- To create extended MAC ACL with the command **mac access-list extended**, rules must be configured under the extended MAC ACL configuration mode.
- Sequence means the sequence number of rules in the entire ACL. ACLs match and filter packets by numbers from small to large, and those will a small sequence number takes effect first. When the packet doesn't match any of the rules, the default discarding action will be performed, i.e. all the packets that have not been permitted to pass will be discarded.

Configure Extended MAC ACL Named with Figures

The extended MAC ACL rules named with figures allow users to quickly identify the type of ACL. But they have some limitations, such as limited number of access lists and complicated process for users to identify ACL rules. The extended MAC ACL has more abundant, accurate and flexible content than standard MAC ACL.

Table 72 Configuring Extended MAC ACL Named with Figures

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Extended MAC ACL Named with Figures	**access-list** *access-list-number* { **permit** | **deny** } { **any** | *source-addr source-wildcard* | **host** *source-addr* } { **any** | *destination-addr destination-wildcard* | **host** *destination-addr* } [**ether-type** *type*] [**cos** *cos*] [**vlan-id** *vlan*] [**time-range** *time-range-name*] **[log]** [**l2-action-group** *l2-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**vfp-action-group** *vfp-action-group-name*]	Mandatory By default, no extended MAC ACL named with figures is configured. Value range of extended MAC ACL: 3001 ~ 4000
Configure the comment for extended MAC ACL named with figures	**access-list** *access-list-number* **remark** *comment*	Optional By default, no comment for extended MAC ACL rules named with figures is configured.

Note

- If the ACL with a specified number doesn't exist, create a new ACL and add new rules. If the ACL with a specified number exists, add new rules only.

72.2.5 Configure Extended Hybrid ACL

The extended Hybrid ACL can set classification rules according to source MAC address, destination MAC address, Ethernet Type, IP protocol number, source IP address, destination IP address, packet priority, VLAN ID and 802.1p priority to filter the packets.

Configuration Condition

None

Configure Extended Hybrid ACL

The extended Hybrid ACL name comprises figures or user-defined character strings. When figures are used as extended Hybrid ACL name, the maximum number of ACLs can be enabled; if user-defined character strings are used as extended Hybrid ACL name, the maximum number of ACLs can be disabled. Users can choose an appropriate ACL name according to the actual situation. The extended Hybrid ACL is more abundant, accurate and flexible content than that separately defined using IP ACL and MAC ACL. But extended Hybrid ACL can be globally applied only and can only be used to filter the packets received.

Table 72 Configuring Extended Hybrid ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Extended Hybrid ACL	**hybrid access-list extended** { *access-list-number* | *access-list-name* }	Mandatory By default, no extended Hybrid ACL is configured. Value range of extended Hybrid ACL: 5001 ~ 6000
Configure ACL permit rules	[*sequence*] **permit** { **any** | *source-mac -addr source-wildcard* | **host** *source-mac-addr* } { **any** | *destination-mac-addr destination-wildcard* | **host** *destination-*	Optional By default, no ACL permit rule is configured.

Step	Command	Description
	mac-addr } [**cos** *cos*] [**vlan-id** *vlan*] [**time-range** *time-range-name*] **[egr-action-group** *egr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**ether-type**] { *etherne-type* | *ipv4 protocol* } { **any** | *source-ip-addr source-wildcard* | **host** *source-ip-addr* } { **any** | *destination -ip-addr destination -wildcard* | **host** *destination-ip-addr* }**[precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] [**time-range** *time-range-name*] [**egr-action-group** *egr-action-group-name*] [**l3-action-group** *l3-action-group-name*]	
Configure ACL deny rules	[*sequence*] **deny** { **any** | *source-mac -addr source-wildcard* | **host** *source-mac-addr* } { **any** | *destination-mac-addr destination-wildcard* | **host** *destination-mac-addr* } [**cos** *cos*] [**vlan-id** *vlan*] [**time-range** *time-range-name*] **[egr-action-group** *egr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**ether-type**] { *etherne-type* | *ipv4 protocol* } { **any** | *source-ip-addr source-wildcard* | **host** *source-ip-addr* } { **any** | *destination -ip-addr destination -wildcard* | **host** *destination-ip-addr* }**[precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] [**time-range** *time-range-name*] [**egr-action-group** *egr-action-group-name*]	Optional By default, no ACL deny rule is configured.

Step	Command	Description
	[**l3-action-group** *l3-action-group-name*]	
Configure ACL comment	[*sequence*] **remark** *comment*	Optional By default, no comment of ACL rules is configured.

Note

- To create extended Hybrid ACL with the command **hybrid access-list extended**, rules must be configured under the extended Hybrid ACL configuration mode.
- Sequence means the sequence number of rules in the entire ACL. ACLs match and filter packets by numbers from small to large, and those will a small sequence number takes effect first. When the packet doesn't match any of the rules, the default discarding action will be performed, i.e. all the packets that have not been permitted to pass will be discarded.

Configure Extended Hybrid ACL Named with Figures

The extended Hybrid ACL rules named with figures allow users to quickly identify the type of ACL. But they have some limitations, such as limited number of access lists and complicated process for users to identify ACL rules.

Table 72 Configuring Extended Hybrid ACL Named with Figures

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Extended Hybrid ACL Named with Figures	**access-list** *access-list-number* { **permit** | **deny** } { **any** | *source-mac -addr source-wildcard* | **host** *source-mac-addr* } { **any** | *destination-mac-addr destination-wildcard* | **host** *destination-mac-addr* } [**cos** *cos*] [**vlan-id** *vlan*] [**time-range** *time-range-name*] **[egr-action-group** *egr-action-group-name*] [**l3-**	Mandatory By default, no extended Hybrid ACL named with figures is configured. Value range of extended Hybrid ACL: 5001 ~ 6000

Step	Command	Description
	action-group *l3-action-group-name*] [**ether-type**] { *etherne-type* | *ipv4 protocol* } { **any** | *source-ip-addr source-wildcard* | **host** *source-ip-addr* } { **any** | *destination -ip-addr destination -wildcard* | **host** *destination-ip-addr* }[**precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] [**time-range** *time-range-name*] [**egr-action-group** *egr-action-group-name*] [**l3-action-group** *l3-action-group-name*]	
Configure the comment for extended Hybrid ACL named with figures	**access-list** *access-list-number* **remark** *comment*	Optional By default, no comment for extended Hybrid ACL rules named with figures is configured.

Note

- If the ACL with a specified number doesn't exist, create a new ACL and add new rules. If the ACL with a specified number exists, add new rules only.

72.2.6 Configure Standard IPv6 ACL

The standard IPv6 ACL can set classification rules according to the source IPv6 address field to filter the packets.

Configuration Condition

None

Configure Standard IPv6 ACL

The standard IPv6 ACL name comprises figures or user-defined character strings. When figures are used as standard IPv6 ACL name, the maximum number of ACLs can be

enabled; if user-defined character strings are used as standard IPv6 ACL name, the maximum number of ACLs can be disabled. Users can choose an appropriate ACL name according to the actual situation.

Table 1 Configuring Standard IPv6 ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Standard IPv6 ACL	**ipv6 access-list standard** { *access-list-number* | *access-list-name* }	Mandatory By default, no standard IPv6 ACL is configured.
Configure ACL permit rules	[*sequence*] **permit** { **any** | *source-addr/source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*]	Optional By default, no ACL permit rule is configured.
Configure ACL deny rules	[*sequence*] **deny** { **any** | *source-addr/source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**pbr-action-group** *pbr-action-group-name*]	Optional By default, no ACL deny rule is configured.
Configure ACL comment	[*sequence*] **remark** *comment*	Optional By default, no comment of ACL rules is configured.

Note

- To create standard IPv6 ACL with the command **ipv6 access-list standard**, rules must be configured under the standard IPv6 ACL configuration mode.
- Sequence means the sequence number of rules in the entire ACL. ACLs match and filter packets by numbers from small to large, and those will a small sequence number takes effect first. When the packet doesn't match any of the rules, the default discarding action will be performed, i.e. all the packets that have not been permitted to pass will be denied.

Configure Standard IPv6 ACL Named with Figures

The standard IPv6 ACL rules named with figures allow users to quickly identify the type of ACL. But they have some limitations, such as limited number of access lists and complicated process for users to identify ACL rules.

Table 2 Configuring Standard IPv6 ACL Named with Figures

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Standard IPv6 ACL Named with Figures	**access-list** *access-list-number* { **permit** | **deny** } { **any** | *source-addr/source-wildcard* | **host** *source-addr* } [**time-range** *time-range-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*] [**pbr-action-group** *pbr-action-group-name*]	Mandatory By default, no standard IPv6 ACL named with figures is configured. Value range of standard IPv6 ACL: 6001 ~ 7000
Configure the comment for standard IPv6 ACL named with figures	**access-list** *access-list-number* **remark** *comment*	Optional By default, no comment for standard IPv6 ACL rules named with figures is configured.

Note

- If the ACL with a specified number doesn't exist, create a new ACL and add new rules. If the ACL with a specified number exists, add new rules only.

72.2.7 Configure Extended IPv6 ACL

The extended IPv6 ACL can set classification rules according to IPv6 protocol number, source IPv6 address, destination IPv6 address, source TCP/UDP port number, destination TCP/UDP port number, packet priority, and TCP flag to filter the packets.

Configuration Condition

None

Configure Extended IPv6 ACL

The extended IPv6 ACL name comprises figures or user-defined character strings. When figures are used as extended IPv6 ACL name, the maximum number of ACLs can be enabled; if user-defined character strings are used as extended IPv6 ACL name, the maximum number of ACLs can be disabled. Users can choose an appropriate ACL name according to the actual situation.

Table 3 Configuring Extended IPv6 ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Extended IPv6 ACL	**ipv6 access-list extended** { *access-list-number* | *access-list-name* }	Mandatory By default, no extended IPv6 ACL is configured.
Configure ACL permit rules	[*sequence*] **permit** *protocol* { **any** | *source-addr/source-wildcard* | **host** *source-addr* } [*operator source-port*] { **any** | *destination-addr/destination-wildcard* | **host** *destination-addr* } [*operator destination-port*] [**ack** / **fin** / **psh** / **rst** / **syn** / **urg**] [**precedence**	Optional By default, no ACL permit rule is configured.

Step	Command	Description
	precedence] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] [**time-range** *time-range-name*] [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*]	
Configure ACL deny rules	[*sequence*] **deny** *protocol* { **any** | *source-addr/source-wildcard* | **host** *source-addr* } [*operator source-port*] { **any** | *destination-addr/destination-wildcard* | **host** *destination-addr* } [*operator destination-port*] [**ack** / **fin** / **psh** / **rst** / **syn** / **urg**] [**precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] [**time-range** *time-range-name*] [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*]	Optional By default, no ACL deny rule is configured.
Configure ACL comment	[*sequence*] **remark** *comment*	Optional By default, no comment of ACL rules is configured.

Note

- To create extended IPv6 ACL with the command **ipv6 access-list extended**, rules must be configured under the extended IPv6 ACL configuration mode.
- Sequence means the sequence number of rules in the entire ACL. ACLs match and filter packets by numbers from small to large, and those will a small sequence number takes effect first. When the packet doesn't match any of the rules, the default discarding action will be performed, i.e. all the packets that have not been permitted to pass will be denied.

Configure Extended IPv6 ACL Named with Figures

The extended IPv6 ACL rules named with figures allow users to quickly identify the type of ACL. But they have some limitations, such as limited number of access lists and complicated process for users to identify ACL rules.

Table 4 Configuring Extended IPv6 ACL Named with Figures

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Extended IPv6 ACL Named with Figures	**access-list** *access-list-number* { **permit** | **deny** } *protocol* { **any** | *source-addr/source-wildcard* | **host** *source-addr* } [*operator source-port*] { **any** | *destination-addr/destination-wildcard* | **host** *destination-addr* } [*operator destination-port*] [**ack** / **fin** / **psh** / **rst** / **syn** / **urg**] [**precedence** *precedence*] [**tos** *tos*] [**dscp** *dscp*] [**fragments**] [**time-range** *time-range-name*] [**pbr-action-group** *pbr-action-group-name*] [**l3-action-group** *l3-action-group-name*] [**egr-action-group** *egr-action-group-name*]	Mandatory By default, no extended IPv6 ACL named with figures is configured. Value range of extended IPv6 ACL: 7001 ~ 8000
Configure the comment for extended IPv6 ACL named with figures	**access-list** *access-list-number* **remark** *comment*	Optional By default, no comment for extended IPv6 ACL rules named with figures is configured.

Note

- If the ACL with a specified number doesn't exist, create a new ACL and add new rules. If the ACL with a specified number exists, add new rules only.

72.2.8 Configure Commit Operation

Commit operating command is used to confirm the ACL rules configured, including whether the rules added or deleted take effect. After an ACL rule is added or deleted, Commit operation must be performed. Otherwise, the rule added or deleted will not take effect. When the configuration is saved, the added rule without Committing will not be saved to the Startup file.

Configuration Condition

Configure ACL

Configure Commit operation

After an ACL rule is configured, it is required to perform Commit operation to commit current ACL rule added or deleted.

Table 5 Configuring Commit Operation for ACL Rules

Step	Command	Description
Enter the ACL configuration mode	**ip access-list standard** { *access-list-number* | *access-list-name* }	Mandatory By default, no standard IP ACL is configured. Value range of standard IP ACL: 1 ~ 1000 The ACL configuration mode is not limited to standard IP ACL. Commit operation supports all the ACL configuration modes.
Commit ACL rules	**commit**	Mandatory By default, the rule added or deleted is not Committed.

72.2.9 Configure Limit of ACL Rule Entries

Configuration Condition

None

Configure Limit of ACL Rule Entries

After it is enabled, at most 1024 rule entries can be configured in a single ACL.

Table 6 Configuring Limit of ACL Rule Entries

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Disable/enable the limit of ACL rule entries	**access-list rule-limit** { **enable** | **disable** }	Mandatory By default, this function is disabled, i.e. the number of rule entries configured in each ACL is not limited by the maximum number 1024.

72.2.10Configure Time Domain

Time domain is a set of time periods. A time domain can contain multiple time periods, and the time scope of time domain is the union of all time periods. Time domain can be bound to ACL or ACL rule as a precondition for the ACL or ACL rule to take effect or not.

Configuration Condition

Before configuring the time domain function, do the following:

- Configure the ACL.

Configure Time Domain

Configure whether the application object of time domain is limited by the time domain. When it is enabled, all application objects are limited by time domain. Otherwise, they are not limited by time domain.

Table 7 Configuring Time Domain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to enable/disable time domain	**set time-range** { **enable** | **disable** }	Mandatory It is enabled by default.

Configure Periodic Time Period

Periodic time period means one or several days from Monday to Sunday and the period from start time to end time are selected as time periods, which can repeatedly take effect per week.

Table 8 Configuring Periodic Time Period

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Time Domain	**time-range** *time-range-name*	Mandatory By default, time domain is not configured.
Configure Periodic Time Period	[*sequence*] **periodic** [*day-of-the-week*] [*hh*：*mm* [：*ss*]] **to** [*day-of-the-week*] [*hh*：*mm* [：*ss*]] [*sequence*] **periodic** { **weekdays** | **weekend** | **daily** } [*hh*：*mm* [：*ss*]] **to** [*hh*：*mm* [：*ss*]]	At least one option must be selected. By default, no periodic time period is configured. The previous command can specify the time scope as a single day (e.g. Monday) or several days (Monday, Friday). The latter command can specify the time scope as every day, weekend, or working days.

Configure Absolute Time Period

Absolute time period takes effect in the specified date and time scope.

Table 9 Configuring Absolute Time Period

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Time Domain	**time-range** *time-range-name*	Mandatory By default, time domain is not configured.

Step	Command	Description
Configure absolute time period of time domain	[*sequence*] **absolute start** *hh*：*mm* [： *ss*] [*day* [*month* [*year*]]] **end** *hh*：*mm* [： *ss*] [*day* [*month* [*year*]]]	Mandatory By default, the absolute time period of time domain is not configured.

Configure Refresh Period

Time domain has two statuses, i.e. valid and invalid. By default, it automatically refreshes every 1 minute according to current system time. Therefore, the status refresh may have 0-60 seconds of time delay compared to the system time.

Table 10 Configuring Refresh Period

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure time domain refresh period	**set time-range frequency** {*frequency-min*	**seconds** *frequency-sec*}	Mandatory The default value is 1 minute. The refresh period is the interval between two refreshes, in minute or second.

Configure the Maximum Time Deviation

The maximum time deviation means the maximum deviation between the accumulated time of the counter and the system time. Once the time statistics exceed the deviation value, the status of each time domain will be judged and updated at the time of next refreshing so as to get increasingly accurate time statistics.

Table 11 Configuring Maximum Time Deviation

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure the maximum time deviation of time domain	**set time-range max-offset** *max-offset-number*	Mandatory The default value is 100. The time deviation, in seconds, has a value range of 1~300.

Configure Binding of Time Domain to ACL Rules

When it's necessary to make a user access network resources during a specified period of time, you can set the time domain-based ACL rules to filter packets. Whether the time domain takes effect has a direct impact on the ACL rules associated with it.

Table 12 Configuring Binding of Time Domain to ACL Rules

Step	Command	Description
Configure to bind with standard IP ACL rules	Please see "Configure Standard IP ACL"	-
Configure to bind with extended IP ACL rules	Please see "Configure Extended IP ACL"	-
Configure to bind with standard MAC ACL rules	Please see "Configure Standard MAC ACL"	-
Configure to bind with extended MAC ACL rules	Please see "Configure Extended MAC ACL"	-
Configure to bind with extended Hybrid ACL rules	Please see "Configure Extended Hybrid ACL"	-
Configure to bind with standard IPv6 ACL rules	Please see "Configure Standard IPv6 ACL"	-
Configure to bind with extended IPv6 ACL rules	Please see "Configure Extended IPv6 ACL"	-

Note

- When the time domain to which ACL rules are bound doesn't exist, the ACL rules take effect.

Configure Binding of Time Domain to ACL

When it's necessary to make some users access network resources during the same period of time, you can set the time domain-based ACL to filter packets. Whether the time domain takes effect has a direct impact on the rules contained in the entire ACL.

Table 13 Configuring Binding of Time Domain to ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure binding of time domain to IP ACL	**ip time-range** *time-range-name* **access-list** { *access-list-number* | *access-list-name* }	Mandatory By default, the time domain is not bound to IP ACL.
Configure binding of time domain to MAC ACL	**mac time-range** *time-range-name* **access-list** { *access-list-number* | *access-list-name* }	Mandatory By default, the time domain is not bound to MAC ACL.
Configure binding of time domain to Hybrid ACL	**hybrid time-range** *time-range-name* **access-list** { *access-list-number* | *access-list-name* }	Mandatory By default, the time domain is not bound to Hybrid ACL.
Configure binding of time domain to IPv6 ACL	**ipv6 time-range** *time-range-name* **access-list** { *access-list-number* | *access-list-name* }	Mandatory By default, the time domain is not bound to IPv6 ACL.

Note

- When the time domain to which ACL is bound doesn't exist, the ACL takes effect.

72.2.11Configure ACL Application

ACL can be applied to global, VLAN, port and interface. IP ACL can be applied globally in the incoming direction, to VLAN, port and interface in both incoming and outgoing directions; Hybrid ACL can be applied to global, port and interface in both incoming and outgoing directions; MAC ACL can be applied to port and interface in both incoming and outgoing directions; IPv6 ACL can be applied to port and interface in both incoming and outgoing directions.

When ACL is applied globally, it will filter all packets in the incoming direction of the device port; when ACL is applied to VLAN, it will filter all packets in the incoming direction and the forwarded packets in the outgoing direction of the port in the VLAN; when ACL is applied to a port, all packets in the incoming direction and the forwarded packets in the outgoing direction of the port will be filtered; when ACL is applied to an interface, the layer-3 forwarded packets will be filtered.

ACL matches by priority from high to low: apply to port, apply to VLAN, and apply globally.

If the packets simultaneously match the ACL rules of applying to port, applying to VLAN and applying globally, the permitted packet with a high priority is matched first, and the packet with a filtering result of deny is directly discarded.

Configuration Condition

Before configuring ACL application, do the following:

- Configure the ACL.

Configure Application of IP ACL to Port

Apply IP ACL to the port to analyze and process the packets passing through this port according to the IP ACL.

Table 14 Configuring Application of IP ACL to Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode,
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		the subsequent configuration takes effect only within the aggregation group.
Configure to apply IP ACL to port	**ip access-group** { *access-list-number* | *access-list-name* } { **in** | **out** | **vfp** }	Mandatory By default, no IP ACL is applied to the port.

Note

- If the ACL applied to port doesn't exist, all the packets passing through this port will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IPv6 ACL to Port

Apply IPv6 ACL to the port to analyze and process the packets passing through this port according to the IPv6 ACL.

Table 15 Configuring Application of IPv6 ACL to Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	

Step	Command	Description
		only within the aggregation group.
Configure to apply IPv6 ACL to port	**ipv6 access-group** { *access-list-number* | *access-list-name* } { **in** | **out** }	Mandatory By default, no IPv6 ACL is applied to the port.

Note

- If the ACL applied to port doesn't exist, all the packets passing through this port will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of MAC ACL to Port

Apply MAC ACL to the port to analyze and process the packets passing through this port according to the MAC ACL.

Table 16 Configuring Application of MAC ACL to Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
Configure to apply MAC ACL to port	**mac access-group** { *access-list-number* | *access-list-name* } { **in** | **out** | **vfp** }	Mandatory By default, no MAC ACL is applied to the port.

Note

- If the ACL applied to port doesn't exist, all the packets passing through this port will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of HYBRID ACL to Port

Apply HYBRID ACL to the port to analyze and process the packets passing through this port according to the HYBRID ACL.

Table 17 Configuring Application of HYBRID ACL to Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure to apply HYBRID ACL to port	**hybrid access-group** { *access-list-number* |	Mandatory

Step	Command	Description
	access-list-name } { **in** | **out** }	By default, no HYBRID ACL is applied to the port.

Note

- If the ACL applied to port doesn't exist, all the packets passing through this port will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IP ACL to VLAN

Apply IP ACL to VLAN to analyze and process the packets passing through this VLAN according to the IP ACL.

Table 18 Configuring Application of IP ACL to VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure to apply IP ACL to VLAN	**ip access-group** { *access-list-number* | *access-list-name* } { **in** | **out** | **vfp** }	Mandatory By default, no IP ACL is applied to VLAN.

Note

- If the ACL applied to VLAN doesn't exist, all the packets passing through this VLAN will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of MAC ACL to VLAN

Apply MAC ACL to VLAN to analyze and process the packets passing through this VLAN according to the MAC ACL.

Table 19 Configuring Application of MAC ACL to VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure to apply MAC ACL to VLAN	**mac access-group** { *access-list-number* | *access-list-name* } { **in** | **out** }	Mandatory By default, no MAC ACL is applied to VLAN.

Note

- If the ACL applied to VLAN doesn't exist, all the packets passing through this VLAN will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IPv6 ACL to VLAN

Apply IPv6 ACL to VLAN to analyze and process the packets passing through this VLAN according to the IPv6 ACL.

Table 20 Configuring Application of IPv6 ACL to VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure to apply IPv6 ACL to VLAN	**ipv6 access-group** { *access-list-number* | *access-list-name* } { **in** | **out** }	Mandatory By default, no IPv6 ACL is applied to VLAN.

Note

- If the ACL applied to VLAN doesn't exist, all the packets passing through this VLAN will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of MAC ACL to VLAN RANGE

Apply MAC ACL to VLAN RANGE to analyze and process the packets passing within this VLAN RANGE according to the MAC ACL.

Table 21 Configuring Application of MAC ACL to VLAN RANGE

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to apply MAC ACL to VLAN RANGE	**mac access-group** { *access-list-number* | *access-list-name* } { **in** | **out** } **vlan range** <1-4094>	Mandatory By default, no MAC ACL is applied to VLAN RANGE.

Note

- If the ACL applied to VLAN RANGE doesn't exist, all the packets passing through this VLAN RANGE will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IP ACL to VLAN RANGE

Apply IP ACL to VLAN RANGE to analyze and process the packets passing within this VLAN RANGE according to the IP ACL.

Table 22 Configuring Application of IP ACL to VLAN RANGE

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to apply IP ACL to VLAN RANGE	**ip access-group** { *access-list-number* | *access-list-name* } { **in** | **out** } **vlan range** <1-4094>	Mandatory By default, no IP ACL is applied to VLAN RANGE.

Note

- If the ACL applied to VLAN RANGE doesn't exist, all the packets passing through this VLAN RANGE will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IPv6 ACL to VLAN RANGE

Apply IPv6 ACL to VLAN RANGE to analyze and process the packets passing within this VLAN RANGE according to the IPv6 ACL.

Table 23 Configuring Application of IPv6 ACL to VLAN RANGE

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to apply IPv6 ACL to VLAN RANGE	**ipv6 access-group** { *access-list-number* | *access-list-name* } { **in** | **out** } **vlan range** <1-4094>	Mandatory By default, no IPv6 ACL is applied to VLAN RANGE.

Note

- If the ACL applied to VLAN RANGE doesn't exist, all the packets passing through this VLAN RANGE will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of MAC ACL to VLAN RANGE of Layer-3 Interface

Apply MAC ACL to VLAN RANGE of layer-3 interface to analyze and process the packets passing within this VLAN RANGE of layer-3 interface according to the MAC ACL.

Table 24 Configuring Application of MAC ACL to VLAN RANGE of Layer-3 Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure application of MAC ACL to VLAN RANGE of layer-3 interface	**mac access-group** { *access-list-number* | *access-list-name* } { **in** | **out** } **interface vlan range** <1-4094>	Mandatory By default, no MAC ACL is applied to VLAN RANGE of layer-3 interface.

Note

- If the ACL applied to VLAN RANGE of layer-3 interface doesn't exist, all the packets passing through this VLAN RANGE will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IP ACL to VLAN RANGE of Layer-3 Interface

Apply IP ACL to VLAN RANGE of layer-3 interface to analyze and process the packets passing within this VLAN RANGE of layer-3 interface according to the IP ACL.

Table 25 Configuring Application of IP ACL to VLAN RANGE of Layer-3 Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure application of IP ACL to VLAN RANGE of layer-3 interface	**ip access-group** { *access-list-number* | *access-list-name* } { **in** | **out** } **interface vlan range** <1-4094>	Mandatory By default, no IP ACL is applied to VLAN RANGE of layer-3 interface.

Note

- If the ACL applied to VLAN RANGE of layer-3 interface doesn't exist, all the packets passing through this VLAN RANGE will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IPv6 ACL to VLAN RANGE of Layer-3 Interface

Apply IPv6 ACL to VLAN RANGE of layer-3 interface to analyze and process the packets passing within this VLAN RANGE of layer-3 interface according to the IPv6 ACL.

Table 26 Configuring Application of IPv6 ACL to VLAN RANGE of Layer-3 Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure application of IPv6 ACL to VLAN RANGE of layer-3 interface	**ipv6 access-group** { *access-list-number* | *access-list-name* } { **in** | **out** } **interface vlan range** <1-4094>	Mandatory By default, no IPv6 ACL is applied to VLAN RANGE of layer-3 interface.

Note

- If the ACL applied to VLAN RANGE of layer-3 interface doesn't exist, all the packets passing through this VLAN RANGE will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IP ACL to Global

Apply IP ACL globally to analyze and process the packets passing through all ports according to the IP ACL.

Table 27 Configuring Global Application of IP ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure to apply IP ACL globally	**global ip access-group** { *access-list-number* | *access-list-name* } **in**	Mandatory By default, no IP ACL is applied globally.

Note

- If the ACL applied globally doesn't exist, and no ACL is set on all ports, all the packets passing through the port will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Global Application of Hybrid ACL

Apply Hybrid ACL globally to analyze and process the packets passing through all ports according to the Hybrid ACL.

Table 28 Configuring Global Application of Hybrid ACL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to apply Hybrid ACL globally	**global hybrid access-group** { *access-list-number* | *access-list-name* } **{ in | out }**	Mandatory By default, no Hybrid ACL is applied globally.

Note

- If the ACL applied globally doesn't exist, and no ACL is set on all ports, all the packets passing through all ports will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IP ACL to Interface

Apply IP ACL to interface to analyze and process the packets passing through this interface according to the IP ACL.

Table 29 Configuring Application of IP ACL to Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure to apply IP ACL to interface	**ip access-group** { *access-list-number* | *access-list-name* } { **in** | **out** }	Mandatory By default, no IP ACL is applied to the interface.

Note

- If the ACL applied to interface doesn't exist, all the packets passing through this interface will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of MAC ACL to Interface

Apply MAC ACL to interface to analyze and process the packets passing through this interface according to the MAC ACL.

Table 30 Configuring Application of MAC ACL to Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure to apply MAC ACL to interface	**mac access-group** { *access-list-number* | *access-list-name* } { **in** | **out** }	Mandatory By default, no MAC ACL is applied to interface.

Note

- If the ACL applied to interface doesn't exist, all the packets passing through this interface will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of IPv6 ACL to Interface

Apply IPv6 ACL to interface to analyze and process the packets passing through this interface according to the IPv6 ACL.

Table 15-42 Configuring Application of Ipv6 ACL to Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure to apply IPv6 ACL to interface	**ipv6 access-group** { *access-list-number* | *access-list-name* } { **in** | **out** }	Mandatory By default, no IPv6 ACL is applied to the interface.

Note

- If the ACL applied to interface doesn't exist, all the packets passing through this interface will be permitted.
- This device does not support the ACL in the outgoing direction.

Configure Application of HYBRID ACL to Interface

Apply HYBRID ACL to interface to analyze and process the packets passing through this interface according to the HYBRID ACL.

Table 31 Configuring Application of HYBRID ACL to Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure to apply HYBRID ACL to interface	**hybrid access-group** { *access-list-number* | *access-list-name* } { **in** | **out** }	Mandatory By default, no HYBRID ACL is applied to interface.

Note

- If the ACL applied to interface doesn't exist, all the packets passing through this interface will be permitted.
- This device does not support the ACL in the outgoing direction.

72.2.12Configure ACL Mode

When the same ACL is applied on different ports, there are two modes. The first one is Port mode. In this mode, the same ACL uses different ACL resources on different ports, and the traffic on different ports uses different resources for matching. The other one is BitMap mode. In this mode, the same ACL uses the same ACL resources on different ports. Port matches through bitmaps. The traffic of different ports uses related resources for matching. Therefore, this mode can save resources. By default, the ACL is in Port mode.

Configuration Condition

None

Configure ACL Mode

When the same ACL is used on different ports, mode can be utilized to adjust whether ACL will separately issues resources on the port or share resources through BitMap.

Table 32 Configuring ACL Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure ACL mode	**acl mode { port | bitmap }**	Mandatory By default, ACL is in Port mode.

72.2.13ACL Monitoring and Maintaining

Table 33 ACL Monitoring and Maintaining

Command	Description
show access-list [*access-list-number* | *access-list-name*]	Show the ACL configuration information
show acl-object [global | interface [vlan [in | out] | switchport [in | out | vfp]] | vlan [in | out] | vlan-range [in | out]]	Show the information of VLAN, port, global application of ACL and interface VLAN
show hybrid access-list [*access-list-number* | *access-list-name*]	Show the configuration information of Hybrid extension and advanced ACL
show ip access-list [*access-list-number* | *access-list-name*]	Show the IP ACL configuration information
show ip interface list	Show the information of IP ACL applied to interface
show ipv6 access-list [*access-list-number* | *access-list-name*]	Show the configuration information of IPv6 ACL
show mac access-list [*access-list-number* | *access-list-name*]	Show the MAC ACL configuration information
show mac interface list	Show the information of MAC ACL applied to interface
show time-range [*time-range-name*]	Show the configuration of time domain and status information

Command	Description
show time-range-state [*time-range-name*]	Show status information of time domain
show acl mode	Show the information of ACL mode

72.3 Typical Configuration Example of ACL

72.3.1 Configure Standard IP ACL

Network Requirements

- PC1, PC2 and PC3 access IP network through the Device.
- Configure standard IP ACL rules so that PC1 instead of PC2 and PC3 can access the IP Network.

Network Topology

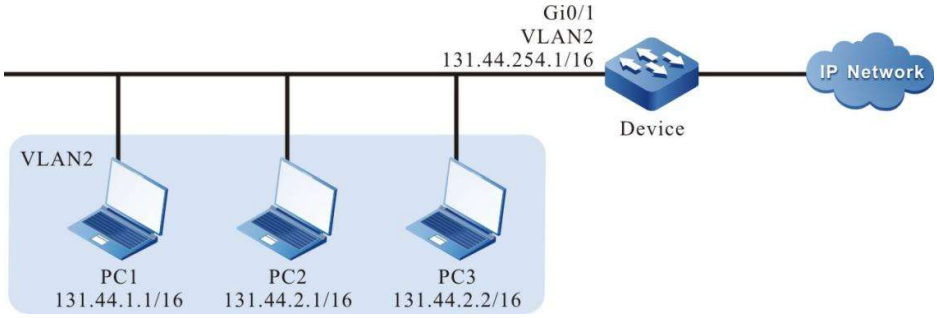


Figure 11-1 Network Topology for Configuring Standard IP ACL

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 2: Configure corresponding VLAN interface and IP address on the Device. (Omitted)

Step 3: Configure the standard IP ACL.

#Configure the standard IP ACL numbered 1 on Device.

```
Device(config)#ip access-list standard 1
```

#Configure rules to permit PC1 to access the IP Network.

```
Device(config-std-nacl)#permit host 131.44.1.1
```

#Configure rules to prevent the network segment 131.44.2.0/24 from accessing the IP Network.

```
Device(config-std-nacl)#deny 131.44.2.0 0.0.0.255
```

#Commit the rules configured

```
Device(config-std-nacl)#commit
Device(config-std-nacl)#exit
```

#View the information of ACL 1 on the Device.

```
Device#show ip access-list 1
ip access-list standard 1
 10 permit host 131.44.1.1
 20 deny 131.44.2.0 0.0.0.255
```

Step 4: Configure applying of the standard IP ACL.

#Apply the standard IP ACL numbered 1 to the ingress direction of port gigabitethernet0/1 of Device.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#ip access-group 1 in
Device(config-if-gigabitethernet0/1)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
-----------Interface-----Bind-----Instance--------------
Interface----------------Direction----AclType----AclName
gi0/1                  IN          IP        1
-----------Interface-----Bind-----Instance--------------
Interface VlanId---------Direction----AclType----AclName
Device#
```

Step 5: Check the result.

#PC1 instead of PC2 and PC3 can access the IP Network.

72.3.2 Configure Extended IP ACL with Time Domain

Network Requirements

- PC1, PC2 and PC3 access IP network through the Device.
- Configure extended IP ACL rules so that PC1 can access the IP Network within the specified time, PC2 can access the FTP services in the IP Network, and PC3 cannot access the IP Network.

Network Topology

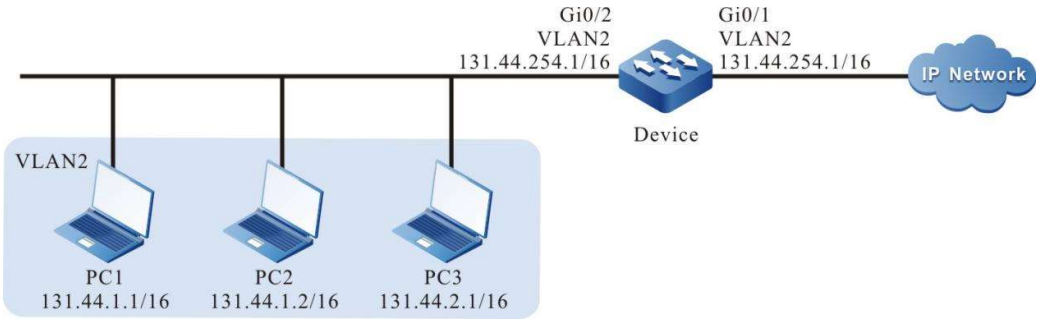


Figure 72-2 Network Topology for Configuring Extended IP ACL with Time Domain

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of the ports gigabitethernet0/1 and gigabitethernet0/2 as Access, permitting the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1,0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure corresponding VLAN interface and IP address on the Device. (Omitted)

Step 3: Configure time domain.

#Configure time domain "time-range-work" on the Device, from 08:00:00 to 18:00:00 per day.

```
Device(config)#time-range time-range-work
Device(config-time-range)#periodic daily 08:00:00 to 18:00:00
Device(config-time-range)#exit
```

#View current system time on the Device.

```
Device#show clock

UTC FRI APR 05 15:26:31 2013
```

#View the information of defined time domain "time-range-work" on the Device.

```
Device#show time-range time-range-work
Timerange name:time-range-work  (STATE:active)
  10  periodic daily 08:00:00 to 18:00:00 (active)
```

Step 4: Configure extended IP ACL.

#Configure the extended IP ACL numbered 1001 on the Device.

```
Device(config)#ip access-list extended 1001
```

#Configure rules to prevent the network segment 131.44.2.0/24 from accessing the IP Network.

```
Device(config-ext-nacl)#deny ip 131.44.2.0 0.0.0.255 any
```

#Configure rules to permit PC2 to access the FTP services of IP Network.

```
Device(config-ext-nacl)#permit tcp host 131.44.1.2 any eq ftp
Device(config-ext-nacl)#permit tcp host 131.44.1.2 any eq ftp-data
```

#Configure rules to permit PC1 to access the IP Network within the scope of the defined time domain "time-range-work".

```
Device(config-ext-nacl)#permit ip host 131.44.1.1 any time-range time-range-work
```

#Commit the rules configured

```
Device(config-ext-nacl)#commit
Device(config-ext-nacl)#exit
```

#View the information of ACL 1001 on the Device.

```
Device#show ip access-list 1001
ip access-list extended 1001
 10 deny ip 131.44.2.0 0.0.0.255 any
 20 permit tcp host 131.44.1.2 any eq ftp
 30 permit tcp host 131.44.1.2 any eq ftp-data
 40 permit ip host 131.44.1.1 any time-range time-range-work (active)
```

Step 5: Configure to apply extended IP ACL.

#Apply the extended IP ACL numbered 1001 in the incoming direction of port gigabitethernet0/2 of the Device.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/1)#ip access-group 1001 in
Device(config-if-gigabitethernet0/1)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
-----------Interface-----Bind-----Instance--------------
Interface----------------Direction----AclType----AclName
gi0/2                 IN         IP        1001
```

```
----------Interface-----Bind-----Instance--------------
Interface VlanId---------Direction----AclType----AclName
```

Step 6: Check the result.

#PC1 can access the IP Network from 08:00 to 18:00 per day; PC2 can access the FTP server in the IP Network, and PC3 cannot access the IP Network.

72.3.3 Configure Standard MAC ACL

Network Requirements

- PC1, PC2 and PC3 access IP network through the Device.
- Configure standard MAC ACL rules so that PC1 instead of PC2 and PC3 can access the IP Network.

Network Topology

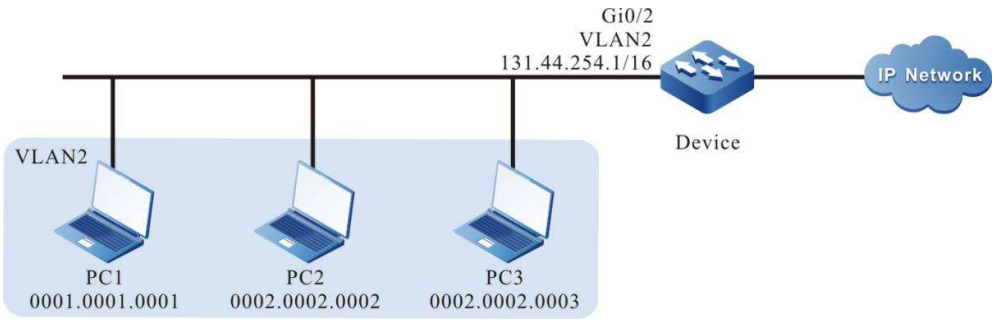


Figure 72-3 Network Topology for Configuring Standard MAC ACL

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/2 to Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#switchport mode access
Device(config-if-gigabitethernet0/2)#switchport access vlan 2
Device(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure corresponding VLAN interface and IP address on the Device. (Omitted)

Step 3: Configure standard MAC ACL.

#Configure the standard MAC ACL numbered 2001 on the Device.

```
Device(config)#mac access-list standard 2001
```

#Configure rules to permit PC1 to access the IP Network.

```
Device(config-std-mac-nacl)#permit host 0001.0001.0001
```

#Configure rules to prevent the network segment with MAC address of 0002.0002.0000 and mask of ffff.ffff.0000 from accessing the IP Network.

```
Device(config-std-mac-nacl)#deny 0002.0002.0000 0000.0000.ffff
```

#Commit the rules configured

```
Device(config-std-mac-nacl)#commit
```

#View the information of ACL 2001 on the Device.

```
Device#show mac access-list 2001
mac access-list standard 2001
 10 permit host 0001.0001.0001
 20 deny 0002.0002.0000 0000.0000.ffff
```

Step 4: Configure to apply standard MAC ACL.

#Apply the standard MAC ACL numbered 2001 in the incoming direction of port gigabitethernet0/1 of the Device.

```
Device(config)#interface gigabitethernet 0/2
Device(config-if-gigabitethernet0/2)#mac access-group 2001 in
Device(config-if-gigabitethernet0/2)#exit
```

#View on Device, the information of the ACL applied to the port.

```
Device#show acl-object interface
-----------Interface-----Bind-----Instance--------------
Interface----------------Direction----AclType----AclName
gi0/2                IN          MAC        2001
-----------Interface-----Bind-----Instance--------------
Interface VlanId---------Direction----AclType----AclName
```

Step 5: Check the result.

#PC1 instead of PC2 and PC3 can access the IP Network.

72.3.4 Configure Extended MAC ACL

Network Requirements

- PC1, PC2 and IP Phone access the IP network through Device1.

- Configure extended MAC ACL rules on Device2 so that VLAN2 users cannot access the IP Network, and VLAN3 users others than voice users can access it.

Network Topology

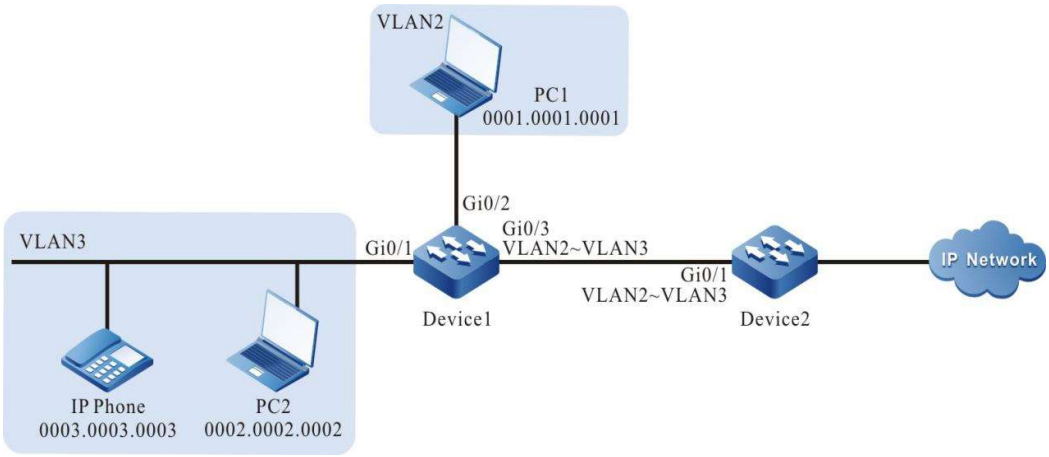


Figure 72-4 Network Topology for Configuring Extended MAC ACL

Configuration Steps

Step 1: Configure VLAN and port link type on Device2.

#Create VLAN2 and VLAN3.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit

Device2#configure terminal
Device2(config)#vlan 3
Device2(config-vlan3)#exit
```

#Configure the link type of port gigabitethernet0/1 as Trunk, and allow services of VLAN2 and VLAN3 to pass.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#switchport trunk vlan 2-3
Device2(config-if-gigabitethernet0/1)#exit
```

Step 2: Configure corresponding VLAN interface and IP address on Device1 and Device2. (Omitted)

Step 3: Configure Voice-VLAN on Device1 and set the cos value of IP Phone packet as 7. (omitted)

Step 4: Configure extended MAC ACL.

#Configure the extended MAC ACL numbered 3001 on Device2.

```
Device2(config)#mac access-list extended 3001
```

#Configure rules to prevent the users in VLAN2 from accessing the IP Network.

```
Devic2(config-ext-mac-nacl)#deny any any vlan-id 2
```

#Configure rules to prevent the voice users in VLAN3 from accessing the IP Network.

```
Device2(config-ext-mac-nacl)#deny any any cos 7 vlan-id 3
```

#Configure rules to prevent other users in VLAN3 from accessing the IP Network.

```
Device2(config-ext-mac-nacl)#permit any any vlan-id 3
```

#Commit the rules configured

```
Device2(config-ext-mac-nacl)#commit
```

#View the information of ACL 3001 on Device2.

```
Device2#show access-list 3001
mac access-list extended 3001
 10 deny any any vlan-id 2
 20 deny any any cos 7 vlan-id 3
 30 permit any any vlan-id 3
```

Step 5: Configure to apply extended MAC ACL.

#Apply the extended MAC ACL numbered 3001 in the incoming direction of port gigabitethernet0/1 of Device2.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#mac access-group 3001 in
Device2(config-if-gigabitethernet0/1)#exit
```

#View on Device2 the information of the ACL applied to the port.

```
Device#show acl-object interface
-----------Interface-----Bind-----Instance--------------
Interface----------------Direction----AclType----AclName
gi0/1                IN          MAC       3001
-----------Interface-----Bind-----Instance--------------
Interface VlanId---------Direction----AclType----AclName
```

Step 6: Check the result.

#PC2 instead of PC1 and IP Phone can access the IP Network.

Note

- For configurations related to Voice-VLAN, refer to the Voice-VLAN-related chapter in the User Manual.

72.3.5 Configure Extended Hybrid ACL

Network Requirements

- PC1, PC2 and PC3 access IP network through the Device.
- Configure extended Hybrid ACL rules so that PC1 instead of PC2 and PC3 can access the IP Network within the specified time range.

Network Topology

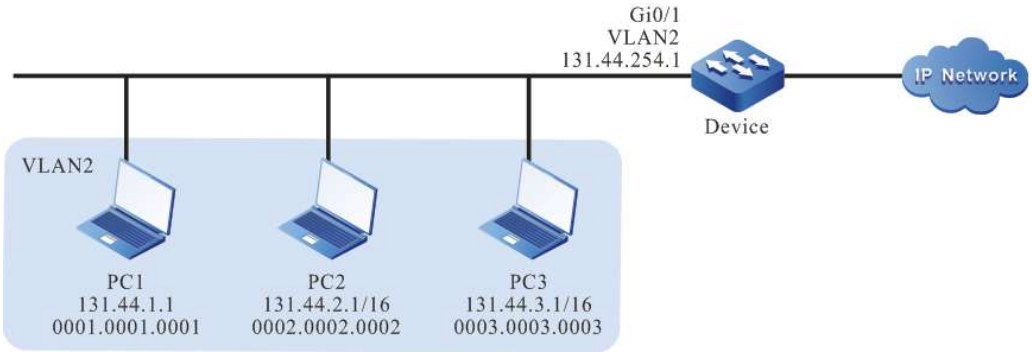


Figure 72-5 Network Topology for Configuring Extended Hybrid ACL

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of port gigabitethernet0/1 as Access to allow services of VLAN 2 to pass.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#switchport mode access
Device(config-if-gigabitethernet0/1)#switchport access vlan 2
Device(config-if-gigabitethernet0/1)#exit
```

Step 2: Configure corresponding VLAN interface and IP address on the Device. (Omitted)

Step 3: Configure time domain.

#Configure time domain "time-range-work" on the Device, from 08:00 to 18:00 per day.

```
Device(config)#time-range time-range-work
Device(config-time-range)#periodic daily 08:00 to 18:00
Device(config-time-range)#exit
```

#View current system time on the Device.

```
Device#show clock

UTC FRI APR 05 15:26:31 2013
```

#View the information of defined time domain "time-range-work" on the Device.

```
Device#show time-range time-range-work
Timerange name:time-range-work  (STATE:active)
  10  periodic daily 08:00 to 18:00 (active)
```

Step 4: Configure extended Hybrid ACL.

#Configure the extended Hybrid ACL numbered 5001 on the Device.

```
Device(config)#hybrid access-list extended 5001
```

#Configure rules to permit PC1 to access the IP Network within the scope of the defined time domain "time-range-work".

```
Device(config-hybrid-nacl)# permit host 0001.0001.0001 any ether-type ipv4 ip any any time-range time-range-workwork
```

#Configure rules to prevent the network segment 131.44.0.0/16 from accessing the IP Network.

```
Device(config-hybrid-nacl)# deny any any ether-type ipv4 ip 131.44.0.0 0.0.255.255 any
```

#Configure rules to permit all the packets from IP Network to pass through the Device.

```
Device(config-hybrid-nacl)# permit any any ether-type ipv4 ip any any
```

#Commit the rules configured

```
Device(config-hybrid-nacl)#commit
Device(config-hybrid-nacl)#exit
```

#View the information of ACL 5001 on the Device.

```
Device#show hybrid access-list 5001
hybrid access-list extended 5001

 10 permit host 0001.0001.0001 any ether-type ipv4 ip any any time-range time-range-work (active)
 20 deny any any ether-type ipv4 ip 131.44.0.0 0.0.255.255 any
 30 permit any any ether-type ipv4 ip any any
```

Step 5: Configure to apply extended Hybrid ACL.

#Apply the extended Hybrid ACL numbered 5001 in the incoming direction of global.

```
Device(config)#global hybrid access-group 5001 in
```

#View on Device the information of the ACL applied globally.

```
Device#show acl-object global

----------------Global-----Bind-----Instance-----------
Global-------------------Direction----AclType----AclName
global                IN          HYBRID     5001
```

Step 6: Check the result.

#PC1 can access the IP Network from 08:00 to 18:00 per day; PC2 and PC3 cannot access the IP Network.

73 Attack Detection

73.1 Overview

Attack defense is an important function for the maintenance of network security. It analyzes the content of packets passing through the device to determine whether they have the characteristics of attack, and takes some preventive measures for those with attack characteristics according to the configuration, such as intercepting attack packet, recording attack packet log, and adding attack source to blacklist. By configuring the device with attack defense function, on one hand, you can prevent the device from becoming abnormal due to network attack to improve the device's anti-attack ability; on the other hand, the attack traffic forwarded by the device can be intercepted to prevent other devices on the network from working abnormally due to the attack.

73.2 Attack Defense Function Configuration

Table 73 Attack Defense Function Configuration List

Configuration Task	
Configure single-packet attack defense function	1) Hardware detection supports the configuration of intercepting the following 13 types of attack packet: frag-icmp, icmpv4-large, icmpv6-large, ping-of-death, smurf, src-dst-mac-equal, src-dst-ip-equal, src-dst-port-equal , tcp-flag-seq-zero, tcp-hdr-incomplete, tcp-invalid-flag, tcp-syn-fin, and smac-zero (the actual results are subject to the capability set of each chip). 2) Configure to intercept the following 20 types of attack packet for software: fraggle, fragment, tcp-land, REDIRECT, UNREACH, ECHOREPLY, SOURCEQUENCH, ECHO, ROUTERADVERT, ROUTERSOLICIT, TIMXCEED, PARAMPROB, TSTAMP, TSTAMPREPLY, IREQ, IREQREPLY, MASKREQ, MASKREPLY, small-packet, and icmp code none-zero.

Configure flood defense function	Configure to intercept the following types of flood attack packets: tcp syn, tcp syn-ack, tcp ack, tcp fin, tcp rst, tcp port, udp, udp port, icmp, icmpv6, dns, http, and ip.
Configure scanning attack defense function	Configure to intercept ip scanning and port scanning attack packets
Configure blacklist function	Configure blacklist function and discard the packets of corresponding source address

Note: The packet interception configured on software of the switch is applicable to the packet of local device only.

73.2.1 Configure single-packet Attack Defense Function

Single-packet attack defense can determine whether the packets passing through the device are offensive by analyzing their characteristics. Generally, it is only valid for the packets applied with attack defense policies in the incoming direction. After the single-packet attack defense function is configured, if the device finds that a packet is offensive, it will output an alarm log, discard the packet, and perform statistics of discarded packets.

Configuration Condition

None

Configure Different Types of Single-packet Attack Defense Function

When the attack packet configured is detected, it will be discarded, and statistics of discarded packets will be performed.

Table 73 Configuring Single-packet Attack List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure to intercept specified type of single-packet attack packet	**anti-attack detect { fraggle | fragment | frag-icmp | icmp-large [***max-length***] | icmpv6-large [***max-length***] | ping-of-death | src-dst-ip-equal | src-dst-mac-equal | src-dst-port-equal | smurf | tcp-flag-seq-zero | tcp-hdr-incomplete | tcp-**	Mandatory By default, the default value of *max-length* is 512.

	invalid-flags | tcp-land | tcp-syn-fin | tear-drop | udp-snork | udp-bomb | winnuke | traceroute | ip-option-source-route | ip-option-record-route | ip-option-time-stamp | icmp-redirect | icmp-unreachable | icmp-echoreply | icmp-sourcequench | icmp-echo | icmp-routeradvert | icmp-routersolicit | icmp-timxceed | icmp-paramprob | icmp-tstamp | icmp-tstampreply | icmp-ireq | icmp-ireqreply | icmp-maskreq | icmp-maskreply | icmpv6-unreachable | icmpv6-packetbig | icmpv6-timxceed | icmpv6-paramprob | icmpv6-echo | icmpv6-echoreply | icmpv6-routersolicit | icmpv6-routeradvert | icmpv6-neighborsolicit | icmpv6-neighboradvert | icmpv6-redirect | smac-zero | small-packet [*mini-length***] }** **anti-attack drop { fragment [max-off** *max-off*] **| small-packet [***mini-length***]| subnet-broadcast masklen [***length***] | icmp { type { REDIRECT | UNREACH | ECHOREPLY | SOURCEQUENCH | ECHO | ROUTERADVERT | ROUTERSOLICIT | TIMXCEED | PARAMPROB | TSTAMP | TSTAMPREPLY | IREQ | IREQREPLY | MASKREQ | MASKREPLY} | code none-zero }}**	By default, the default value of *mini-length* is 64. By default, the default value of *max-off* is 65535. By default, the default value of *length* is 0. For single-packet attack defense, the detection of packets with such characteristics is disabled.

Configure Single-packet Attack Defense Logging

When the device finds single-packet attack, it discards the packet while logging.

Table 73 Configuring Single-packet Attack Log Output

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Configure single-packet attack type of log output	**attack-defense action logging detect**	Mandatory By default, the single-packet attack defense log is not enabled.

73.2.2 Configure Flood Defense Function

Flood attack is mainly used to protect servers from the impact of large-traffic packets. Generally, it is applied to the interface of the device connecting external network, and valid for the packets in the incoming direction of the interface where the attack defense policy is applied. After the flood defense policy is applied to the interface, the interface begins to detect attack. When it finds that the rate of a certain type of keeps exceeding the specified trigger threshold value, it considers that the interface has been flooded and enters the attack defense status. Then, it starts corresponding defense policy according to the configuration (output alarm logs, discard packets, and add attack source to the dynamic blacklist which takes effect after traceability function is configured). When the device finds the traffic of this type of packet is less than the threshold value for 5 seconds in succession, the attack status is cancelled, and attack defense measures stop.

Configuration Condition

Configure attack defense policy, and flood defense in the policy configuration mode.

Apply attack defense policy, and enable the flood defense detection in the policy.

Configure Different Types of Flood Defense Function

When the packet configured with flood detection exceeds the threshold value, corresponding defense measures should be taken.

Table 73 Configuring Flood Defense List

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the policy configuration mode	**attack-defense policy** *policy*	Mandatory The defense policy is differentiated according to policy name

Configure flood detection type and defense action	**detect { tcp-syn | tcp-ack | tcp-syn-ack | tcp-fin | tcp-rst| tcp {port [** *port-number* | **bgp**| **ftp**| **ldp | ssh | syslog | telnet]} | udp {port [** *port-number* | **snmp** | **syslog** | **tftp]} | icmp | icmpv6 | dns | http | ip } flood threshold** *threshold-value* **action { drop | blacklist }***	threshold-*value*: Configure the threshold value of flood detection By default, corresponding type of flood detection is not enabled. When the policy is applied, corresponding flood detection function takes effect.

Configure the Function of Tracing Attack Source in Flood Detection

Trace the packet configured with flood defense, and summarize the number of packets based on each source address.

Table 73 Configuring Flood Defense and Tracing Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the policy configuration mode	**attack-defense policy** *policy*	Mandatory The defense policy is differentiated according to policy name
Configure flood defense and tracing function	**trace-type {source-ip | source-mac} max-count** *max-source-number*	*max-source-number*: Configure the number of packets for flood detection and tracing. For the node of the source address where tracing number is exceeded, tracing operation is not performed.

		By default, the detection of unisource threshold value is not performed according to the source address.

Configure Application of Attack Defense Policy

Flood attack is configured based on policy, and the configuration takes effect when the policy is applied.

Table 73 Configuring Application of Attack Defense Policy

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure application of attack defense policy	**attack-defense global apply policy** *policy-name*	By default, all flood defense functions are invalid. *policy-name*: Enable specific defense policy

Configure Application of Attack Defense Policy Under the Port

Flood attack is configured based on policy, and the configuration takes effect when the policy is applied. The policy can be separately applied based on interface. If there is both global application policy and configuration under interface, the latter takes valid first.

Table 73 Configuring Application of Attack Defense Policy Under Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure application of attack	**attack-defense apply policy** *policy-name*	By default, the policy is not separately applied under interface.

defense policy		*policy-name*: Enable specific defense policy

Configure Flood Defense Logging

When the device finds flood attack, it takes defense policies while logging.

Table 73 Configuring Flood Attack Log Output

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure flood attack log output	**attack-defense action logging flood**	By default, the flood defense log is not enabled.

73.2.3 Configure Scanning Attack Defense Function

Scanning attack defense mainly detects the detection behavior by monitoring the rate of initiating connections to the target system by network users to prevent them from detecting network status. Generally, it is applied to the interface of the device connecting external network, and valid for the packets in the incoming direction of the interface where the attack defense policy is applied.

After the scanning attack defense is configured, when the number of IPs accessed in the network or the number of ports accessed on a certain device exceeds the threshold value, it is considered that a scanning attack has happened in the network, and the attack source is automatically detected and added to the dynamic blacklist. At the same time, a scanning attack defense log will be output according to the configuration.

Configuration Condition

Configure attack defense policy, and scanning attack defense in the policy configuration mode.

Apply attack defense policy, and enable the scanning attack defense detection in the policy.

Configure Scanning Attack Defense Function

After the scanning attack defense level is configured, and the number of destination addresses accessed in the network or the number of ports accessed on a certain destination address exceeds the threshold value, a scanning attack log will be output according to the configuration and the attack source will be added to the blacklist.

High means high-level defense. The number of destination IP addresses permitted for simultaneous access at this level is 16, and 4 ports are permitted for simultaneous access under the same destination address. Medium means medium-level defense. This level allows 32 destination IP addresses to be accessed at the same time and 8 ports to be accessed simultaneously under the same destination address. Low means low-level defense. The number of destination IP addresses permitted for simultaneous access at this level is 64, and 16 ports can be accessed simultaneously under the same destination address.

Table 73 Configure Scanning Attack Defense Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the policy configuration mode	**attack-defense policy** *policy*	Mandatory The defense policy is differentiated according to policy name
Configure scanning attack defense function	**detect scan level {high | medium | low} action blacklist**	By default, the scanning attack defense function is not enabled. When the policy is applied, corresponding scanning attack detection function takes effect.

Configure Application of Attack Defense Policy

Scanning attack is configured based on policy, and the configuration takes effect when the policy is applied.

Table 1 Configuring Application of Attack Defense Policy

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Configure application of attack defense policy	**attack-defense global apply policy** *policy-name*	By default, the scanning attack defense function is invalid. *policy-name*: Enable specific defense policy

Configure Application of Attack Defense Policy Under the Port

Scanning attack is configured based on policy, and the configuration takes effect when the policy is applied. The policy can be separately applied based on interface. If there is both global application policy and configuration under interface, the latter takes valid first.

Table 2 Configuring Application of Attack Defense Policy Under Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure application of attack defense policy	**attack-defense apply policy** *policy-name*	By default, the policy is not separately applied under interface. *policy-name*: Enable specific defense policy

Configure Scanning Attack Defense Logging

When the device finds any scanning attack, it begins logging.

Table 3 Configuring Scanning Attack Log Output

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure scanning	**attack-defense action logging scan**	By default, the scanning attack

attack log output		defense log is not enabled.

73.2.4 Configure Blacklist Function

The blacklist function is an attack defense feature which filters packets according to the source IP or IPv6 address of packets. Compared to the packet filtering function based on ACL (Access Control List), blacklist uses a simple way to match packets. It can rapidly filter and effectively shield packets. Blacklist can be added or deleted by the device dynamically or the user manually.

Configuration Condition

None

Configure static blacklist

Dynamic blacklist is dynamically added by functions like flood defense and scanning attack defense, while static blacklist is manually configured by the user.

The blacklist on the switching device is implemented through ACL, and that on the routing device is implemented through software.

Table 4 Configuring Static Blacklist

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure static blacklist	**blacklist {ip** *ip-address* **| ipv6** *ipv6-address* **}**	*ip*-address and *ipv6-address* are used to configure the blacklist function of specified source address.

73.2.5 Attack Defense Monitoring and Maintaining

Table 5 Attack Defense Monitoring and Maintaining List

Step	Command	Description
Clear statistics of NULL SCAN on all members	**clear attack-defense nullscan stastiscs**	-
Show statistics of single-packet attack	**show anti-attack detect statistic [member** *member-ID* | **lpu** *lpu-ID***]**	-
Show the attack defense policy applied at present	**show attack-defense applied policy**	-
Show the configuration of attack defense policy	**show attack-defense policy [***policy-name***]**	-
Show flood defense status	**show attack-defense flood [member** *member-ID* | **lpu** *lpu-ID***] [interface** *interface-name***]**	-
Show scanning attack defense status	**show attack-defense scan { ip-scan | ipv6-scan | port-scan | ipv6-port-scan } [member** *member-ID* | **lpu** *lpu-ID***]**	-
Show the scanning attack defense status on the specified interface	**show attack-defense scan { statistic | ipv6-statistic } [member** *member-ID* | **lpu** *lpu-ID***] interface** *interface-name*	-
Show attack tracing status	**show attack-defense trace [member** *member-ID* | **lpu** *lpu-ID***] [interface** *interface-name***]**	-

Show the information of blacklist	**show blacklist { ip | ipv6 | config | mac } [member** *member-ID* | **lpu** *lpu-ID***]**	-
Show the statistics of NULL SCAN	**show attack-defense nullscan stastiscs [member** *member-ID* | **lpu** *lpu-ID***]**	-

73.3 Typical Configuration Example of Attack Defense

73.3.1 Configure single-packet attack detection

Network Requirements

- The attacker and PC access the Device through interface.
- The single-packet attack detection function is configured for the Device so that it can give an alarm when an attack packet is detected and discards it. Take common Smurf, Land and Ping of death attacks as examples.

Network Topology

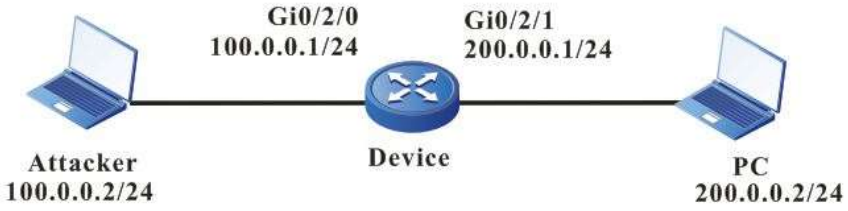


Figure 6 Network Topology for Configuring Single-packet Attack Detection

Configuration Steps

Step 1: Configures IP addresses for the ports. (Omitted)

Step 2: Configure Smurf, Land and Ping of death attack detection function on the Device and turn on the single-packet attack log switch.

#Configure Smurf attack detection.

```
Device#configure terminal
Device(config)#anti-attack detect smurf
```

#Configure Land attack detection.

```
Device(config)#anti-attack detect tcp-land
```

#Configure Ping of death attack detection.

```
Device(config)#anti-attack detect ping-of-death
```

#Turn on the single-packet attack log switch on the Device.

```
Device(config)#attack-defense action logging detect
```

Step 3: Check the result.

#When the attacker launches Smurf, Land and Ping of death attacks on the PC, if this function is not configured, the attack packets can be captured on the PC; if this function is configured, the attack packets cannot be captured on the PC, in which case, you need to check log and statistical information on the Device.

#When there is a Smurf attack on the Device, it will output the following log information:

```
%ANTIATTACK-DETECT_ATTACK-4: gigabitethernet0/2/0 detect attack, type smurf
```

#When there is a Land attack on the Device, it will output the following log information:

```
%ANTIATTACK-DETECT_ATTACK-4: gigabitethernet0/2/0 detect attack, type tcp-land
```

#When there is a Ping of death attack on the Device, it will output the following log information:

```
%ANTIATTACK-DETECT_ATTACK-4: gigabitethernet0/2/0 detect attack, type ping-of-death
```

#Execute the command **show anti-attack detect statistic** on the Device to view the statistical information of discarded packets.

```
Device#show anti-attack detect statistic lpu 0
    detect-type              DropCount
    ------------------------------------------------------
    fraggle                  0
    fragment                 0
    frag-icmp                0
    ping-of-death            125
    smurf                    87
    src-dst-ip-equal         0
    src-dst-mac-equal        0
    src-dst-port-equal       0
    tcp-flag-seq-zero        0
    tcp-hdr-incomplete       0
    tcp-invalid-flag         0
    tcp-syn-fin              0
    tcp-land                 456
    tear-drop                0
    udp-snork                0
    udp-bomb                 0
    winnuke                  0
```

traceroute 0

icmp-redirect 0

icmp-unreachable 0

icmp-echoreply 0

icmp-sourcequench 0

icmp-echo 0

icmp-routeradvert 0

icmp-routersolicit 0

icmp-timxceed 0

icmp-paramprob 0

icmp-tstamp 0

icmp-tstampreply 0

icmp-ireq 0

icmp-ireqreply 0

icmp-maskreq 0

icmp-maskreply 0

ip-option-source-route 0

ip-option-record-route 0

ip-option-time-stamp 0

icmpv6-unreachable 0

icmpv6-packetbig 0

icmpv6-timxceed 0

icmpv6-paramprob 0

icmpv6-echo 0

icmpv6-echoreply 0

icmpv6-routersolicit 0

icmpv6-routeradvert 0

icmpv6-neighborsolicit 0

icmpv6-neighboradvert 0

icmpv6-redirect 0

smac-zero 0

icmp-large 0

icmpv6-large 0

small-packet 0

Note

- The hardware processing of single-packet attack detection on the switch is valid for both forwarded and local packets, and no log or statistical information will be generated; the software processing of single-packet attack detection is only valid for local packets, and log

and statistical information will be generated.

73.3.2 Configure Flood Attack Detection

Network Requirements

- The Device accesses the IP Network through gigabitethernet0/2/0.
- The flood attack detection function is configured for the Device so that it can give an alarm log when an attack packet of corresponding type is detected and discards it. Take common tcp syn flood and icmp flood attacks as examples.

Network Topology

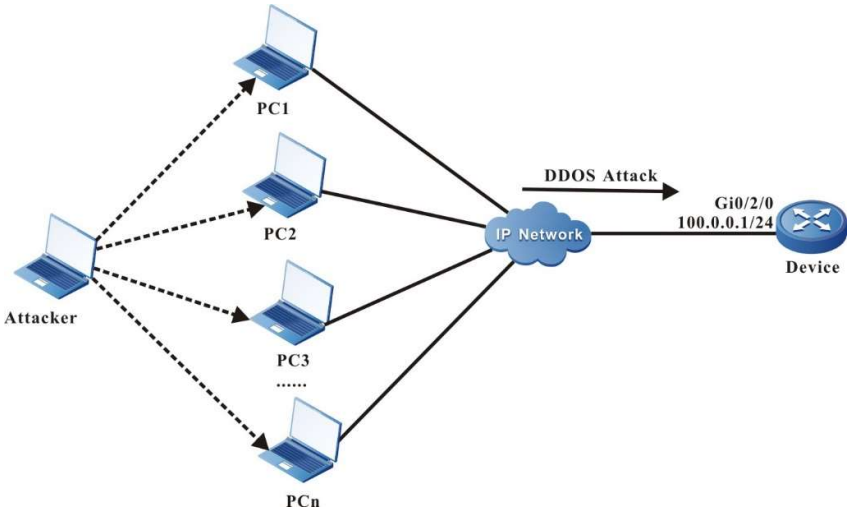


Figure 7 Network Topology for Configuring Flood Attack Detection

Configuration Steps

Step 1: Configure interface IP address. (Omitted)

Step 2: Configure attack defense policy a on the Device, add tcp syn flood and icmp flood attack detection function to the policy, and configure IP address-based attack traceability.

```
Device(config)#attack-defense policy a
Device(config-anti-policy-a)#detect tcp-syn flood threshold 500 action drop
Device(config-anti-policy-a)#detect icmp flood threshold 500 action blacklist
Device(config-anti-policy-a)#trace-type source-ip max-count 5
Device(config-anti-policy-a)#exit
```

#Configure global application of attack defense policy a on the Device.

```
Device(config)#attack-defense global apply policy a
```

#Turn on the flood attack log switch on the Device.

```
Device(config)#attack-defense action logging flood
```

Step 3: Check the result.

#View current attack defense policy on the Device.

```
Device#show attack-defense applied policy
attack-defense policy a
 detect tcp-syn flood threshold 500 action drop
 detect icmp flood threshold 500 action blacklist
 trace-type source-ip max-count 5
```

#When an attacker launches tcp syn flood and icmp flood attacks on the Device, view the flood attack log output on the Device.

```
%ANTIATTACK-FLOOD_ATTACK-4:gigabitethernet0/2/0 detect attack, type tcp-syn.
%ANTIATTACK-FLOOD_IP_ATTACK-4:gigabitethernet0/2/0 detect attack, type icmp, ipaddr 100.0.0.2.
```

#View attack tracing entries on the Device.

```
Device#show attack-defense trace lpu 0
   Trace Info:
   IpAddr, Interface, LastRecvTime
      Type            DropCount       Token
-------------------------------------------------------------
 100.0.0.2, gigabitethernet0/2/0, Mon May 04 16:55:46 2020
      tcp-syn       , 0             , 299
      icmp          , 0             , 0
   100.0.0.3, gigabitethernet0/2/0, Mon May 04 16:55:50 2020
      tcp-syn       , 0             , 250
      icmp          , 0             , 400
   100.0.0.4, gigabitethernet0/2/0, Mon May 04 16:55:50 2020
      tcp-syn       , 0             , 250
      icmp          , 0             , 400
   100.0.0.5, gigabitethernet0/2/0, Mon May 04 16:55:50 2020
      tcp-syn       , 0             , 250
      icmp          , 0             , 400
```

#View flood attack defense status on the Device.

```
Device#show attack-defense flood lpu 0
   Flood Info:
      Type            DropCount       Token          LastRecvTime
-----------------------------------------------------------------------------------------
   gigabitethernet0/2/0
```

```
tcp-syn       , 1851          , 50            , Mon May 04 16:55:50 2020
icmp          , 0             , 100           , Mon May 04 16:55:46 2020
```

#View the dynamic blacklist entries generated by tracing on the Device.

```
Device#show blacklist ip lpu 0
  Blacklist Info:
  IpAddr,              CreateTime,            Agetime
------------------------------------------------------------------------
  100.0.0.2          ,    Mon May 04 16:55:47 2020      , 93
```

73.3.3 Configure Scanning Attack Detection

Network Requirements

- The Device accesses the IP Network through gigabitethernet0/2/0.
- Scanning attack detection function is configured on the Device. When IP scanning or Port scanning is detected, output an alarm log, add the attack source to the blacklist, and intercept all packets of the attack source before aging of the blacklist.

Network Topology

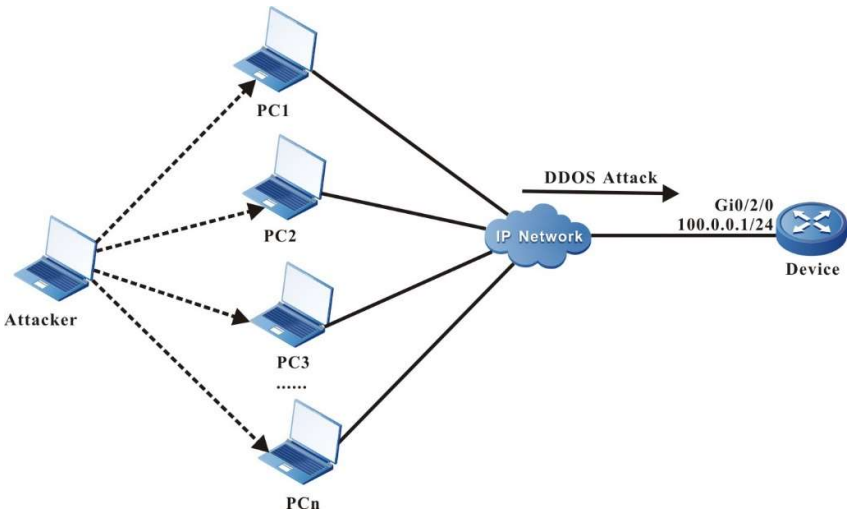


Figure 73 Network Topology for Configuring Scanning Attack Detection

Configuration Steps

Step 1: Configure interface IP address. (Omitted)

Step 2: Configure attack defense policy a on the Device, and the scanning attack detection function in the policy, with the scanning level being high.

```
Device(config)#attack-defense policy a
Device(config-anti-policy-a)#detect scan level high action blacklist
```

```
Device(config-anti-policy-a)#exit
```

#Configure global application of attack defense policy a on the Device.

```
Device(config)#attack-defense global apply policy a
```

#Turn on the scanning attack log switch on the Device.

```
Device(config)#attack-defense action logging scan
```

Step 3: Check the result.

#View current attack defense policy on the Device.

```
Device#show attack-defense applied policy
attack-defense policy a
 detect scan level high action blacklist
```

#When an attacker launches a scanning attack on the Device, view the scanning attack log output on the Device.

```
%ANTIATTACK-SCAN_PORT_ATTACK-4:gigabitethernet0/2/0 detect port scan attack.
%ANTIATTACK-SCAN_PORT_ATTACK-4:Detect 100.0.0.2 is attacking the system.
%ANTIATTACK-SCAN_IP_ATTACK-4:gigabitethernet0/2/0 detect ip scan attack.
```

#View attack IP scanning entries on the Device.

```
Device#show attack-defense scan ip-scan lpu 0
  IP Scan Statistic :
   sip                dip-count              interface
   ------------------------------------------------------------


   100.0.0.3              4              gigabitethernet0/2/0
   100.0.0.4              4              gigabitethernet0/2/0
   100.0.0.5              4              gigabitethernet0/2/0
    100.0.0.6             4              gigabitethernet0/2/0
```

#View Port scanning entries on the Device.

```
Device#show attack-defense scan port-scan lpu 0
  Port Scan Statistic :
   sip                dip                dport-count        interface
   ------------------------------------------------------------------------------
   100.0.0.3          101.0.0.1          1              gigabitethernet0/2/0
   100.0.0.3          101.0.0.2          1              gigabitethernet0/2/0
        100.0.0.3          101.0.0.3          1              gigabitethernet0/2/0
   100.0.0.3          101.0.0.4          1              gigabitethernet0/2/0
        100.0.0.4          101.0.0.5          1              gigabitethernet0/2/0
   100.0.0.4          101.0.0.6          1              gigabitethernet0/2/0
        100.0.0.4          101.0.0.7          1              gigabitethernet0/2/0
```

```
100.0.0.4       101.0.0.8       1       gigabitethernet0/2/0
100.0.0.5       101.0.0.9       1       gigabitethernet0/2/0
100.0.0.5       101.0.0.10      1       gigabitethernet0/2/0
    100.0.0.5       101.0.0.11      1       gigabitethernet0/2/0
100.0.0.5       101.0.0.12      1       gigabitethernet0/2/0
    100.0.0.6       101.0.0.13      1       gigabitethernet0/2/0
100.0.0.6       101.0.0.14      1       gigabitethernet0/2/0
    100.0.0.6       101.0.0.15      1       gigabitethernet0/2/0
100.0.0.6       101.0.0.16      1       gigabitethernet0/2/0
```

#View the dynamic blacklist entries generated by scanning on the Device.

```
Device#show blacklist ip lpu 0
  Blacklist Info:
  IpAddr,           CreateTime,           Agetime
  ------------------------------------------------------------------------
  100.0.0.2       ,   Mon May 04 17:36:45 2020    , 94
```

Note

- Both flood attack and scanning attack detection functions are only valid for local packets of the switch.
- After specific attack source is identified for flood attack source tracing or scanning attack, it will be added to a dynamic blacklist with an aging time of 2 minutes. Before the blacklist ages, all packets of the attack source will be intercepted.

74 AARF

74.1 Overview

Anti Attack Resilient Framework is called AARF for short.

74.2 Introduction

In the network environment, switches are often attacked by malicious packets (e.g. ARP and ICMP). These attacks cause a heavy burden on the switch system, bring it to stop. Generally, too many packets will consume the CPU utilization, memory, entries or other resources of the switch so that the system cannot process other normal protocol and management packets. Sometimes, they may even cause suspended operation of the entire network.

AARF can effectively identify attacks and prevent the switch from being attacked. When the switch is attacked, it can ensure the normal operation of the system and protect the CPU from excessive load so that the entire network can operate normally.

74.3 Principle

Generally, it prevents the attack of protocol packets by counting the packets sent to CUP, calculating their sending rates, and compare them with the attack threshold value set. If the rate has reached the threshold value, it is considered that the packet is offensive, and the host with such offensive behavior will be limited, such as discarding CPU, limiting speed and filter, so as to protect the CPU.

As a matter of fact, different anti-attack functions for protocol packets use the same way to implement packet counting, identification and attack policy application. We can build an AARF by abstracting the same processing methods. AARF is used to implement some common processing mechanisms of the anti-attack module to improve the extensibility of this module and reduce the workload in developing new module.

Currently, AARF supports arp-guard.

74.4 ARP-guard

ARP-guard is used to monitor the ARP packets on CUP in real time so as to prevent too many ARP packets from impacting the CPU and improve device security.

ARP-guard has three functions, i.e. ARP-guard based on host, ARP-guard based on port, and ARP scanning and identification.

The ARP-guard based on host counts the number of ARP packets received and compares the value with the threshold value set. If it exceeds the threshold value, they are identified as overspeed or offensive. Statistics and identification are based on either source IP address/VLAN ID/port or link layer source MAC address/VLAN ID/port.

The ARP-guard based on port counts the number of ARP packets that are received by the port and don't attack the host. If the value exceeds the threshold value set on the port, they are identified as overspeed or offensive. Port statistics exclude the ARP packets that have been identified as offensive for the host (host entries are generated and attack protection policy is applied).

ARP scanning and identification can identify ARP scanning with fixed MAC address yet constantly changing source IP, or that with fixed IP yet constantly changing destination IP.

74.4.1 ARP-guard Function Configuration

Table 17-1 ARP-guard Function Configuration List

Configuration Task	
Configure Basic Functions of ARP-guard	Enable Global ARP-guard Function
	Enable ARP-guard Function of the Port
Configure ARP-guard Monitoring Policy	Configure Global Monitoring Policy
	Configure Port Monitoring Policy

74.4.2 Configure Basic Functions of ARP-guard

The ARP-guard function based on port can take effect only after the global ARP-guard function is enabled.

Configuration Condition

None

Enable Global ARP-guard Function

Table 17-2 Enablinge Global ARP-guard Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the AARF configuration mode	**aarf**	-
Enable Global ARP-guard Function	**arp-guard enable**	Mandatory By default, the ARP-guard function is disabled globally.

Enable ARP-guard Function of the Port

Table 17-3 Enabling ARP-guard Function of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable ARP-guard Function of the Port	**aarf arp-guard enable**	Mandatory By default, the ARP-guard function is disabled on the port.

74.4.3 Configure ARP-guard Monitoring Policy

Configuration Condition

No.

Configure Global ARP-guard Monitoring Policy

Table 17-4 Configuring Global ARP-guard Monitoring Policy

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the AARF configuration mode	**aarf**	-
Configure global ARP-guard monitoring policy	**arp-guard policy { filter | monitor | punish macbased}**	By default, the global ARP-guard monitoring policy is monitor.

Configure ARP-guard Monitoring Policy for Port

Table 17-5 Configuring ARP-guard Monitoring Policy for Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure ARP-guard monitoring policy for port	**aarf arp-guard policy { filter | monitor | punish macbased}**	By default, the ARP-guard monitoring policy for port is not configured. The global ARP-guard monitoring policy is considered as the valid value.

The command **aarf arp-guard policy filter** is the host filtering protection policy under the port applied to the host or port with ARP attack behavior. After the filtering policy is configured, the host with ARP overspeed or attack behavior under the port will generate attack alarm. If the host sends ARP at a rate between the speed limit and attack threshold value, the rate of sending ARP packet to CUP will be limited to the speed limit, and the ARP packet in the forwarding direction will be forwarded at a host sending rate; if the rate of sending ARP by the host exceeds the attack threshold value, the ARP packet sent to CUP and forwarded will be discarded. If any overspeed or attack behavior is detected on the port (i.e. the total rate of receiving ARP packets that do not attack the host by the port is no less than the port rate limit or attack threshold value), an attack alarm will be generated. If the total rate of such ARP packets received by the port is between the port rate limit and the attack threshold value, it will limit the speed of the ARP packets sent to CPU according to the port rate limit, and the ARP packets to be forwarded will be forwarded at the original rate; If the total rate of such ARP packets received by the port is no less than the port attack threshold value, all ARP packets received by the port will be discarded in the forwarding direction and will not be sent to CPU.

The command **aarf arp-guard policy monitor** is the host monitoring protection policy under the port applied to the host or port with ARP attack behavior. After the monitoring policy is configured, if any host packets or port with ARP overspeed or attack behavior are detected under the port, an attack alarm will be

generated, and the packets will be sent to CPU at the rate limit, with the ARP packets that exceed the rate limit being discarded by CPU; the ARP packets to be forwarded will be forwarded at the original rate.

The command **aarf arp-guard policy punish macbased** is the punishment-based rate limit protection policy under the port applied to the MAC host with ARP attack behavior. After the punishment-based rate limit policy is configured, when the MAC host packets with ARP overspeed or attack behavior are detected under the port, an attack alarm will be generated. If the rate of packets sent by the MAC host is between the rate limit and the attack threshold value, it will take effect according to the monitor policy. If the ARP packet rate is no less than the attack threshold value, the MAC packets attacking the host will be sent to CPU and forwarded at the rate which is half of the MAC rate limit. If the attack stops or the rate drops below the MAC rate limit, the host protection policy will be cancelled when the aging period expires. In addition, under this policy mode, both the port and IP host use the monitor policy.

74.4.4 ARP-guard Monitoring and Maintaining

Table 17-6 ARP-guard Monitoring and Maintaining

Command	Description
show aarf arp-guard configure	Show the configuration of ARP-guard.
show aarf arp-guard hosts	Show the information of the monitored host.
show aarf arp-guard ports	Show the information of the monitored port.
show aarf arp-guard scan	Show the information of the scanning host.

74.5 Typical Example of Configuration of AARF ARP-GUARD

74.5.1 Configure Basic Functions of AARF ARP-GUARD

Network Requirements

- PC1, PC2 and PC3 access IP network through the Device.
- PC1 sends ARP packets to attack the Device which turns on AARF ARP-Guard and normally identifies ARP overspeed, ARP attack, ARP MAC scanning and ARP MAC-IP scanning so that the anti-attack policy takes effect.

Network Topology

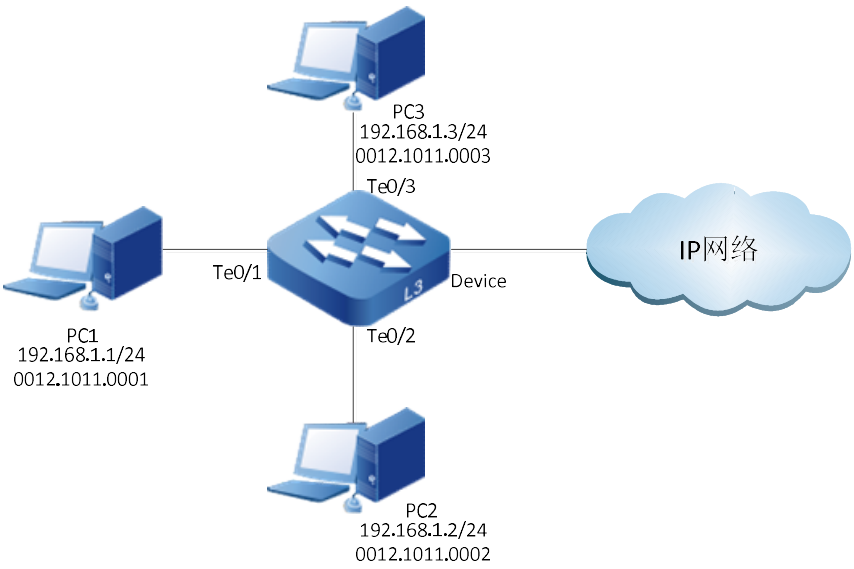


Figure 17-1 Network Topology for Configuring ARP-guard Function

Configuration Steps

Step 1: Configure VLAN and port link type on Device.

#Create VLAN 2.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports tengigabitethernet0/1, tengigabitethernet0/2 and tengigabitethernet0/3 as Access to allow services of VLAN2 to pass.

```
Device(config)#interface tengigabitethernet 0/1-0/3
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
```

Step 2: Configure the gateway of PC1, PC2 and PC3 on the Device.

#Configure VLAN interface 2 as the gateway of PC1, PC2 and PC3

```
Device(config)#interface vlan 2
Device(config-if-vlan2)#ip address 192.168.1.254 24
```

Step 3: Configure AARF ARP-Guard on the Device.

#Globally enable AARF ARP-Guard

```
Device(config)#aarf
Device(config-aarf)#arp-guard enable
```

#Enable AARF ARP-Guard on the port tengigabitethernet0/1, relevant threshold value is default configuration, and the configuration policy is filter.

```
Device(config-if-tengigabitethernet0/1)# aarf arp-guard enable
Device(config-if-tengigabitethernet0/1)# aarf arp-guard policy filter
```

Step 4: Check the result.

#View AARF ARP-Guard-related configuration information

```
Device#show aarf arp-guard configure  interface tengigabitethernet 0/1
(Format of column Rate-limit and Attack-threshold is per-src-ip/per-src-mac/per-interface.)
-------------------------------------------------------------------------------------------
Interface/Global  Status    Rate-limit   Attack-threshold   Scan-threshold  Attack-policy
-------------------------------------------------------------------------------------------
te0/1             Enabled   4/4/100      8/8/200           15              filter
```

#When the rate of ARP Request packets sent by PC1 to request the gateway IP address of the Device is no less than the host-based rate limit 4pps and less than the host-based attack threshold value 8pps, related entries will be formed and log information will be output, and the Device can identify the overspeed host-based ARP packets.

```
Device#show aarf arp-guard hosts
-------------------------------------------------------------------------------------------
Interface               Vlan                                IP                      MAC
     Action             Policy
-------------------------------------------------------------------------------------------
te0/1                     2                           192.168.1.1             -
 overspeed               monitor
te0/1                     2                           -                       0012.1011.0001
 overspeed               monitor
Total: 2 record(s).
```

#Log output:

```
Dec 20 2016 03:45:28: %AARF-INTERFACE-3:<arp-guard>There are overspeed, attack or scan detected on interface te0/1.(TUE DEC 20 03:45:25 2016)
Dec 20 2016 03:45:28: %AARF-DETECTED-3:<arp-guard>Host<IP=N/A,MAC=0012.1011.0001,interface= te0/1,VLAN=2> overspeed was detected.(TUE DEC 20 03:45:25 2016)
Dec 20 2016 03:45:28: %AARF-DETECTED-3:<arp-guard>Host<IP=192.168.1.1,MAC=N/A,interface= te0/1,VLAN=2> overspeed was detected.(TUE DEC 20 03:45:25 2016)
```

#When the rate of ARP Request packets sent by PC1 to request the gateway IP address of the Device is larger than the host-based attack threshold value 8pps, the Device will filter out these ARP packets, generate entries, output log information, and identify the host-based ARP packet attack.

```
Device#show aarf arp-guard hosts
-------------------------------------------------------------------------------------------
Interface               Vlan                                IP                      MAC
          Action                    Policy
-------------------------------------------------------------------------------------------
te0/1                     2                           192.168.1.1             -
 attack                  filter
te0/1                     2                           -                       0012.1011.0001
 attack                  filter
Total: 2 record(s).
```

#Log output:

```
Dec 20 2016 04:30:33: %AARF-INTERFACE-3:<arp-guard>There are overspeed, attack or scan detected on interface te0/1.(TUE DEC 20 04:30:30 2016)
Dec 20 2016 04:30:33: %AARF-FILTER-3:<arp-guard>Host<IP=N/A,MAC=0012.1011.0001,interface=
te0/1,VLAN=2> attack was filter.(TUE DEC 20 04:30:30 2016)
Dec 20 2016 04:30:33: %AARF-FILTER-3:<arp-guard>Host<IP=192.168.1.2,MAC=N/A,interface=
te0/1,VLAN=2> attack was filter.(TUE DEC 20 04:30:30 2016)
```

#When PC1 sends several types of non-offensive ARP Request packets, and the sending rate is no less than the port-based rate limit 100 and less than the port-based attack threshold value 200, the Device will generate related entries, output log information, and identify the overspeed port-based ARP packets.

```
Device#show aarf arp-guard ports
-------------------------------------------------------------------------------
Interface                Hosts                Scan                 Action
 Policy
-------------------------------------------------------------------------------
te0/1                    0                    0                    overspeed
     monitor
```

#Log output:

```
Dec 22 2016 06:36:32: %AARF-INTERFACE-3:<arp-guard>Interface te0/1 was overspeed.(THU DEC 22 06:36:29 2016)
```

#When PC1 sends several types of non-offensive ARP Request packets, and the sending rate is no less than the host-based attack threshold value 200, the Device will filter out all the ARP packets of this port, generate related entries, output log information, and identify the host-based ARP attack.

```
Device#show aarf arp-guard ports
-------------------------------------------------------------------------------
Interface                Hosts                Scan                 Action
 Policy
-------------------------------------------------------------------------------
te0/1                    0                    0                    attack
          filter
```

#Log output:

```
Dec 22 2016 06:46:58: %AARF-INTERFACE-3:<arp-guard>Interface te0/1 was filter.(THU DEC 22 06:46:57 2016)
```

#When PC1 sends the ARP Request packets with source MAC unchanged and Sender IP increasing, and more than 15 ARP Request packets are sent within 10 seconds, the Device will generate related entries, output log information, and identify ARP MAC scanning.

```
Device#show aarf arp-guard scan
-------------------------------------------------------------------------------
Interface          Vlan                 IP                   MAC
                   Time-stamp
-------------------------------------------------------------------------------
te0/1              2                    N/A                  0012.1011.0001       THU
DEC 22 03:16:30 2016
Total: 1 record(s).
```

#Log output:

```
Dec 22 2016 03:16:19: %AARF-INTERFACE-3:<arp-guard>There are overspeed, attack or scan detected on interface
te0/1.(THU DEC 22 03:16:16 2016)
Dec 22 2016 03:16:19: %AARF-SCAN-4:<arp-guard>Host<IP=N/A,MAC=0012.1011.0001,interface=
te0/1,VLAN=2> scan was detected.(THU DEC 22 03:16:16 2016)
```

#When PC1 sends the ARP Request packets with both source MAC and Sender IP unchanged and Target IP increasing, and more than 15 ARP Request packets are sent within 10 seconds, the Device will generate related entries, output log information, and identify ARP MAC-IP scanning.

```
Device#show aarf arp-guard scan
-------------------------------------------------------------------------------
Interface          Vlan                 IP                   MAC
                   Time-stamp
-------------------------------------------------------------------------------
```

te0/1 2 192.168.1.254 0012.1011.0001 THU DEC 22 03:38:52 2016
Total: 1 record(s).

#Log output:

Dec 22 2016 03:37:33: %AARF-INTERFACE-3:<arp-guard>There are overspeed, attack or scan detected on interface te0/1.(THU DEC 22 03:37:30 2016)
Dec 22 2016 03:37:33:%AARF-SCAN-4:<arp-guard>Host<IP=192.168.1.254,MAC=0012.1011.0001, interface=te0/1,VLAN=2> scan was detected.(THU DEC 22 03:37:30 2016)

75 PPPoE +

75.1 Introduction to Basic Functions of PPPoE +

PPPoE + (Point-Point Protocol over Ethernet Plus) realizes point-to-point binding of user terminal to server by obtaining the PPPoE request packets sent by PPPoE client, and adding the port information accessed to the terminal user host to its load field and then forwarding it to the PPPoE server.

75.2 Principle of PPPoE +

PPPoE+ obtains the PADI packet sent by the PPPoE client. Then it adds one or multiple PPPoE TAGs to the load information field of the packet and floods it to the PPPoE server. After receiving the PADI packet containing Tag, the server will send a PADO packet the PPPoE client. When the PPPoE client receives the PADO packet, it will send a PADR packet. Then, PPPoE+ obtains the PADR packet, adds one or more PPPoE TAGs to the load information field of the packet, and then forwards it to the PPPoE server according to the destination address query FDB table in the packet. After receiving the packet with Tag, the PPPoE server will randomly generate a session-id, add it to the PADS packet field, and then send it to the PPPoE client. This can achieve the point-to-point PPP negotiation and PPPoE packet interaction with the client.

75.3 Overview of Vendor-id TAG

In order that the PPPoE server can obtain the physical location information of PPPoE client, vendor-id Tag can be added to the PPPoE request packet.

When PPPoE packet interaction happens on the device, some user-related device information can be added to the PPPoE request packet through vendor-id TAG. The vendor-id TAG option records the interface information of the client. Circuit-id is circuit ID, and remote-id is remote ID.

When the PPPoE+ function is enabled, after the device receives the PPPoE request packets, it may process them by the following manners according to the processing policy and fill method of vendor-id TAG of PPPoE packet configured by users:

Table 18-1 PPPoE Request Packet Processing Policy

PPPoE **request packet**	**Processing policy**	**Fill method**	**Packet processing principle**
Without vendor-id TAG	Add	Default fill format	Fill and forward in default format
	Add	Extend fill format	Fill and forward in the user-defined format
With vendor-id TAG	maintained	Not filled	No processing or forwarding of PPPoE packet
	Filter	Discard the packet	Discard the packet
	Replacements	Default fill format	Replace the original vendor-id TAG content in default format and forward
		Extend fill format	Replace the original vendor-id TAG in the user-defined format and forward

75.4 Configure Basic Functions of PPPoE +

Table 18-2 PPPoE + Function Configuration List

Configuration Task	
Configure PPPoE + Function	Enable PPPoE+ Function of Port
Configure the processing policy for PPPoE packet	Configure Processing Policy of Port for PPPoE Packet
Configure Fill Policy for PPPoE Packet	Configure Fill Policy of Port for PPPoE Packet
Configure Fill Policy for Circuit-id	Configure Fill Policy of Port for Circuit-id

Configuration Task	
Configure Fill Policy for Remote-id	Configure Fill Policy of Port for Remote-id
Configure value of vendor-id	Configure Value of Port Vendor-id

75.4.1 Enable/Disable the PPPoE+ Function.

Configuration Condition

Layer-2 Ethernet interface or aggregation group mode

Table 18-3 Enabling/Disabling PPPoE+ Function

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter layer-2 Ethernet interface mode	interface *interface name*	Enable/disable PPPoE+ under the port mode
Enter the port aggregation group	interface link-aggregation *link-aggregation-id*	Enable/disable the PPPoE + function under the aggregation group mode
Enable/Disable PPPoE+ Function	pppoe relay enable/no pppoe relay enable	By default, the PPPoE + function is disabled.

75.4.2 Configure Processing Policy of PPPoE+ Function for PPPoE Packet with Vendor-id Tag

Configuration Condition

Layer-2 Ethernet interface or aggregation group mode

Table 18-4 Configuring Processing Policy of PPPoE + for PPPoE Packet with Vendor-id Tag

Step	Command	Description
Enter the global configuration mode.	configure terminal	-

Enter layer-2 Ethernet interface mode	interface *interface name*	The configuration takes effect under the port mode only
Enter the port aggregation group	interface link-aggregation link-aggregation-id	The configuration takes effect under the aggregation group mode only
Configure a policy (processing policy of packet with vendor-id tag option)	pppoe relay information policy {keep|drop|replace}	By default, it is replace, i.e. replace and forward the packet field containing vendor-id tag.

The command pppoe relay information policy keep is used to forward the PPPoE packet containing vendor-id tag as is under the port/aggregation group mode.

The command pppoe relay information policy drop is used to filter the PPPoE packet containing vendor-id tag under the port/aggregation group mode.

The command pppoe relay information policy drop is used to replace and forward the vendor-id tag of PPPoE packet under the port/aggregation group mode.

75.4.3 Configure the sub-option of circuit-id of vendor-id tag field

Configuration Condition

Layer-2 Ethernet interface or aggregation group mode

Table 18-5 Configuring Content of Circuit-id Sub-option in Vendor-id Tag Field

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter layer-2 Ethernet interface mode	interface *interface name*	The configuration takes effect under the port mode only.
Enter the port aggregation group	interface link-aggregation *link-aggregation-id*	The configuration takes effect under the aggregation group mode only.
Configure the content of circuit-id	pppoe relay information format circuit-id{*LINE*|default}	By default, fill Vlan-interfance in the packet.

The command pppoe relay information format circuit-id *LINE* is used to allow users to configure the port to fill in the content of circuit-id.

The command pppoe relay information format circuit-id default is used to configure the port to fill vlan-interface in circuit-id.

75.4.4 Configure the sub-option of remote-id of vendor-id tag field

Configuration Condition

Layer-2 Ethernet interface or aggregation group mode

Table 18-6 Configuring Content of Remote-id Sub-option in Vendor-id Tag Field

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter layer-2 Ethernet interface mode	interface *interface name*	The configuration takes effect under the port mode only.
Enter the port aggregation group	interface link-aggregation *link-aggregation-id*	The configuration takes effect under the aggregation group mode only.
Configure the content of remote-id	pppoe relay infotmation format remote-id{*LINE*|default }	By default, the mac address of the device port is filled in the packet.

The command pppoe relay information format remote-id *LINE* is used to allow users to configure the port to fill in the content of remote-id.

The command pppoe relay information format remote-id default is used to configure the port to fill switch-mac in circuit-id.

75.4.5 Configure Fill Policy of PPPoE+ Function for Packet with Vendor-id Tag

Configuration Condition

Layer-2 Ethernet interface or aggregation group mode

Table 18-7 Configuring Fill Policy of PPPoE+ Function for Packet with Vendor-id Tag

Step	Command	Description

Enter the global configuration mode.	configure terminal	-
Enter layer-2 Ethernet interface mode	interface *interface name*	The configuration takes effect under the port mode only
Enter the port aggregation group	interface link-aggregation *link-aggregation-id*	The configuration takes effect under the aggregation group mode only
Configure the number of sub-options of vendor-id tag	pppoe relay information encapsulation {circuit-id|remote-id|both}	By default, circuit-id and remote-id are filled with default values.

75.4.6 Configure to Fill Value of Vendor-id in Vendor-id Tag

Configuration Condition

Layer-2 Ethernet interface or aggregation group mode

Table 18-8 Configuring to Fill Value of Vendor-id in Vendor-id Tag

Step	Command	Description
Enter the global configuration mode.	configure terminal	-
Enter layer-2 Ethernet interface mode	interface *interface name*	The configuration takes effect under the port mode only
Enter the port aggregation group	interface link-aggregation *link-aggregation-id*	The configuration takes effect under the aggregation group mode only
Configure value of vendor-id	pppoe relay information vendor-id *vendor-id*	The value range is 0-4294967295. By default, the value of vendor-id is 2011.

76 HA

76.1 Overview

HA (High Availability) is one high availability management platform on the device, and it provides the regular detection for some system faults, ensuring that the services are not interrupted.

76.2 HA Function Configuration

76.2.1 HA Monitoring and Maintaining

Table 1 HA Monitoring and Maintaining

Command	Description
show ham job	Show current HA task processing table of local device

77 ULFD

77.1 Overview

In the traditional Ethernet, we usually use the fiber and other physical medium to connect the devices. In the actual networking, the fiber crossover connection (Figure 2-1), or one fiber not connected or disconnected (Figure 2-2) may result in the uni-directional communication. This kind of faulty link is called uni-directional link. The uni-directional link causes a series of problems. For example, the spanning tree detection failure results in the topology calculation error.

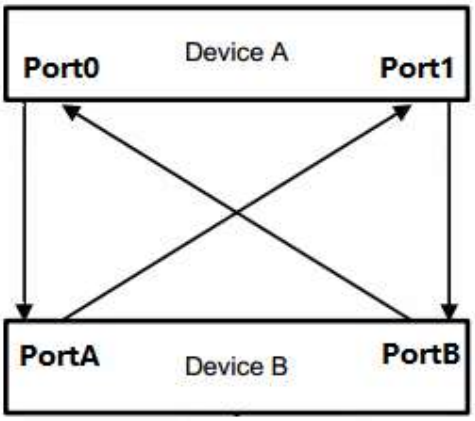


Figure 77 Fiber Cross-Connect

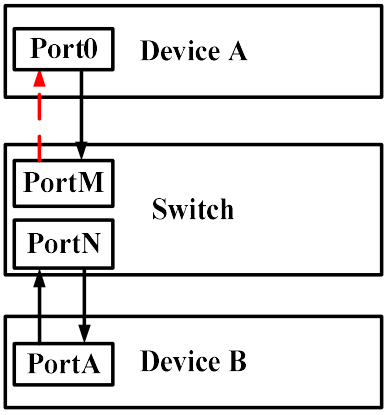


Figure 1 A Fiber not Connected or Disconnected

ULFD (Unidirectional Link Fault Detection) can monitor whether the fiber or twisted-pair has the uni-directional link. When ULFD detects the uni-directional link, it is responsible for closing the physical and logical uni-directional connection, sending the alarm information to the user and blocking the failure of other protocols.

77.2 ULFD Function Configuration

Table 77 ULFD Function Configuration List

Configuration Task	
Configure ULFD Basic Functions	Enable global ULFD function
	Enable the port ULFD function
Configure ULFD Parameters	Configure Sending Period of ULFD Detection Packet
	Reset Port Disabled by ULFD

77.2.1 Configure ULFD Basic Functions

Configuration Condition

Before configuring the ULFD basic functions, complete the following task:

- Ensure that the ULFD detection port is connected normally

Enable Global ULFD Function

ULFD has two work modes, that is, normal and aggressive. For the two modes, the basis of judging the uni-directional link is different. The normal mode is often used to check the uni-direction caused by the crossover connection. The aggressive mode is used to check the uni-directional connection caused by the crossover connection or disconnection.

Table 1 Enabling Global ULFD Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enable global ULFD function	**ulfd** { **aggressive** | **enable** }	Mandatory By default, the global ULFD function is disabled.

Enable the Port ULFD Function

ULFD detection needs to enable the global ULFD detection function and the port ULFD detection function. If the ULFD function is not enabled globally, but just enabled on the port, the ULFD function cannot take effect.

If the global enabled ULFD detection mode and port enabled ULFD detection mode are inconsistent, the port ULFD detection mode takes effect first.

Table 2 Enabling Ethernet ULFD Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2/3 Ethernet interface configuration mode	**interface** *interface-name*	-
Enable the port ULFD function	**ulfd port** [**aggressive**]	Mandatory By default, the Ethernet ULFD function is disabled.

Note

- To switch over the ULFD work mode on the port, first cancel the previous work mode and then configure the new mode.
- When enabling the ULFD function on the port, ensure that the neighbor port is also configured with the ULFD function and works in the same detection mode.

77.2.2 Configure ULFD Parameters

Configuration Condition

Before configuring the ULFD parameters, first complete the following task:

- Enable the ULFD function

Configure Sending Period of ULFD Detection Packet

ULFD periodically sends the detection packets to detect whether the network has the uni-directional link. We can modify the sending period of the detection packets according to the actuality of the network. The sending period of the detection packets is 7-90s. By default, it is 15s.

Table 3 Configuring Sending Period of ULFD Detection Packet

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the sending period of ULFD packet	**ulfd message time** *time-value*	Optional By default, the sending period of uni-directional detection packets is sent is 15 seconds.

Reset Port Disabled by ULFD

If ULFD detects the uni-direction and disables the port and we want to re-enable the ULFD detection function of the port, the user needs to perform the reset operation manually. The operation sets the port to UP and re-enables the ULFD detection.

Table 4 Resetting Port Disabled by ULFD

Step	Command	Description
Reset Port Disabled by ULFD	**ulfd reset** [**interface** *interface-name*]	Optional By default, the Ethernet port cannot automatically reset after it is disabled.

77.2.3 ULFD Monitoring and Maintaining

Table 5 ULFD Monitoring and Maintaining

Command	Description
show ulfd [**all** | **interface** *interface-name* [**detail**]]	Show the global configuration information of ULFD and ULFD configuration of all/specified Ethernet ports

77.3 Typical Configuration Example of ULFD

77.3.1 Configure ULFD Basic Functions

Network Requirements

- Device1 is connected to Device2 through fiber.
- Configure aggressive ULFD to disable the port when a uni-directional link is detected.

Network Topology

Figure 2 Network Topology for Configuring Basic Functions of ULFD

Configuration Steps

Step 1: Configure ULFD functions.

#Enable ULFD functions on Device1, and configure ULFD mode as aggressive on the port gigabitethernet0/1.

```
Device1#configure terminal
Device1(config)#ulfd aggressive
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#ulfd port aggressive
Device1(config-if-gigabitethernet0/1)#exit
```

#Enable ULFD functions on Device2, and configure ULFD mode as aggressive on port gigabitethernet0/1.

```
Device2#configure terminal
Device2(config)#ulfd aggressive
Device2(config)#interface gigabitethernet 0/1
```

```
Device2(config-if-gigabitethernet0/1)#ulfd port aggressive
Device2(config-if-gigabitethernet0/1)#exit
```

#View the ULFD information of port gigabitethernet0/1 on Device1.

```
Device1#show ulfd interface gigabitethernet 0/1
Interface name      : gigabitethernet0/1
ULFD config mode    : Aggressive
ULFD running mode   : Aggressive
Link status         : Link Up
Link direction      : Bidirectional
ULFD fsm status     : Advertisement

Neighbors number    : 1
----------
  Device ID          : 00017a787878
  Interface name     : gigabitethernet0/1
  Device Name        : Device2
  Message Interval   : 15
  Timeout Interval   : 5
  Link Direction     : Bidirectional
  Aging Time         : 40
  Time to Die        : 36
-------------------------------------
```

Note

- The ULFD information of port on Device2 is viewed the same way as that on Device1. (Omitted)

Step 2: Check the result.

#In the actual networking environment, as shown in Figure 2-1 and 2-2, when the fibers have crossover connection or a fiber is not connected or disconnected, uni-directional communication will happen. After the ULFD function is configured, when unti-directional communication is detected on Device1, port gigabitethernet0/1 will be closed and the following log information will be output:

```
%ULFD_LOG_WARN: gigabitethernet0/1: detected Unidirectional neighbor: device ID[00017a787878], device name[Device2], interface name[gigabitethernet0/1]!
%LINK-INTERFACE_DOWN-3: interface gigabitethernet0/1, changed state to down
%ULFD-UNDIR_LINK_ERR_V3-4: ULFD shutdown interface gigabitethernet0/1 successful
```

#It is indicated that port gigabitethernet0/1 is disabled.

```
Device1#show interface gigabitethernet 0/1


gigabitethernet0/1 configuration information
    Description     :
    Status          : Enabled
    Link            : Down  (Err-disabled)
    Set Speed       : Auto
    Act Speed       : Unknown
    Def Speed       : Auto
    Set Duplex      : Auto
    Act Duplex      : Unknown
    Def Duplex      : Auto
    Set Flow Control : Off
    Act Flow Control : Off
    Mtu             : 1824
    Port mode       : LAN
    Port ability    : 100M FD,1000M FD
    Link Delay      : No Delay
    Storm Control   : Unicast Disabled
    Storm Control   : Broadcast Disabled
    Storm Control   : Multicast Disabled
    Storm Action    : None
    Port Type       : Nni
    Pvid            : 1
    Set Medium      : Fiber
    Act Medium      : Fiber
    Single-fiber    : Disable
    Mac Address     : 0000.1111.2224
```

Note

- When configuring the ULFD function, ensure that the ULFDs at both ends of the link are working in the same detection mode.
- For normal ULFD, please refer to this configuration method. Normal mode only supports the detection of uni-directional communication caused by fiber cross connect.

78 EIPS

78.1 Overview

In the layer-2 Ethernet, STP protocol is generally used for network reliability. As a standard ring protection protocol developed by IEEE, it has been widely applied. However, this protocol has been restricted by network size, and the convergence time is affected by network topology. Generally, STP has a second-level convergence time which increases with the growth of network diameter.

In order to reduce the convergence time and eliminate the influence of network size, EIPS (Ethernet Intelligent Protection Switching) technology is born. EIPS is a link layer protocol dedicated for Ethernet ring. It can prevent the broadcast storm caused by data loop in the Ethernet ring; when a link on the Ethernet ring is disconnected, the backup link can be quickly enabled to restore the communication between nodes on the ring network. Compared to STP protocol, EIPS is characterized by fast topological convergence (less than 50ms) and no relation between convergence time and the number of nodes on the ring network.

EIPS technology supports two modes, i.e. subring and hierarchy segment. In subring mode, two crossed rings are broken up into a main ring and a subring, and there is a common link between them; in the mode of hierarchy segment, when processing two crossed rings, one of them is selected as a main ring, and the ring on the main ring with the common link part shared with the main ring removed becomes a low-level link. Simply put, the subring mode splits the crossed rings into a main ring and a subring, while the hierarchy segment mode splits the crossed rings into a main ring and a low-level link. There is only one main ring, yet multiple subrings or low-level links.

78.1.1 Basic Concepts

To better understand the basic concepts mentioned in this section, please refer to the typical topologies of subring mode and hierarchy segment mode below.

EIPS Domain

The interconnected devices with the same domain ID and same control VLAN constitute an EIPS domain. An EIPS domain may contain multiple EIPS rings, one main ring and the others subrings. The EIPS domain is composed of the following elements: EIPS ring, EIPS control VLAN, master node, transmission node, edge control node, and assistant edge node.

EIPS Ring

EIPS ring is identified by integer IDs. It physically corresponds to a ring-shaped Ethernet topology. There is only one main ring and multiple subrings. Subrings intersect with the main ring through edge nodes, and subrings intersect with each other through the main ring. The main ring is level 0, lower than subrings.

EIPS Node

The switches on the EIPS ring are called nodes, each of which is a unique domain ID and ring ID. Each node is connected to the ring via two ports. The master port and slave port are specified by the user.

Master port: It serves as both the initiator of ring network status polling and the decision maker of operation performance after the status of network topology is changed. There is only one master node on each ring.

Transmission node: All except master node on the master ring of EIPS are transmission nodes. Transmission nodes are responsible for monitoring the status of the link directly connected to them, and reporting the status change through EIPS protocol packet to the master node which makes decisions on how to process it.

The two nodes where subring and master ring intersect are called edge nodes (called transmission nodes on the master ring) that include edge control nodes and assistant edge nodes. These two types of nodes must be used in pair to detect the integrity or failure status of subring.

EIPS Control VLAN

Control VLAN is used to transmit EIPS protocol packets. The port on the EIPS ring must be added to the control VLAN, and no IP address is permitted to configure on the control VLAN interface. In the subring mode, the port on master ring should be added to the control VLAN of both master ring and subring, and that on subring is required to be added to the control VLAN of subring only. In the hierarchy segment mode, the same VLAN on master ring and low-level segment can be used as control VLAN.

EIPS Port

EIPS port is an abstract concept, which corresponds to a link makes up an EIPS ring. This link can be either a single physical link or an aggregation port composed of multiple physical links. Each EIPS node has two ports connected to EIPS ring. Since there are EIPS rings intersecting, an EIPS port may belong to multiple EIPS nodes.

Master and secondary EIPS port: There is master port and slave port on the master node and transmission nodes. The master port on the master node sends hello packet, and the slave port receives this packet. This can ensure the integrity of the loop. When the loop is complete, it is required to obstruct the data VLAN of the slave port on the master node. For transmission nodes, neither master port nor slave port has special meanings.

Topology Level

Topology level means the ring hierarchical division of EIPS domain. EIPS domain is composed of one ring or several rings intersecting with each other. When there is a single ring in the domain, it is a major-level ring, numbered 0; when there are multiple rings intersecting with each other in the domain, one of them is selected as a major-level ring, numbered 0, and the ring connected to this major-level ring with the common part shared with the major-level ring removed becomes a link in low-level segment.

Low-level link is the set of links with the common part connected to the upper layer removed.

The major-level ring has the highest level number (0). The lower the level, the larger the level number.

Topology Segment

In EIPS, segment number is used to differentiate different low-level links in the same level. Multiple low-level links can appear in the same level of the domain. The multiple low-level links in the same level are defined with different segment numbers. In particular, the segment number of the major-level ring is 0.

After dividing levels and segments in the EIPS domain, corresponding ring or low-level ring in each level and segment has unique level and segment numbers, called level segment. The low-level link where level and segment numbers are defined are called low-level segments.

78.1.2 Operating Mechanism

Polling Mechanism

With the polling mechanism, the master node of EIPS ring actively detects the integrity of the ring network.

The master node periodically sends from its master port Hello packet which passes every transmission node and spread on the ring. If the loop is healthy, the slave port of the master node will receive Hello packet before time-out of the timer, and the master node will maintain the slave port obstructed. If the loop is broken so that the slave port of the master node cannot receive Hello packet before time-out of the timer, the master node will cancel the obstruction status of data VLAN on the slave port and send COMM-FLUSH-FDB packet to notify all transmission nodes so that they can update their forwarding entries.

Link Down Alarm Mechanism

When the transmission node or edge node finds any of its port which belongs to EIPS ring becomes down, it will immediately send a Link-Down packet to the master node. After receiving the Link-Down packet, the master node will immediately cancel the obstruction status of data VLAN on the slave port and send COMM-FLUSH-FDB packet to notify all transmission and edge nodes so that they can update their forwarding entries. After the nodes update their entries, the data flow switch to the normal link.

Loop Recovery Mechanism

When the port which belongs to EIPS ring on transmission node or edge node is up again, the master node may find loop recovery after a period of time. For data VLAN, there may be a temporary loop in the network and then broadcast storm during this period of time.

In order to avoid temporary loop, non-master node immediately obstructs the port connecting to the ring network (only permitting the packet of control VLAN to pass) once it finds this port is up again until it believes no loop will be generated.

Load Balancing Mechanism

Load balancing is achieved by configuring multiple EIPS domains on the same ring network and permitting different EIPS domains to send traffic of different data VLANs, i.e. traffic of different VLANs is forwarded along different paths.

Backup Master Node Mechanism

The transmission node directly connected to the slave port of the master node is considered as the backup master node. When the master node is normal, the backup master node works as a transmission node; when the master node crashes, the backup master node will continue to work on behalf of the master node.

78.1.3 Typical Topology of Subring Mode

Single Ring

Domain1 of EIPS domain has an EIPS ring Ring1, a master node Master, three transmission nodes Transit1, Transit2 and Transit3, as shown in the figure below.

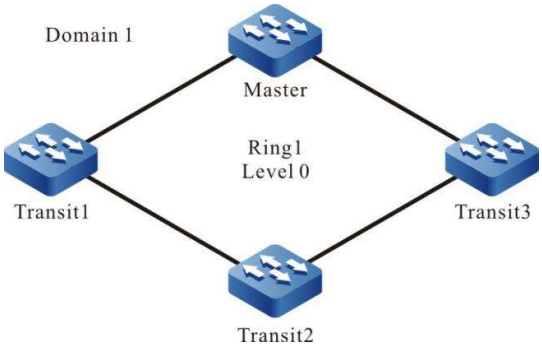


Figure 78 Topology of Single Ring

This networking is characterized by rapid response and short convergence time in case of topology change.

Typical Networking of Intersecting Rings

Domain1 of EIPS domain contains two EIPS rings, i.e. Ring1 and Ring2. In particular, Ring1 is the main ring, and Ring2 is the subring. The main ring Ring1 has a master node Master and two transmission nodes Transit1 and Transit2; the sub-ring Ring2 includes the edge control node Edge control (i.e. Transit3), assistant edge node Edge assistant (i.e. Transit4), transmission nodes Sub Transit1 and Sub Transit2, and edge nodes Edge control and Edge assistant that are also the transmission nodes of Ring1. This is shown in the image below.

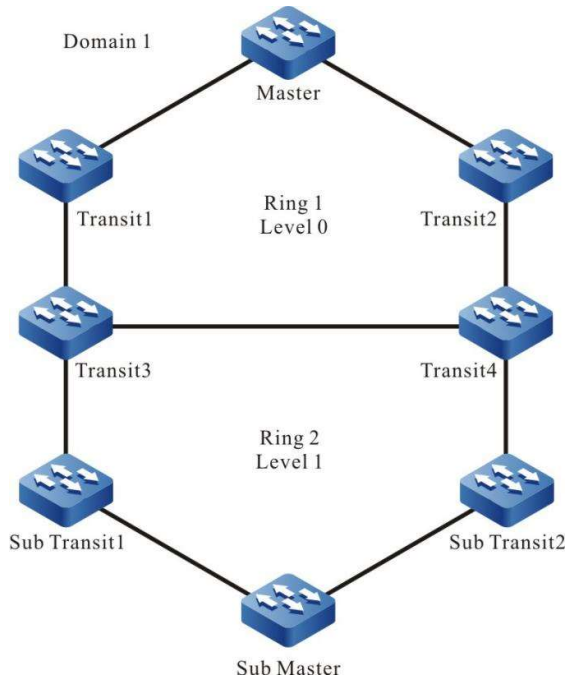


Figure 78 Typical Network Topology of Intersecting Rings

In this typical application of networking, subrings can be dual-homed to uplink with two edge nodes to provide uplink backup.

78.1.4 Typical Topology of Hierarchy Segment Mode

Single Ring

Domain1 of EIPS domain has an EIPS ring Ring1, a master node Master, and three transmission nodes Transit1, Transit2 and Transit3. Master port Primary and slave port Slave are configured on the master node. There is only one ring in Domain1. This single ring is defined as the major-level ring, the level as 0, and the segment as 0. When there is no fault in the major-level ring, EIPS blocks the data VLAN of the slave port Slave. This is shown in the image below.

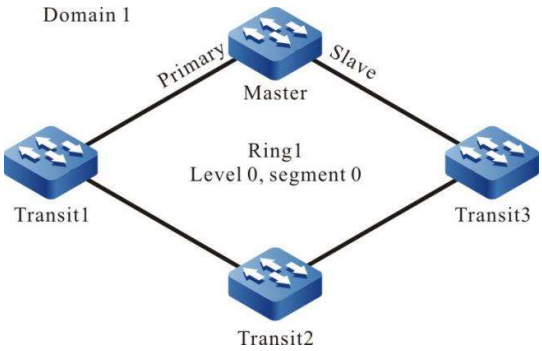


Figure 78 Topology of Single Ring in Hierarchy Segment Mode

Topology of Intersecting Rings

There are rings intersecting in Domain1 which is decomposed into a hierarchical structure containing a major-level ring and a low-level segment. Both level and segment of main ring Ring1 are defined as 0; the ring intersecting with Ring1 becomes a low-level segment after removing the common part connected to Transit2 and Transit3, which is assigned level and segment numbers of 1.

The major-level ring (level 0, segment 0) contains a master node Master and four transmission nodes Transit1, Transit2, Transit3 and Transit4. It is a single ring. The low-level segment (Level 1, segment 1) has edge control node Edge control (i.e. Transit2) and assistant edge node Edge assistant (i.e. Transit3), and transmission nodes Transit5 and Transit6, as shown below.

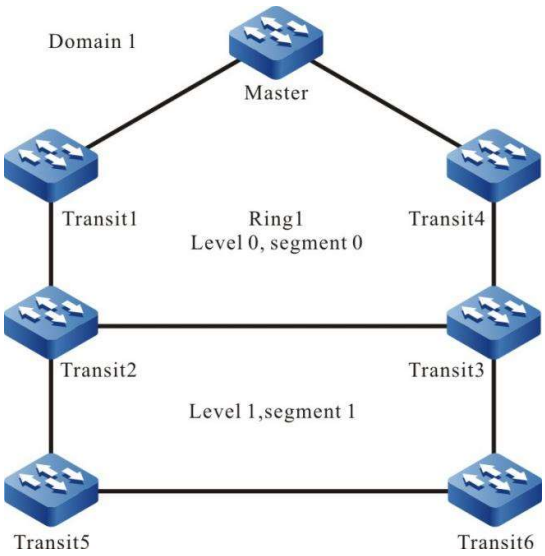


Figure 1 Topology of Intersecting in Hierarchy Segment Mode

78.2 EIPS Function Configuration

Table 78 EIPS Function Configuration List

Configuration Task	
Configure EIPS Ring	Configure EIPS Master Node
	Configure Transmission Node of EIPS
	Configure Edge Control Node of EIPS

	Configure Assistant Edge Node of EIPS
	Configure EIPS Domain
	Configure EIPS Control VLAN
	Configure EIPS Level Number
	Configure EIPS Segment Number
	Configure EIPS Data Instance
Configure EIPS Reliability	Configure EIPS Backup Master Node
	Configure EIPS uni-directional detection
Configure EIPS Timer	Configure EIPS Timer

Note

- EIPS technology supports two modes, i.e. subring and hierarchy segment.
- Hierarchy segment mode is recommended.
- There is little difference between hierarchy segment mode and subring mode in configuration. In hierarchy segment mode, parameter **segment** must be used in creating various EIPS nodes, and EIPS segment number needs to be configured.

78.2.1 Configure EIPS Ring

When configuring EIPS ring, you are required to configure the ports that will access EIPS ring on each node and the nodes on the ring.

Configuration Condition

Before configuring EIPS ring, do the following:

- Configure the type of the ports to be added to each node as nni;
- Close the spanning tree protocol of the ports to be added to each node;
- Configure the ports to be added to each node as trunk mode;
- Add the ports to be added to each node to the control VLAN to which the node belongs.

Configure EIPS Master Node

Please configure the device to be configured as a master node as follows.

Table 1 Configuring EIPS Master Node

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create EIPS master node	**eips ring** *ring-id* **master** [**segment**]	Mandatory By default, no EIPS master node is created. Parameter segment is recommended to specify the EIPS ring network as hierarchy segment mode. Otherwise, it is subring mode.
Configure master port of the master node	**primary interface** *interface-name*	Mandatory By default, master port of the master node is not configured.
Configure slave port of the master node	**secondary interface** *interface-name*	Mandatory By default, slave port of the master node is not configured.
Configure data instance of the master node	**instance** *instance-id*	Mandatory By default, data instance of the master node is not configured. The data VLAN permitted by the EIPS port should be included in the EIPS data instance, and all nodes of the same EIPS domain should be configured with the same data instance.

Note

- In subring mode, all ports on the main ring need to be added to the control VLAN of the subring.

Configure Transmission Node of EIPS

Please configure the device to be configured as a transmission node as follows.

Table 2 Configuring Transmission Node of EIPS

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create transmission node of EIPS	**eips ring** *ring-id* **transit** [**segment**]	Mandatory By default, no transmission node of EIPS is created. Parameter segment is recommended to specify the EIPS ring network as hierarchy segment mode. Otherwise, it is subring mode.
Configure master port of the transmission node	**primary interface** *interface-name*	Mandatory By default, master port of the transmission node is not configured.
Configure slave port of the transmission node	**secondary interface** *interface-name*	Mandatory By default, slave port of the transmission node is not configured.
Configure data instance of the transmission node	**instance** *instance-id*	Mandatory By default, data instance of the transmission node is not configured. The data VLAN permitted by the EIPS port should be

		included in the EIPS data instance, and all nodes of the same EIPS domain should be configured with the same data instance.

Configure Edge Control Node of EIPS

Please configure the device to be configured as an edge control node as follows.

Table 3 Configuring Edge Control Node of EIPS

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure edge control node	**eips ring** *ring-id* **edge** [**segment**]	Mandatory By default, no edge control node is configured. Parameter segment is recommended to specify the EIPS ring network as hierarchy segment mode. Otherwise, it is subring mode.
Associate edge control node with transmission node	**transit ring** *ring-id*	Mandatory By default, edge control node is not associated with transmission node. Only when the edge control node is associated with the transmission node, low-level segments or sub-rings can work together with the main ring
Configure edge port of edge control node	**edge interface** *interface-name*	Mandatory By default, no edge port is designated for edge control node.

		Edge port is used to connect low-level segment or subring with main ring
Configure data instance of edge control node	**instance** *instance-id*	Mandatory By default, no data instance is configured for edge control node. The data VLAN permitted by the EIPS port should be included in the EIPS data instance, and all nodes of the same EIPS domain should be configured with the same data instance.

Configure Assistant Edge Node of EIPS

Please configure the device to be configured as an assistant edge node as follows.

Table 4 Configuring Assistant Edge Node of EIPS

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure assistant edge node	**eips ring** *ring-id* **assistant** [**segment**]	Mandatory By default, no assistant edge node is configured. Parameter segment is recommended to specify the EIPS ring network as hierarchy segment mode. Otherwise, it is subring mode.
Associate assistant edge node with transmission node	**transit ring** *ring-id*	Mandatory By default, assistant edge node is not associated with transmission node. Only when the assistant edge node is associated

		with the transmission node, low-level segments or sub-rings can work together with the main ring
Configure edge port of assistant edge node	**edge interface** *interface-name*	Mandatory By default, edge port of the assistant edge node node is not configured. Edge port is used to connect low-level segment or subring with main ring
Configure data instance of assistant edge node	**instance** *instance-id*	Mandatory By default, no data instance is configured for assistant edge node. The data VLAN permitted by the EIPS port should be included in the EIPS data instance, and all nodes of the same EIPS domain should be configured with the same data instance.

Configure EIPS Domain

Specify the domain to which the EIPS ring or hierarchy segment belongs, and configure all nodes in the same EIPS domain with the same domain ID.

Table 78 Configuring EIPS Domain

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the EIPS configuration mode	**eips ring** *ring-id* { **master** | **transit** | **edge** | **assistant** } [**segment**]	-
Configure EIPS Domain	**domain id** *domain-id*	Mandatory

		By default, EIPS domain is not configured.

Configure EIPS Control VLAN

Configure the control VLAN of EIPS ring or hierarchy segment; configure the control VLAN prior to enabling EIPS protocol; configure all nodes in the same EIPS ring with the same control VLAN. Therefore, when configuring control VLAN, please select a VLAN that has been created yet has not been used by other layer-2 protocols. Otherwise, the configuration cannot succeed.

EIPS control VLAN is used to transmit EIPS protocol packets. Data packets are not permitted to enter the control VLAN.

Table 78 Configuring EIPS Control VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the EIPS configuration mode	**eips ring** *ring-id* { **master** | **transit** | **edge** | **assistant** } [**segment**]	-
Configure EIPS Control VLAN	**control vlan** *vlan-id*	Mandatory By default, no EIPS control VLAN is configured.

Configure EIPS Level Number

EIPS level number is an important sign to distinguish main ring from subring or low-level segment. The level numbers of all main rings are 0, those of first-level subrings or hierarchy segments are 1, and so on. Node of subring must be configured, and the level numbers of subrings or hierarchy numbers at the same level must be the same.

Table 78 Configuring EIPS Level Number

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Enter the EIPS configuration mode	**eips ring** *ring-id* { **master** | **transit** | **edge** | **assistant** } [**segment**]	-
Configure the level number of subring or hierarchy segment	**level** *level-id*	Mandatory By default, level number is not configured for subring or hierarchy segment.

Configure EIPS Segment Number

Segment number is an important sign in the hierarchy segment mode. The segment number of main ring is 0, and that of low-level segment is defined by users. The hierarchy segment with a level number greater than 0 must be configured with a segment number, and all nodes on the same hierarchy segment must have the same segment numbers.

Table 5 Configuring EIPS Number

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the EIPS configuration mode	**eips ring** *ring-id* { **master** | **transit** | **edge** | **assistant** } [**segment**]	-
Configure EIPS Segment Number	**segment** *segment-id*	Mandatory By default, segment number is not configured for the hierarchy segment. This command is exclusive for EIPS-level segment. The subring mode doesn't have this command. Segment number is configured on the edge control node, assistant edge node and transmission node of low-level segment.

Configure EIPS Data Instance

Data instance is configured prior to configuring EIPS ring or hierarchy segment; the data VLAN permitted by the EIPS port should be included in the EIPS data instance; all nodes of the same EIPS domain should be configured with the same data instance.

Data instance is configured by referencing MSTP (Multiple Spanning Tree Protocol Instance). Therefore, before configuring EIPS ring or hierarchy segment, the mapping relationship between the MSTP instance and the VLAN to be included should be configured.

Table 6 Configuring EIPS Data Instance

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the MSTP configuration mode	**spanning-tree mst configuration**	-
Configure MSTP instance	**instance** *instance-id* **vlan** *vlan-range*	Mandatory By default, MSTP creates instance 0 which contains all VLANs. Configure MSTP and map to corresponding data VLAN
Activate MST domain parameter configuration.	**active configuration pending**	Mandatory By default, MST domain parameters do not take effect immediately after modification unless this command is executed.
Enter the global configuration mode.	**exit**	-
Enter the EIPS configuration mode	**eips ring** *ring-id* { **master** | **transit** | **edge** | **assistant** } [**segment**]	-
Configure EIPS Data Instance	**instance** *instance-id*	Mandatory By default, EIPS data instance is not configured.

Enable EIPS Protocol

Upon completion of the configuration mentioned above, use this command to enable EIPS protocol.

Table 7 Enabling Protocol on EIPS Node

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the EIPS configuration mode	**eips ring** *ring-id* { **master** | **transit** | **edge** | **assistant** } [**segment**]	-
Enable EIPS protocol	**eips start**	Mandatory By default, EIPS protocol is not enabled on the node.

78.2.2 Configure EIPS Reliability

Configuration Condition

None

Configure EIPS Backup Master Node

In order to improve the reliability of EIPS ring network, the backup master node will replace the master node to perform its functions when the master node crashes.

The backup master node needs to be configured on the transmission node directly connected to the master node.

Table 8 Configuring EIPS Backup Master Node

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the EIPS configuration mode	**eips ring** *ring-id* { **master** | **transit** | **edge** | **assistant** } [**segment**]	-

Configure the specified transmission node as a backup master node	**backup master**	Mandatory By default, backup master node is not configured.

Configure EIPS Uni-directional Detection

Enable the uni-directional function under the port or port group.

Table 9 Configuring EIPS Uni-directional Detection of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure EIPS uni-directional detection of port	**eips udld interval** [*value*]	Mandatory By default, the uni-directional detection function is not disabled on the port.

78.2.3 Configure EIPS Timer

Configuration Condition

Before configuring EIPS timer, do the following:

- Configure basic EIPS functions.

Configure EIPS Timer

The master node and the edge control node in hierarchy segment mode use timer to control the frequency of sending hello packet and the timeout period of receiving hello packet, and the transmission node uses blocking timer to control the time taken for node to transform to complete state when the failure of transmission node recovers.

Table 10 Configuring EIPS Timer

Step	Command	Description

Enter the global configuration mode.	**configure terminal**	-
Enter the EIPS configuration mode	**eips ring** *ring-id* { **master** | **transit** | **edge** | **assistant** } [**segment**]	-
Configure timer of EIPS node	**timer** { **hello** | **receive** | **block** } *timer-value*	Mandatory By default, the timeout period of hello timer is 1 second, that of receive timer is 5 seconds, and that of block timer is 10 seconds.

Note

- The timer for sending hello packet can be configured on the master node or edge control node only, and the blocking timer on the transmission node only.

Caution

- If backup master node is configured, the timeout period of hello timer on master node cannot be configured as 0.

78.2.4 EIPS Monitoring and Maintaining

Table 11 EIPS Monitoring and Maintaining

Command	Description
clear eips { **interface** [*interface-name*] | **interface link-aggregation** [*link-aggregation-number*] | **ring** [*ring-id*] | **udld** }	Clear EIPS-related statistics
show eips { **config** [*ring-id*] | **interface** [*interface-name*] | **interface link-**	Show the configuration, status and statistical information of EIPS. This

Command	Description
aggregation [*link-aggregation-number*] | **mac-control-table** | **ring** [*ring-id*] / **ticktimer** [*ticktime-name*] / **topology** [**ring** *ring-id*] / **topology-summary** [**ring** *ring-id*] | **udld** [**interface** *interface-name*] }	includes EIPS port, aggregation port, address table, node, topology, timer-related information, and information related to UDLD uni-directional communication.

78.3 Typical Configuration Example of EIPS

78.3.1 Configure Single Ring in EIPS Hierarchy Segment Mode

Network Requirements

- There are four devices in Ring 1 of EIPS within LAN. Configure EIPS hierarchy segment mode, and protect the ring network by blocking the slave port gigabitethernet0/2 of Master node.
- When the link between transmission nodes Transit1 and Transit2 is disconnected, it can cancel the spanning tree blocking state of the Master node's slave port gigabitethernet0/2 so that data switch and the communication within the LAN are not affected.

Network Topology

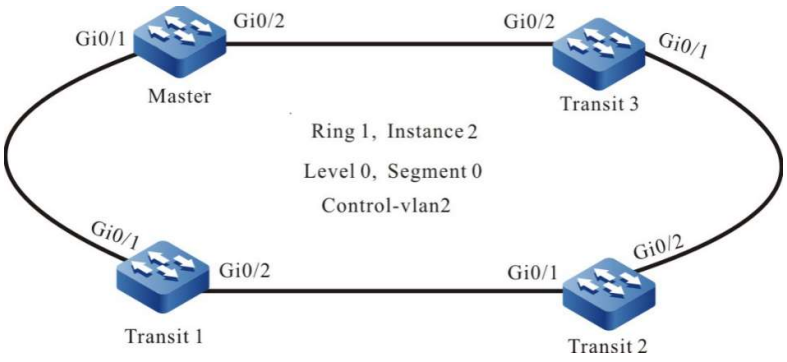


Figure 2 Network Topology for Configuring Single Ring in EIPS Hierarchy Segment Mode

Configuration Steps

Step 1: Configure VLANs, and configure the link type of the ports.

#On Master, create VLAN2 and VLAN3, and configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN3 to pass. Configure PVID as 1.

```
Master#configure terminal
```

```
Master(config)#vlan 2-3
Master(config)#interface gigabitethernet 0/1-0/2
Master(config-if-range)#switchport mode trunk
Master(config-if-range)#switchport trunk allowed vlan add 2-3
Master(config-if-range)#switchport trunk pvid vlan 1
```

#On Master, map VLAN3 to the spanning tree instance 2, and close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2.

```
Master (config)#spanning-tree mst configuration
%Alert: Commands configured under the mode would not take effect immediately, you should active them explicitly!
Master (config-mst)#instance 2 vlan 3
Master (config-mst)#active configuration pending
Master(config-if-range)#exit
Master(config)#interface gigabitethernet 0/1-0/2
Master(config-if-range)#no spanning-tree enable
Master(config-if-range)#no storm-control multicast
Master(config-if-range)#no storm-control unicast
Master(config-if-range)#no storm-control broadcast
Master(config-if-range)#exit
```

#On the transmission node Transit1, create VLAN2 and VLAN3, map VLAN3 to the spanning tree instance 2, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN3 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

#On Transit2, create VLAN2 and VLAN3, map VLAN3 to the spanning tree instance 2, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN3 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

#On the transmission node Transit3, create VLAN2 and VLAN3, map VLAN3 to the spanning tree instance 2, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN3 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

Note

- VLAN2 is a control VLAN used to transmit EIPS protocol packets, and VLAN3 is a data VLAN used to forward services.
- To use the EIPS function, you must map the EIPS data VLAN to corresponding spanning tree instance, and disable the spanning tree function on the port.

Step 2: Configure the EIPS hierarchy segment mode.

#On the master node Master, create master node Ring1 of the major ring in hierarchy segment mode, configure the level and segment number of EIPS ring as 0, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Master(config)#eips ring 1 master segment
Master(config-eips)#control vlan 2
Master(config-eips)#level 0
Master(config-eips)#segment 0
Master(config-eips)#instance 2
Master(config-eips)#primary interface gigabitethernet 0/1
Master(config-eips)#secondary interface gigabitethernet 0/2
Master(config-eips)#eips start
Master(config-eips)#exit
```

#On the transmission node Transit1, create transmission node Ring1 in hierarchy segment mode, configure the level and segment number of EIPS ring as 0, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Transit1(config)#eips ring 1 transit segment
Transit1(config-eips)#control vlan 2
Transit1(config-eips)#level 0
Transit1(config-eips)#segment 0
Transit1(config-eips)#instance 2
Transit1(config-eips)#primary interface gigabitethernet 0/1
Transit1(config-eips)#secondary interface gigabitethernet 0/2
Transit1(config-eips)#eips start
Transit1(config-eips)#exit
```

#On the transmission node Transit2, create transmission node Ring1 in hierarchy segment mode, configure the level and segment number of EIPS ring as 0, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Transit2(config)#eips ring 1 transit segment
Transit2(config-eips)#control vlan 2
Transit2(config-eips)#level 0
Transit2(config-eips)#segment 0
Transit2(config-eips)#instance 2
Transit2(config-eips)#primary interface gigabitethernet 0/1
Transit2(config-eips)#secondary interface gigabitethernet 0/2
Transit2(config-eips)#eips start
Transit2(config-eips)#exit
```

#On the transmission node Transit3, create transmission node Ring1 in hierarchy segment mode, configure the level and segment number of EIPS ring as 0, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Transit3(config)#eips ring 1 transit segment
Transit3(config-eips)#control vlan 2
Transit3(config-eips)#level 0
Transit3(config-eips)#segment 0
Transit3(config-eips)#instance 2
Transit3(config-eips)#primary interface gigabitethernet 0/1
Transit3(config-eips)#secondary interface gigabitethernet 0/2
Transit3(config-eips)#eips start
Transit3(config-eips)#exit
```

Step 3: Check the result.

#By executing show eips topology-summary on the four devices, you can see that the EIPS ring status is round, and the topology content is consistent.

```
Master#show eips topology-summary
 ring ID     : 1
 topo status  : round
 seq  host-name       mac            type      interface1        link    interface2        link    isBorder
 ---------------------------------------------------------------------------------------------------------------
 1    Transit3        0000.0000.008b  transit   gi0/2             UP      gi0/1             UP      NO
 2    Transit2        0001.7a22.2224  transit   gi0/2             UP      gi0/1             UP      YES
 3    Transit1        0000.0010.0017  transit   gi0/2             UP      gi0/1             UP      YES
 4    Master          0001.7a54.5d71  master    gi0/1             UP      gi0/2             UP      NO

Transit3#show eips topology-summary
 ring ID     : 1
 topo status  : round
 seq  host-name       mac            type      interface1        link    interface2        link    isBorder
 ---------------------------------------------------------------------------------------------------------------
 1    Master          0001.7a54.5d71  master    gi0/2             UP      gi0/1             UP      NO
 2    Transit1        0000.0010.0017  transit   gi0/1             UP      gi0/2             UP      YES
 3    Transit2        0001.7a22.2224  transit   gi0/1             UP      gi0/2             UP      YES
 4    Transit3        0000.0000.008b  transit   gi0/1             UP      gi0/2             UP      NO

Transit1#show eips topology-summary
 ring ID     : 1
```

```
topo status  : round
seq  host-name       mac            type      interface1        link    interface2        link    isBorder
-------------------------------------------------------------------------------------------------------------
1    Transit2        0001.7a22.2224  transit   gi0/1             UP      gi0/2             UP      YES
2    Transit3        0000.0000.008b  transit   gi0/1             UP      gi0/2             UP      NO
3    Master          0001.7a54.5d71  master    gi0/2             UP      gi0/1             UP      NO
4    Transit1        0000.0010.0017  transit   gi0/1             UP      gi0/2             UP      YES

Transit2#show eips topology-summary
ring ID     : 1
topo status  : round
seq  host-name       mac            type      interface1        link    interface2        link    isBorder
-------------------------------------------------------------------------------------------------------------
1    Transit3        0000.0000.008b  transit   gi0/1             UP      gi0/2             UP      NO
2    Master          0001.7a54.5d71  master    gi0/2             UP      gi0/1             UP      NO
3    Transit1        0000.0010.0017  transit   gi0/1             UP      gi0/2             UP      YES
4    Transit2        0001.7a22.2224  transit   gi0/1             UP      gi0/2             UP      YES
```

#By executing show eips topology on the four devices, you can see that the slave port gigabitethernet0/2 of the master node Master is blocked, and all other ports are unblocked.

```
Master#show eips topology
ring ID     : 1
topo status  : round
topo index 1   :
      host name      : Transit3
      eips type      : transit
      eips status    : COMPLETE
      border         : NO
      base MAC       : 0000.0000.008b
      sys oid        : 1.3.6.1.4.1.5651.1.102.146
      interface1     : gi0/2
       MAC           : 0000.0000.008b
       role          : second
       block-status  : unblock
       link-status   : UP
      interface2     : gi0/1
       MAC           : 0000.0000.008b
       role          : primary
       block-status  : unblock
       link-status   : UP
```

```
topo index 2   :
      host name      : Transit2
      eips type      : transit
      eips status    : COMPLETE
      border         : YES
      base MAC       : 0001.7a22.2224
      sys oid        : 1.3.6.1.4.1.5651.1.102.146
      interface1     : gi0/2
       MAC           : 0001.7a22.2224
       role          : second
       block-status  : unblock
       link-status   : UP
      interface2     : gi0/1
       MAC           : 0001.7a22.2224
       role          : primary
       block-status  : unblock
       link-status   : UP
topo index 3   :
      host name      : Transit1
      eips type      : transit
      eips status    : COMPLETE
      border         : YES
      base MAC       : 0000.0010.0017
      sys oid        : 1.3.6.1.4.1.5651.1.102.140
      interface1     : gi0/2
       MAC           : 0000.0010.0017
       role          : second
       block-status  : unblock
       link-status   : UP
      interface2     : gi0/1
       MAC           : 0000.0010.0017
       role          : primary
       block-status  : unblock
       link-status   : UP
topo index 4   :
      host name      : Master
      eips type      : master
      eips status    : COMPLETE
       border        : NO
      base MAC       : 0001.7a54.5d71
```

```
 sys oid        : 1.3.6.1.4.1.5651.1.102.145
interface1      : gi0/1
 MAC            : 0001.7a54.5d71
 role           : primary
 block-status   : unblock
 link-status    : UP
interface2      : gi0/2
 MAC            : 0001.7a54.5d71
 role           : second
 block-status   : block
 link-status    : UP
```

#When the link between transmission nodes Transit1 and Transit2 is disconnected, you can see through show eips topology that status of the ring turns to round, status of EIPS becomes FAULT, slave port gigabitethernet0/2 of the master node Master is unblocked, and Transit1 can communicate with Transit2 through the master node Master to ensure the communication between Transit1 and Transit2 is uninterrupted.

```
Master#show eips topology
ring ID     : 1
topo status  : not round
topo index 1   :
      host name      : Transit1
      eips type      : transit
      eips status    : FAULT
      border         : YES
      base MAC       : 0000.0010.0017
      sys oid        : 1.3.6.1.4.1.5651.1.102.140
      interface1     : gi0/2
       MAC           : 0000.0010.0017
       role          : second
       block-status  : block
       link-status   : DOWN
      interface2     : gi0/1
       MAC           : 0000.0010.0017
       role          : primary
       block-status  : unblock
       link-status   : UP
topo index 2   :
      host name      : Master
      eips type      : master
      eips status    : FAULT
```

```
        border         : NO
        base MAC       : 0001.7a54.5d71
        sys oid        : 1.3.6.1.4.1.5651.1.102.145
        interface1     : gi0/1
          MAC          : 0001.7a54.5d71
          role         : primary
          block-status   : unblock
          link-status    : UP
        interface2     : gi0/2
          MAC          : 0001.7a54.5d71
          role         : second
          block-status   : unblock
          link-status    : UP
topo index 3   :
        host name      : Transit3
        eips type      : transit
        eips status    : FAULT
        border         : NO
        base MAC       : 0000.0000.008b
        sys oid        : 1.3.6.1.4.1.5651.1.102.146
        interface1     : gi0/2
          MAC          : 0000.0000.008b
          role         : second
          block-status   : unblock
          link-status    : UP
        interface2     : gi0/1
          MAC          : 0000.0000.008b
          role         : primary
          block-status   : unblock
          link-status    : UP
topo index 4   :
        host name      : Transit2
        eips type      : transit
        eips status    : FAULT
        border         : YES
        base MAC       : 0001.7a22.2224
        sys oid        : 1.3.6.1.4.1.5651.1.102.146
        interface1     : gi0/2
          MAC          : 0001.7a22.2224
          role         : second
```

```
 block-status    : unblock
 link-status     : UP
interface2       : gi0/1
 MAC             : 0001.7a22.2224
 role            : primary
 block-status    : block
 link-status     : DOWN
```

78.3.2 Configure the Intersecting Rings in EIPS Hierarchy Segment Mode

Network Requirements

- There are six devices within the LAN, which make up two levels of intersecting rings. Protect the ring network by configuring EIPS hierarchy segment mode to block the slave port gigabitethernet0/2 of master node Master and the edge port gigabitethernet0/3 of edge node Transit1.
- When the link between the edge node Transit1 and the assistant edge node Transit2 is disconnected, it can cancel the spanning tree blocking state of the slave port gigabitethernet0/2 of the main ring's master node Master so that data switch and the communication in the main ring Ring1 are not affected.
- When the link between transmission nodes sTransit1 and sTransit2 is disconnected, it can cancel the spanning tree blocking state of the edge node Transit1's edge port gigabitethernet0/3 so that data switch and the communication in the first level of subring Ring2 are not affected.

Network Topology

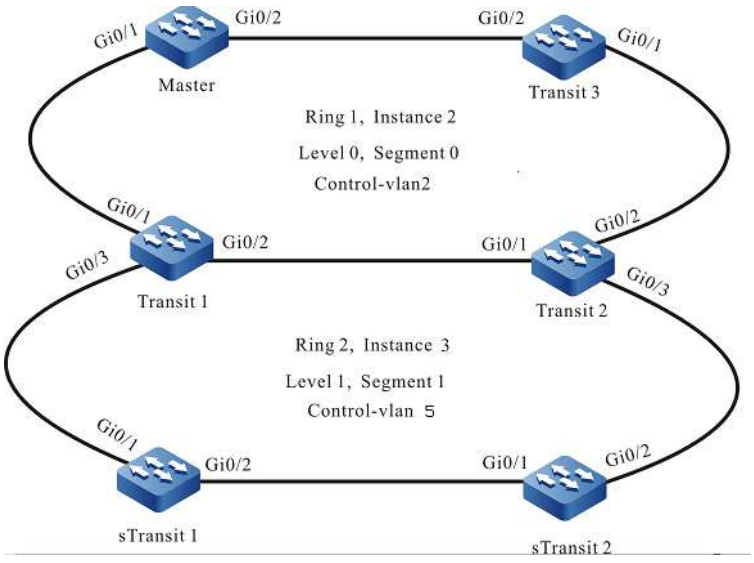


Figure 3 Network Topology for Configuring Intersecting Rings in EIPS Hierarchy Segment Mode

Configuration Steps

Step 1: Configure VLANs, and configure the link type of the ports.

#On Master, create VLAN2 and VLAN3, and configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN3 to pass. Configure PVID as 1.

```
Master#configure terminal
Master(config)#vlan 2-3
Master(config)#interface gigabitethernet 0/1-0/2
Master(config-if-range)#switchport mode trunk
Master(config-if-range)#switchport trunk allowed vlan add 2-3
Master(config-if-range)#switchport trunk pvid vlan 1
```

#On Master, map VLAN3 to the spanning tree instance 2, and close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2.

```
Master (config)#spanning-tree mst configuration
%Alert: Commands configured under the mode would not take effect immediately, you should active them explicitly!
Master (config-mst)#instance 2 vlan 3
Master (config-mst)#active configuration pending
Master(config-if-range)#exit
Master(config)#interface gigabitethernet 0/1-0/2
Master(config-if-range)#no spanning-tree enable
Master(config-if-range)#no storm-control multicast
Master(config-if-range)#no storm-control unicast
Master(config-if-range)#no storm-control broadcast
Master(config-if-range)#exit
```

#On the transmission node Transit1 of the main ring, create VLAN2-5, map VLAN3 to the spanning tree instance 2 and VLAN4 to the spanning tree instance 3, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk to permit services of VLAN2-3 to pass and that of ports gigabitethernet0/2~gigabitethernet0/3 as Trunk to permit services of VLAN4-5 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/3. (Omitted)

#On the transmission node Transit2 of the main ring, create VLAN2-5, map VLAN3 to the spanning tree instance 2 and VLAN4 to the spanning tree instance 3, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk to permit services of VLAN2-3 to pass and that of ports gigabitethernet0/2~gigabitethernet0/3 as Trunk to permit services of VLAN4-5 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/3. (Omitted)

#On the transmission node Transit3 of the main ring, create VLAN2 and VLAN3, map VLAN3 to the spanning tree instance 2, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN3 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

#On the transmission node sTransit1 of the first level of subring, create VLAN4 and VLAN5, map VLAN4 to the spanning tree instance 3, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN4 and VLAN5 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

#On the transmission node Transit2 of the first level of subring, create VLAN4 and VLAN5, map VLAN4 to the spanning tree instance 3, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN4 and VLAN5 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

Note

- VLAN5 is a control VLAN used to transmit EIPS protocol packets, and VLAN4 is a data VLAN used to forward services.
- To use the EIPS function, you must map the EIPS data VLAN to corresponding spanning tree instance, and disable spanning tree and storm suppression functions on the port.

Step 2: Configure the main ring Ring1.

#On the master node Master, create master node Ring1 in hierarchy segment mode, configure the level and segment number of EIPS ring as 0, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Master(config)#eips ring 1 master segment
Master(config-eips)#control vlan 2
Master(config-eips)#level 0
Master(config-eips)#segment 0
Master(config-eips)#instance 2
Master(config-eips)#primary interface gigabitethernet 0/1
Master(config-eips)#secondary interface gigabitethernet 0/2
Master(config-eips)#eips start
Master(config-eips)#exit
```

#On the transmission node Transit1 of the main ring, create transmission node Ring1 in hierarchy segment mode, configure the level and segment number of EIPS ring as 0, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS. (Omitted)

#On the transmission node Transit2 of the main ring, create transmission node Ring1 in hierarchy segment mode, configure the level and segment number of EIPS ring as 0, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS. (Omitted)

#On the transmission node Transit3 of the main ring, create transmission node Ring1 in hierarchy segment mode, configure the level and segment number of EIPS ring as 0, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS. (Omitted)

Step 3: Configure the first-level subring Ring2.

#On the edge node of the first-level subring (transmission node of the main ring), create edge node Ring2 of hierarchy segment mode on Transit1, configure the level and segment number of EIPS ring as 1, instance of EIPS ring as 3, control VLAN as VLAN5, edge port as gigabitethernet0/3 and Ring1 as its associated transmission node, and enable EIPS.

```
Transit1(config)#eips ring 2 edge segment
Transit1(config-eips)#control vlan 5
Transit1(config-eips)#level 1
Transit1(config-eips)#segment 1
Transit1(config-eips)#instance 3
Transit1(config-eips)#transit ring 1
Transit1(config-eips)#edge interface gigabitethernet0/3
Transit1(config-eips)#eips start
Transit1(config-eips)#exit
```

#On the assistant edge node of the first-level subring (transmission node of the main ring), create assistant edge node Ring2 of hierarchy segment mode on Transit2, configure the level and segment number of EIPS ring as 1, instance of EIPS ring as 3, control VLAN as VLAN5, edge port as gigabitethernet0/3 and Ring1 as its associated transmission node, and enable EIPS.

```
Transit2(config)#eips ring 2 assistant segment
Transit2(config-eips)#control vlan 5
Transit2(config-eips)#level 1
Transit2(config-eips)#segment 1
Transit2(config-eips)#instance 3
Transit2(config-eips)#transit ring 1
Transit2(config-eips)#edge interface gigabitethernet0/3
Transit2(config-eips)#eips start
Transit2(config-eips)#exit
```

#On the transmission node sTransit1 of the first-level subring, create transmission node Ring2 in hierarchy segment mode, configure the level and segment number of EIPS ring as 1, instance of EIPS ring as 3, control VLAN as VLAN5, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
sTransit1(config)#eips ring 2 transit segment
sTransit1(config-eips)#control vlan 5
```

```
sTransit1(config-eips)#level 1
sTransit1(config-eips)#segment 1
sTransit1(config-eips)#instance 3
sTransit1(config-eips)#primary interface gigabitethernet 0/1
sTransit1(config-eips)#secondary interface gigabitethernet 0/2
sTransit1(config-eips)#eips start
sTransit1(config-eips)#exit
```

#On the transmission node Transit2 of the first-level subring, create transmission node Ring2 in hierarchy segment mode, configure the level and segment number of EIPS ring as 1, instance of EIPS ring as 3, control VLAN as VLAN5, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
sTransit2(config)#eips ring 2 transit segment
sTransit2(config-eips)#control vlan 5
sTransit2(config-eips)#level 1
sTransit2(config-eips)#segment 1
sTransit2(config-eips)#instance 3
sTransit2(config-eips)#primary interface gigabitethernet 0/1
sTransit2(config-eips)#secondary interface gigabitethernet 0/2
sTransit2(config-eips)#eips start
sTransit2(config-eips)#exit
```

Step 4: Check the result.

#By executing show eips topology-summary on edge node and assistant edge node, you can see that the status of both EIPS main ring and subring is round, and the topology content is consistent.

```
Transit1#show eips topology-summary
ring ID     : 1
topo status  : round
seq  host-name      mac           type     interface1      link   interface2      link   isBorder
-------------------------------------------------------------------------------------------------------
1    Transit2       0001.7a22.2224  transit   gi0/1          UP     gi0/2          UP     YES
2    Transit3       0000.0000.008b  transit   gi0/1          UP     gi0/2          UP     NO
3    Master         0014.0000.1202  master    gi0/2          UP     gi0/1          UP     NO
4    Transit1       0001.7a54.5d71  transit   gi0/1          UP     gi0/2          UP     YES

ring ID     : 2
topo status  : round
seq  host-name      mac           type     interface1      link   interface2      link   isBorder
-------------------------------------------------------------------------------------------------------
1    Transit2       0001.7a22.2224  assistant ----           ----   gi0/3          UP     NO
```

```
2   sTransit2      2012.1209.1728  transit  gi0/2        UP     gi0/1        UP     NO
3   sTransit1      0000.0010.0017  transit  gi0/2        UP     gi0/1        UP     NO
4   Transit1       0001.7a54.5d71  edge     gi0/3        UP     ----         ----   NO

Transit2#show eips topology-summary
ring ID     : 1
topo status  : round
seq  host-name      mac           type     interface1      link   interface2      link   isBorder
-------------------------------------------------------------------------------------------------------------
1   Transit3        0000.0000.008b  transit   gi0/1         UP     gi0/2         UP     NO
2   Master          0014.0000.1202  master   gi0/2         UP     gi0/1         UP     NO
3   Transit1        0001.7a54.5d71  transit  gi0/1         UP     gi0/2         UP     YES
4   Transit2        0001.7a22.2224  transit  gi0/1         UP     gi0/2         UP     YES

ring ID     : 2
topo status  : round
seq  host-name      mac           type     interface1      link   interface2      link   isBorder
-------------------------------------------------------------------------------------------------------------
1   Transit1        0001.7a54.5d71  edge     ----          ----   gi0/3         UP     NO
2   sTransit1       0000.0010.0017  transit  gi0/1         UP     gi0/2         UP     NO
3   sTransit2       2012.1209.1728  transit  gi0/1         UP     gi0/2         UP     NO
4   Transit2     0001.7a22.2224  assistant gi0/3         UP     ----          ----   NO
```

#By executing show eips topology on the edge node, you can see that the slave port gigabitethernet0/2 of the master node Master and the edge port gigabitethernet0/3 of the edge node Transit1 are blocked, and all other ports are unblocked; the EIPS status of main ring and subring is COMPLETE.

```
Transit1#show eips topology
ring ID     : 1
topo status  : round
topo index 1   :
      host name      : Transit2
      eips type      : transit
      eips status    : COMPLETE
      border         : YES
      base MAC       : 0001.7a22.2224
      sys oid        : 1.3.6.1.4.1.5651.1.0.0
      interface1     : gi0/1
       MAC           : 0001.7a22.2224
       role          : primary
       block-status    : unblock
```

```
        link-status     : UP
      interface2      : gi0/2
        MAC             : 0001.7a22.2224
        role            : second
        block-status    : unblock
        link-status     : UP
topo index 2   :
      host name       : Transit3
      eips type       : transit
      eips status     : COMPLETE
      border          : NO
      base MAC        : 0000.0000.008b
      sys oid         : 1.3.6.1.4.1.5651.1.102.146
      interface1      : gi0/1
        MAC             : 0000.0000.008b
        role            : primary
        block-status    : unblock
        link-status     : UP
      interface2      : gi0/2
        MAC             : 0000.0000.008b
        role            : second
        block-status    : unblock
        link-status     : UP
topo index 3   :
      host name       : Master
      eips type       : master
      eips status     : COMPLETE
      border          : NO
      base MAC        : 0014.0000.1202
      sys oid         : 1.3.6.1.4.1.5651.1.102.127
      interface1      : gi0/2
        MAC             : 0014.0000.1202
        role            : second
        block-status    : block
        link-status     : UP
      interface2      : gi0/1
        MAC             : 0014.0000.1202
        role            : primary
        block-status    : unblock
        link-status     : UP
```

```
topo index 4   :
      host name      : Transit1
      eips type      : transit
      eips status    : COMPLETE
      border         : YES
      base MAC       : 0001.7a54.5d71
      sys oid        : 1.3.6.1.4.1.5651.1.102.145
      interface1     : gi0/1
       MAC           : 0001.7a54.5d71
       role          : primary
       block-status    : unblock
       link-status    : UP
      interface2     : gi0/2
       MAC           : 0001.7a54.5d71
       role          : second
       block-status    : unblock
       link-status    : UP

ring ID     : 2
topo status  : round
topo index 1   :
      host name      : Transit2
      eips type      : assistant
      eips status    : COMPLETE
      border         : NO
      base MAC       : 0001.7a22.2224
      sys oid        : 1.3.6.1.4.1.5651.1.0.0
      interface2     : gi0/3
       MAC           : 0001.7a22.2224
       role          : edge
        block-status    : unblock
       link-status    : UP
topo index 2   :
      host name      : sTransit2
      eips type      : transit
      eips status    : COMPLETE
      border         : NO
      base MAC       : 2012.1209.1728
      sys oid        : 1.3.6.1.4.1.5651.1.102.126
      interface1     : gi0/2
```

```
        MAC           : 2012.1209.1728
        role          : second
        block-status  : unblock
        link-status   : UP
      interface2      : gi0/1
        MAC           : 2012.1209.1728
        role          : primary
        block-status  : unblock
        link-status   : UP
topo index 3   :
    host name       : sTransit1
    eips type       : transit
    eips status     : COMPLETE
    border          : NO
    base MAC        : 0000.0010.0017
    sys oid         : 1.3.6.1.4.1.5651.1.102.140
    interface1      : gi0/2
      MAC           : 0000.0010.0017
      role          : second
      block-status  : unblock
      link-status   : UP
    interface2      : gi0/1
      MAC           : 0000.0010.0017
      role          : primary
      block-status  : unblock
      link-status   : UP
topo index 4   :
    host name       : Transit1
    eips type       : edge
    eips status     : COMPLETE
    border          : NO
    base MAC        : 0001.7a54.5d71
    sys oid         : 1.3.6.1.4.1.5651.1.102.145
    interface1      : gi0/3
      MAC           : 0001.7a54.5d71
      role          : edge
      block-status  : block
      link-status   : UP
```

#When the link between edge node Transit1 and assistant edge node Transit2 is disconnected, you can see on the edge node with show eips topology that the status of main ring Ring1 is not round, status of EIPS becomes FAULT, slave port gigabitethernet0/2 of the master node Master is unblocked, and Transit1 can communicate with Transit2 through the master node Master to ensure the communication between Transit1 and Transit2 is uninterrupted; the status of subring Ring2 is still round, the EIPS status is COMPLETE, and the edge port gigabitethernet0/3 of edge node Transit1 is blocked.

```
Transit1#show eips topology ring 1
ring ID     : 1
topo status  : not round
topo index 1   :
      host name      : Transit2
      eips type      : transit
       eips status     : FAULT
      border         : YES
      base MAC       : 0001.7a22.2224
      sys oid        : 1.3.6.1.4.1.5651.1.0.0
      interface1     : gi0/1
       MAC           : 0001.7a22.2224
       role          : primary
       block-status    : block
       link-status     : DOWN
      interface2     : gi0/2
       MAC           : 0001.7a22.2224
       role          : second
       block-status    : unblock
       link-status     : UP
topo index 2   :
      host name      : Transit3
      eips type      : transit
       eips status     : FAULT
      border         : NO
      base MAC       : 0000.0000.008b
      sys oid        : 1.3.6.1.4.1.5651.1.102.146
      interface1     : gi0/1
       MAC           : 0000.0000.008b
       role          : primary
       block-status    : unblock
       link-status     : UP
      interface2     : gi0/2
       MAC           : 0000.0000.008b
```

role : second

block-status : unblock

link-status : UP

topo index 3 :

host name : Master

eips type : master

eips status : FAULT

border : NO

base MAC : 0014.0000.1202

sys oid : 1.3.6.1.4.1.5651.1.102.127

interface1 : gi0/2

MAC : 0014.0000.1202

role : second

block-status : unblock

link-status : UP

interface2 : gi0/1

MAC : 0014.0000.1202

role : primary

block-status : unblock

link-status : UP

topo index 4 :

host name : Transit1

eips type : transit

eips status : FAULT

border : YES

base MAC : 0001.7a54.5d71

sys oid : 1.3.6.1.4.1.5651.1.102.145

interface1 : gi0/1

MAC : 0001.7a54.5d71

role : primary

block-status : unblock

link-status : UP

interface2 : gi0/2

MAC : 0001.7a54.5d71

role : second

block-status : block

link-status : DOWN

Transit1#show eips topology ring 2

ring ID : 2

```
topo status  : round
topo index 1   :
      host name      : Transit2
      eips type      : assistant
      eips status    : COMPLETE
      border         : NO
      base MAC       : 0001.7a22.2224
      sys oid        : 1.3.6.1.4.1.5651.1.0.0
      interface2     : gi0/3
       MAC           : 0001.7a22.2224
       role          : edge
       block-status    : unblock
       link-status     : UP
topo index 2   :
      host name      : sTransit2
      eips type      : transit
      eips status    : COMPLETE
      border         : NO
      base MAC       : 2012.1209.1728
      sys oid        : 1.3.6.1.4.1.5651.1.102.126
      interface1     : gi0/2
       MAC           : 2012.1209.1728
       role          : second
       block-status    : unblock
       link-status     : UP
      interface2     : gi0/1
       MAC           : 2012.1209.1728
       role          : primary
       block-status    : unblock
       link-status     : UP
topo index 3   :
      host name      : sTransit1
      eips type      : transit
      eips status    : COMPLETE
      border         : NO
      base MAC       : 0000.0010.0017
      sys oid        : 1.3.6.1.4.1.5651.1.102.140
      interface1     : gi0/2
       MAC           : 0000.0010.0017
       role          : second
```

```
    block-status    : unblock
    link-status     : UP
  interface2      : gi0/1
    MAC             : 0000.0010.0017
    role            : primary
    block-status    : unblock
    link-status     : UP
topo index 4   :
  host name       : Transit1
  eips type       : edge
  eips status     : COMPLETE
  border          : NO
  base MAC        : 0001.7a54.5d71
  sys oid         : 1.3.6.1.4.1.5651.1.102.145
  interface1      : gi0/3
    MAC             : 0001.7a54.5d71
    role            : edge
    block-status    : block
    link-status     : UP
```

#When only the link between transmission nodes sTransit1 and sTransit2 is disconnected, you can see on the edge node and assistant edge node with show eips topology that the status of subring Ring2 is not round, status of EIPS becomes FAULT, edge port gigabitethernet0/3 of the edge node Transit1 is unblocked, and sTransit1 can communicate with sTransit2 through edge node Transit1 to ensure the communication between sTransit1 and sTransit2 is uninterrupted; the status of main ring Ring1 is still round, the EIPS status is COMPLETE, and the slave port gigabitethernet0/2 of master node Master is blocked.

```
Transit1#show eips topology ring 2
ring ID     : 2
topo status  : not round
topo index 1   :
  host name       : sTransit1
  eips type       : transit
  eips status     : FAULT
  border          : NO
  base MAC        : 0000.0010.0017
  sys oid         : 1.3.6.1.4.1.5651.1.102.140
  interface1      : gi0/2
    MAC             : 0000.0010.0017
    role            : second
    block-status    : block
```

```
        link-status     : DOWN
      interface2      : gi0/1
        MAC             : 0000.0010.0017
        role            : primary
        block-status    : unblock
        link-status     : UP
topo index 2   :
      host name       : Transit1
      eips type       : edge
      eips status     : FAULT
      border          : NO
      base MAC        : 0001.7a54.5d71
      sys oid         : 1.3.6.1.4.1.5651.1.102.145
      interface1      : gi0/3
        MAC             : 0001.7a54.5d71
        role            : edge
        block-status    : unblock
        link-status     : UP
Transit2#show eips topology ring 2
ring ID      : 2
topo status  : not round
topo index 1   :
      host name       : sTransit2
      eips type       : transit
      eips status     : FAULT
      border          : NO
      base MAC        : 2012.1209.1728
      sys oid         : 1.3.6.1.4.1.5651.1.102.126
      interface1      : gi0/1
        MAC             : 2012.1209.1728
        role            : primary
        block-status    : block
        link-status     : DOWN
      interface2      : gi0/2
        MAC             : 2012.1209.1728
        role            : second
        block-status    : unblock
        link-status     : UP
topo index 2   :
      host name       : Transit2
```

```
    eips type       : assistant
    eips status     : FAULT
    border          : NO
    base MAC        : 0001.7a22.2224
    sys oid         : 1.3.6.1.4.1.5651.1.0.0
    interface1      : gi0/3
     MAC            : 0001.7a22.2224
     role           : edge
     block-status    : unblock
     link-status     : UP
Transit1#show eips topology ring 1
ring ID     : 1
topo status  : round
topo index 1   :
    host name       : Transit2
    eips type       : transit
    eips status     : COMPLETE
    border          : YES
    base MAC        : 0001.7a22.2224
    sys oid         : 1.3.6.1.4.1.5651.1.0.0
    interface1      : gi0/1
     MAC            : 0001.7a22.2224
     role           : primary
     block-status    : unblock
     link-status     : UP
    interface2      : gi0/2
     MAC            : 0001.7a22.2224
     role           : second
     block-status    : unblock
     link-status     : UP
topo index 2   :
    host name       : Transit3
    eips type       : transit
    eips status     : COMPLETE
    border          : NO
    base MAC        : 0000.0000.008b
    sys oid         : 1.3.6.1.4.1.5651.1.102.146
    interface1      : gi0/1
     MAC            : 0000.0000.008b
     role           : primary
```

```
        block-status    : unblock
        link-status     : UP
      interface2      : gi0/2
        MAC             : 0000.0000.008b
        role            : second
        block-status    : unblock
        link-status     : UP
topo index 3   :
    host name       : Master
    eips type       : master
    eips status     : COMPLETE
    border          : NO
    base MAC        : 0014.0000.1202
    sys oid         : 1.3.6.1.4.1.5651.1.102.127
    interface1      : gi0/2
      MAC           : 0014.0000.1202
      role          : second
      block-status    : block
      link-status     : UP
    interface2      : gi0/1
      MAC           : 0014.0000.1202
      role          : primary
      block-status    : unblock
      link-status     : UP
topo index 4   :
    host name       : Transit1
    eips type       : transit
    eips status     : COMPLETE
    border          : YES
    base MAC        : 0001.7a54.5d71
    sys oid         : 1.3.6.1.4.1.5651.1.102.145
    interface1      : gi0/1
      MAC           : 0001.7a54.5d71
      role          : primary
      block-status    : unblock
      link-status     : UP
    interface2      : gi0/2
      MAC           : 0001.7a54.5d71
      role          : second
      block-status    : unblock
```

link-status : UP

78.3.3 Configure the Intersecting Rings in EIPS Subring Mode

Network Requirements

- There are six devices within the LAN, which make up two levels of intersecting rings. Protect the ring network by configuring EIPS subring mode to block the slave port gigabitethernet0/2 of main ring's master node Master and the slave port gigabitethernet0/2 of subring's master node sMaster.
- When the link between the main ring's transmission nodes Transit1 and Transit2 is disconnected, it can cancel the spanning tree blocking state of the slave port gigabitethernet0/2 of the main ring's master node Master so that data switch and the communication in the main ring Ring1 are not affected.
- When the link between subring's transmission node sTransit1 and main ring's transmission node Transit2 is disconnected, it can cancel the spanning tree blocking state of the slave port of subring's master node of sMaster gigabitethernet0/2 so that data switch and the communication in subring Ring2 are not affected.

Network Topology

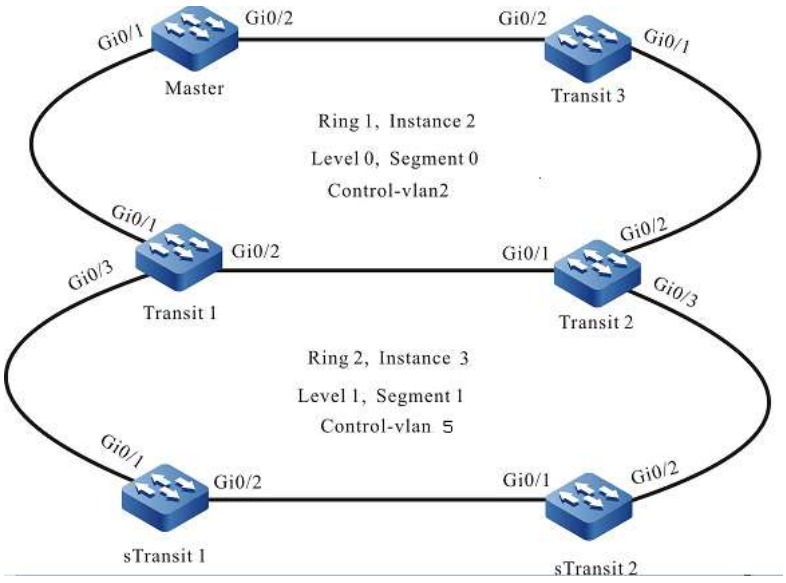


Figure 4 Network Topology for Configuring Intersecting Rings in EIPS Subring Mode

Configuration Steps

Step 1: Configure VLANs, and configure the link type of the ports.

#On Master, create VLAN2~VLAN3, and configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN2-VLAN3 to pass. Configure PVID as 1.

```
Master#configure terminal
Master(config)#vlan 2-4
Master(config)#interface gigabitethernet 0/1-0/2
Master(config-if-range)#switchport mode trunk
Master(config-if-range)#switchport trunk allowed vlan add 2-3
Master(config-if-range)#switchport trunk pvid vlan 1
```

#On Master, map VLAN3 to the spanning tree instance 2, and close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2.

```
Master (config)#spanning-tree mst configuration
%Alert: Commands configured under the mode would not take effect immediately, you should active them explicitly!
Master (config-mst)#instance 2 vlan 3
Master (config-mst)#active configuration pending
Master(config-if-range)#exit
Master(config)#interface gigabitethernet 0/1-0/2
Master(config-if-range)#no spanning-tree enable
Master(config-if-range)#no storm-control multicast
Master(config-if-range)#no storm-control unicast
Master(config-if-range)#no storm-control broadcast
Master(config-if-range)#exit
```

#On the transmission node Transit1 of the main ring, create VLAN2-5, map VLAN3 to the spanning tree instance 2 and VLAN4 to the spanning tree instance 3, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk to permit services of VLAN2-3 to pass and that of ports gigabitethernet0/2~gigabitethernet0/3 as Trunk to permit services of VLAN4-5 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/3. (Omitted)

#On the transmission node Transit2 of the main ring, create VLAN2-5, map VLAN3 to the spanning tree instance 2 and VLAN4 to the spanning tree instance 3, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk to permit services of VLAN2-3 to pass and that of ports gigabitethernet0/2~gigabitethernet0/3 as Trunk to permit services of VLAN4-5 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/3. (Omitted)

#On the transmission node Transit3 of the main ring, create VLAN2 and VLAN3, map VLAN3 to the spanning tree instance 2, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN3 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

#On the transmission node sTransit1 of the first level of subring, create VLAN4 and VLAN5, map VLAN4 to the spanning tree instance 3, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN4 and VLAN5 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

#On the transmission node Transit2 of the first level of subring, create VLAN4 and VLAN5, map VLAN4 to the spanning tree instance 3, configure the link type of ports gigabitethernet0/1~gigabitethernet0/2 as Trunk, permitting services of VLAN4 and VLAN5 to pass, and configure PVID as 1. Close spanning tree and storm suppression functions on ports gigabitethernet0/1~gigabitethernet0/2. (Omitted)

Note

- VLAN2 is a control VLAN of main ring and VLAN5 is a control VLAN of subring, used to transmit EIPS protocol packets; VLAN3-4 are data VLANs used to forward services.
- To use the EIPS function, you must map the EIPS data VLAN to corresponding spanning tree instance, and disable spanning tree and storm suppression functions on the port.

Step 2: Configure the main ring Ring1.

#On the master node Master, create master node Ring1 in subring mode, configure the level of EIPS ring as 0, domain of EIPS ring as 1, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Master(config)#eips ring 1 master
Master(config-eips)#control vlan 2
Master(config-eips)#level 0
Master(config-eips)#domain id 1
Master(config-eips)#instance 2
Master(config-eips)#primary interface gigabitethernet 0/1
Master(config-eips)#secondary interface gigabitethernet 0/2
Master(config-eips)#eips start
Master(config-eips)#exit
```

#On the transmission node Transit1 of the main ring, create transmission node Ring1 in subring mode, configure the level of EIPS ring as 0, domain of EIPS ring as 1, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Transit1(config)#eips ring 1 transit
Transit1(config-eips)#instance 2
Transit1(config-eips)#control vlan 2
Transit1(config-eips)#domain id 1
```

```
Transit1(config-eips)#level 0
Transit1(config-eips)#primary interface gigabitethernet0/1
Transit1(config-eips)#secondary interface gigabitethernet0/2
Transit1(config-eips)#eips start
Transit1(config-eips)#exit
```

#On the transmission node Transit2 of the main ring, create transmission node Ring1 in subring mode, configure the level of EIPS ring as 0, domain of EIPS ring as 1, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Transit2(config)#eips ring 1 transit
Transit2(config-eips)#instance 2
Transit2(config-eips)#domain id 1
Transit2(config-eips)#control vlan 2
Transit2(config-eips)#level 0
Transit2(config-eips)#primary interface gigabitethernet0/1
Transit2(config-eips)#secondary interface gigabitethernet0/2
Transit2(config-eips)#eips start
Transit2(config-eips)#exit
```

#On the transmission node Transit3 of the main ring, create transmission node Ring1 in subring mode, configure the level of EIPS ring as 0, domain of EIPS ring as 1, instance of EIPS ring as 2, control VLAN as VLAN2, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
Transit3(config)#eips ring 1 transit
Transit3(config-eips)#control vlan 2
Transit3(config-eips)#level 0
Transit3(config-eips)#domain id 1
Transit3(config-eips)#instance 2
Transit3(config-eips)#primary interface gigabitethernet 0/1
Transit3(config-eips)#secondary interface gigabitethernet 0/2
Transit3(config-eips)#eips start
Transit3(config-eips)#exit
```

Step 3: Configure the subring Ring2.

#On the edge node of the subring (transmission node of the main ring), create edge node Ring2 of subring mode on Transit1, configure the level and domain of EIPS ring as 1, instance of EIPS ring as 3, control VLAN as VLAN5, edge port as gigabitethernet0/3 and Ring1 as its associated transmission node, and enable EIPS.

```
Transit1(config)#eips ring 2 edge
Transit1(config-eips)#control vlan 5
Transit1(config-eips)#level 1
Transit1(config-eips)#domain id 1
```

```
Transit1(config-eips)#instance 3
Transit1(config-eips)#transit ring 1
Transit1(config-eips)#edge interface gigabitethernet0/3
Transit1(config-eips)#eips start
Transit1(config-eips)#exit
```

#On the assistant edge node of the subring (transmission node of the main ring), create assistant edge node Ring2 of subring mode on Transit2, configure the level and domain of EIPS ring as 1, instance of EIPS ring as 3, control VLAN as VLAN5, edge port as gigabitethernet0/3 and Ring1 as its associated transmission node, and enable EIPS.

```
Transit2(config)#eips ring 2 assistant
Transit2(config-eips)#control vlan 5
Transit2(config-eips)#level 1
Transit2(config-eips)#domain id 1
Transit2(config-eips)#instance 3
Transit2(config-eips)#transit ring 1
Transit2(config-eips)#edge interface gigabitethernet0/3
Transit2(config-eips)#eips start
Transit2(config-eips)#exit
```

#On the master node sMaster of the subring, create master node Ring2 in subring mode, configure the level and domain of EIPS ring as 1, instance of EIPS ring as 3, control VLAN as VLAN5, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
sMaster(config)#eips ring 2 master
sMaster(config-eips)#level 1
sMaster(config-eips)#domain id 1
sMaster(config-eips)#instance 3
sMaster(config-eips)#control vlan 5
sMaster(config-eips)#primary interface gigabitethernet 0/1
sMaster(config-eips)#secondary interface gigabitethernet 0/2
sMaster(config-eips)#eips start
sMaster(config-eips)#exit
```

#On the transmission node sTransit1 of the subring, create transmission node Ring2 in subring mode, configure the level and domain of EIPS ring as 1, instance of EIPS ring as 3, control VLAN as VLAN5, master port as gigabitethernet0/1 and slave port as gigabitethernet0/2, and enable EIPS.

```
sTransit1(config)#eips ring 2 transit
sTransit1(config-eips)#control vlan 5
sTransit1(config-eips)#level 1
sTransit1(config-eips)#domain id 1
sTransit1(config-eips)#instance 3
sTransit1(config-eips)#primary interface gigabitethernet 0/1
```

```
sTransit1(config-eips)#secondary interface gigabitethernet 0/2
sTransit1(config-eips)#eips start
sTransit1(config-eips)#exit
```

Step 4: Check the result.

#By executing show eips topology-summary on edge node and assistant edge node, you can see that the status of both EIPS main ring and subring is round, and the topology content is consistent.

```
Transit1#show eips topology-summary
 ring ID     : 1
 topo status  : round
 seq  host-name       mac            type      interface1        link    interface2        link    isBorder
 ---------------------------------------------------------------------------------------------------------------
 1    Transit2        0001.7a22.2224  transit   gi0/1             UP      gi0/2             UP      YES
 2    Transit3         0000.0000.008b  transit    gi0/1            UP      gi0/2             UP      NO
 3    Master          0014.0000.1202  master    gi0/2             UP      gi0/1             UP      NO
 4    Transit1        0001.7a54.5d71  transit   gi0/1             UP      gi0/2             UP      YES

 ring ID     : 2
 topo status  : round
 seq  host-name       mac            type      interface1        link    interface2        link    isBorder
 ---------------------------------------------------------------------------------------------------------------
 1    Transit2        0001.7a22.2224  assistant ----              ----    gi0/3             UP      NO
 2    sTransit1       2012.1209.1728  transit   gi0/2             UP      gi0/1             UP      NO
 3    sMaster         0000.0010.0017  master    gi0/2             UP      gi0/1             UP      NO
 4    Transit1        0001.7a54.5d71  edge      gi0/3             UP      ----              ----    NO

Transit2#show eips topology-summary
 ring ID     : 1
 topo status  : round
 seq  host-name       mac            type      interface1        link    interface2        link    isBorder
 ---------------------------------------------------------------------------------------------------------------
 1    Transit3         0000.0000.008b  transit    gi0/1            UP      gi0/2             UP      NO
 2    Master          0014.0000.1202  master    gi0/2             UP      gi0/1             UP      NO
 3    Transit1        0001.7a54.5d71  transit   gi0/1             UP      gi0/2             UP      YES
 4    Transit2        0001.7a22.2224  transit   gi0/1             UP      gi0/2             UP      YES

 ring ID     : 2
 topo status  : round
```

```
seq  host-name      mac           type      interface1       link    interface2       link    isBorder
-------------------------------------------------------------------------------------------------------------
1    Transit1       0001.7a54.5d71  edge      ----             ----    gi0/3            UP      NO
2    sMaster        0000.0010.0017  master    gi0/1            UP      gi0/2            UP      NO
3    sTransit1      2012.1209.1728  transit   gi0/1            UP      gi0/2            UP      NO
4    Transit2       0001.7a22.2224  assistant gi0/3            UP      ----             ----    NO
```

#By executing show eips topology on the edge node, you can see that the slave port gigabitethernet0/2 of the main ring's master node Master and the slave port gigabitethernet0/2 of the subring's master node sMaster are blocked, and all other ports are unblocked; the EIPS status of main ring's master node Master and subring's master node sMaster is COMPLETE, and that of all other nodes is LINK-UP.

```
Transit1#show eips topology
ring ID     : 1
topo status  : round
topo index 1   :
      host name      : Transit2
      eips type      : transit
      eips status    : LINK-UP
      border         : YES
      base MAC       : 0001.7a22.2224
      sys oid        : 1.3.6.1.4.1.5651.1.0.0
      interface1     : gi0/1
       MAC           : 0001.7a22.2224
       role          : primary
       block-status    : unblock
       link-status     : UP
      interface2     : gi0/2
       MAC           : 0001.7a22.2224
       role          : second
       block-status    : unblock
       link-status     : UP
topo index 2   :
      host name      : Transit3
      eips type      : transit
      eips status    : LINK-UP
      border         : NO
      base MAC       : 0000.0000.008b
      sys oid        : 1.3.6.1.4.1.5651.1.102.146
      interface1     : gi0/1
       MAC           : 0000.0000.008b
       role          : primary
```

```
        block-status    : unblock
        link-status     : UP
      interface2      : gi0/2
        MAC             : 0000.0000.008b
        role            : second
        block-status    : unblock
        link-status     : UP
topo index 3   :
      host name       : Master
      eips type       : master
      eips status     : COMPLETE
      border          : NO
      base MAC        : 0014.0000.1202
      sys oid         : 1.3.6.1.4.1.5651.1.102.127
      interface1      : gi0/2
        MAC             : 0014.0000.1202
        role            : second
        block-status    : block
        link-status     : UP
      interface2      : gi0/1
        MAC             : 0014.0000.1202
        role            : primary
        block-status    : unblock
        link-status     : UP
topo index 4   :
      host name       : Transit1
      eips type       : transit
      eips status     : LINK-UP
      border          : YES
      base MAC        : 0001.7a54.5d71
      sys oid         : 1.3.6.1.4.1.5651.1.102.145
      interface1      : gi0/1
        MAC             : 0001.7a54.5d71
        role            : primary
        block-status    : unblock
        link-status     : UP
      interface2      : gi0/2
        MAC             : 0001.7a54.5d71
        role            : second
        block-status    : unblock
```

```
        link-status     : UP


ring ID     : 2
topo status  : round
topo index 1   :
      host name      : Transit2
      eips type      : assistant
      eips status    : LINK-UP
      border         : NO
      base MAC       : 0001.7a22.2224
      sys oid        : 1.3.6.1.4.1.5651.1.0.0
      interface2     : gi0/3
       MAC           : 0001.7a22.2224
       role          : edge
       block-status    : unblock
       link-status     : UP
topo index 2   :
      host name      : sTransit1
      eips type      : transit
      eips status    : LINK-UP
      border         : NO
      base MAC       : 2012.1209.1728
      sys oid        : 1.3.6.1.4.1.5651.1.102.126
      interface1     : gi0/2
       MAC           : 2012.1209.1728
       role          : second
       block-status    : unblock
       link-status     : UP
      interface2     : gi0/1
       MAC           : 2012.1209.1728
       role          : primary
       block-status    : unblock
       link-status     : UP
topo index 3   :
      host name      : sMaster
      eips type      : master
       eips status    : COMPLETE
      border         : NO
      base MAC       : 0000.0010.0017
      sys oid        : 1.3.6.1.4.1.5651.1.102.140
```

```
    interface1      : gi0/2
    MAC             : 0000.0010.0017
    role            : second
    block-status    : block
    link-status     : UP
  interface2        : gi0/1
    MAC             : 0000.0010.0017
    role            : primary
    block-status    : unblock
    link-status     : UP
topo index 4   :
  host name         : Transit1
  eips type         : edge
  eips status       : LINK-UP
  border            : NO
  base MAC          : 0001.7a54.5d71
  sys oid           : 1.3.6.1.4.1.5651.1.102.145
  interface1        : gi0/3
    MAC             : 0001.7a54.5d71
    role            : edge
    block-status    : unblock
    link-status     : UP
```

#When the link between transmission nodes of the main ring Transit1 and Transit2 is disconnected, you can see on the edge node with show eips topology that the status of main ring Ring1 is not round, EIPS status of Transit1 and Transit2 becomes LINK-DOWN, EIPS status of the main ring's master node Master becomes FAULT, slave port gigabitethernet0/2 of the main ring's master node Master is unblocked, and Transit1 can communicate with Transit2 through the main ring's master node Master to ensure the communication between Transit1 and Transit2 is uninterrupted; the status of subring Ring2 is still round, the EIPS status of subring's master node sMaster is still COMPLETE, and the slave port gigabitethernet0/2 of subring's master node sMaster is still blocked.

```
Transit1#show eips topology ring 1
ring ID     : 1
topo status  : not round
topo index 1   :
  host name         : Transit2
  eips type         : transit
  eips status       : LINK-DOWN
  border            : YES
  base MAC          : 0001.7a22.2224
  sys oid           : 1.3.6.1.4.1.5651.1.0.0
```

```
        interface1      : gi0/1
         MAC            : 0001.7a22.2224
         role           : primary
         block-status   : block
         link-status    : DOWN
        interface2      : gi0/2
         MAC            : 0001.7a22.2224
         role           : second
         block-status   : unblock
         link-status    : UP
topo index 2   :
        host name       : Transit3
        eips type       : transit
         eips status    : LINK-UP
        border          : NO
        base MAC        : 0000.0000.008b
        sys oid         : 1.3.6.1.4.1.5651.1.102.146
        interface1      : gi0/1
         MAC            : 0000.0000.008b
         role           : primary
         block-status   : unblock
         link-status    : UP
        interface2      : gi0/2
         MAC            : 0000.0000.008b
         role           : second
         block-status   : unblock
         link-status    : UP
topo index 3   :
        host name       : Master
        eips type       : master
        eips status     : FAULT
        border          : NO
        base MAC        : 0014.0000.1202
        sys oid         : 1.3.6.1.4.1.5651.1.102.127
         interface1     : gi0/2
         MAC            : 0014.0000.1202
         role           : second
         block-status   : unblock
         link-status    : UP
        interface2      : gi0/1
```

```
        MAC           : 0014.0000.1202
        role          : primary
        block-status  : unblock
        link-status   : UP
    topo index 4   :
      host name     : Transit1
      eips type     : transit
      eips status   : LINK-DOWN
      border        : YES
      base MAC      : 0001.7a54.5d71
      sys oid       : 1.3.6.1.4.1.5651.1.102.145
      interface1    : gi0/1
        MAC         : 0001.7a54.5d71
        role        : primary
        block-status  : unblock
        link-status   : UP
      interface2    : gi0/2
        MAC         : 0001.7a54.5d71
        role        : second
        block-status  : block
        link-status   : DOWN

Transit1#show eips topology ring 2
 ring ID     : 2
 topo status  : round
 topo index 1   :
      host name     : Transit2
      eips type     : assistant
      eips status   : LINK-UP
      border        : NO
      base MAC      : 0001.7a22.2224
      sys oid       : 1.3.6.1.4.1.5651.1.0.0
      interface2    : gi0/3
        MAC         : 0001.7a22.2224
        role        : edge
        block-status  : unblock
        link-status   : UP
    topo index 2   :
      host name     : sTransit1
      eips type     : transit
```

```
    eips status     : LINK-UP
    border          : NO
    base MAC        : 2012.1209.1728
    sys oid         : 1.3.6.1.4.1.5651.1.102.126
    interface1      : gi0/2
      MAC           : 2012.1209.1728
      role          : second
      block-status  : unblock
      link-status   : UP
    interface2      : gi0/1
      MAC           : 2012.1209.1728
      role          : primary
      block-status  : unblock
      link-status   : UP
topo index 3   :
    host name       : sMaster
    eips type       : master
    eips status     : COMPLETE
    border          : NO
    base MAC        : 0000.0010.0017
    sys oid         : 1.3.6.1.4.1.5651.1.102.140
    interface1      : gi0/2
      MAC           : 0000.0010.0017
      role          : second
      block-status  : block
      link-status   : UP
    interface2      : gi0/1
      MAC           : 0000.0010.0017
      role          : primary
      block-status  : unblock
      link-status   : UP
topo index 4   :
    host name       : Transit1
    eips type       : edge
    eips status     : LINK-UP
    border          : NO
    base MAC        : 0001.7a54.5d71
    sys oid         : 1.3.6.1.4.1.5651.1.102.145
    interface1      : gi0/3
      MAC           : 0001.7a54.5d71
```

```
role          : edge
block-status    : unblock
link-status     : UP
```

#When only the link between the subring's transmission node sTransit1 and the assistant edge node Transit2 is disconnected, you can see on the edge node Transit1 and assistant edge node Transit2 with show eips topology that the status of subring Ring2 is not round, EIPS status of subring's master node sMaster becomes FAULT, slave port gigabitethernet0/2 of the subring's master node sMaster is unblocked, and sTransit1 can communicate with Transit2 through the subring's master node sMaster to ensure the communication between sTransit1 and Transit2 is uninterrupted; the status of main ring Ring1 is still round, the EIPS status is still COMPLETE, and the slave port gigabitethernet0/2 of master node Master is still blocked.

```
Transit1#show eips topology ring 2
ring ID     : 2
topo status  : not round
topo index 1   :
      host name      : sTransit1
      eips type      : transit
      eips status    : LINK-DOWN
      border         : NO
       base MAC       : 2012.1209.1728
      sys oid        : 1.3.6.1.4.1.5651.1.102.126
      interface1     : gi0/2
        MAC           : 2012.1209.1728
       role          : second
       block-status    : block
       link-status     : DOWN
      interface2     : gi0/1
       MAC           : 2012.1209.1728
       role          : primary
       block-status    : unblock
       link-status     : UP
topo index 2   :
      host name      : sMaster
      eips type      : master
      eips status    : FAULT
      border         : NO
      base MAC       : 0000.0010.0017
      sys oid        : 1.3.6.1.4.1.5651.1.102.140
       interface1     : gi0/2
       MAC           : 0000.0010.0017
```

```
        role          : second
        block-status    : unblock
        link-status     : UP
      interface2      : gi0/1
        MAC           : 0000.0010.0017
        role          : primary
        block-status    : unblock
        link-status     : UP
topo index 3   :
    host name       : Transit1
    eips type       : edge
     eips status     : LINK-UP
    border          : NO
    base MAC        : 0001.7a54.5d71
    sys oid         : 1.3.6.1.4.1.5651.1.102.145
    interface1      : gi0/3
      MAC           : 0001.7a54.5d71
      role          : edge
      block-status    : unblock
      link-status     : UP
Transit2#show eips topology ring 2
ring ID     : 2
topo status  : not round
topo index 1   :
    host name       : Transit2
    eips type       : assistant
    eips status     : LINK-DOWN
    border          : NO
    base MAC        : 0001.7a22.2224
    sys oid         : 1.3.6.1.4.1.5651.1.0.0
    interface1      : gi0/3
      MAC           : 0001.7a22.2224
      role          : edge
      block-status    : block
      link-status     : DOWN
Transit1#show eips topology ring 1
ring ID     : 1
topo status  : round
topo index 1   :
    host name       : Transit2
```

```
    eips type       : transit
    eips status     : LINK-UP
    border          : YES
    base MAC        : 0001.7a22.2224
    sys oid         : 1.3.6.1.4.1.5651.1.0.0
    interface1      : gi0/1
     MAC            : 0001.7a22.2224
     role           : primary
     block-status   : unblock
     link-status    : UP
    interface2      : gi0/2
     MAC            : 0001.7a22.2224
     role           : second
     block-status   : unblock
     link-status    : UP
topo index 2   :
    host name       : Transit3
    eips type       : transit
    eips status     : LINK-UP
    border          : NO
    base MAC        : 0000.0000.008b
    sys oid         : 1.3.6.1.4.1.5651.1.102.146
    interface1      : gi0/1
     MAC            : 0000.0000.008b
     role           : primary
     block-status   : unblock
     link-status    : UP
    interface2      : gi0/2
     MAC            : 0000.0000.008b
     role           : second
     block-status   : unblock
     link-status    : UP
topo index 3   :
    host name       : Master
    eips type       : master
    eips status     : COMPLETE
    border          : NO
    base MAC        : 0014.0000.1202
    sys oid         : 1.3.6.1.4.1.5651.1.102.127
    interface1      : gi0/2
```

```
        MAC           : 0014.0000.1202
        role          : second
        block-status  : block
        link-status   : UP
      interface2      : gi0/1
        MAC           : 0014.0000.1202
        role          : primary
        block-status  : unblock
        link-status   : UP
topo index 4  :
    host name       : Transit1
    eips type       : transit
    eips status     : LINK-UP
    border          : YES
    base MAC        : 0001.7a54.5d71
    sys oid         : 1.3.6.1.4.1.5651.1.102.145
    interface1      : gi0/1
      MAC           : 0001.7a54.5d71
      role          : primary
      block-status  : unblock
      link-status   : UP
    interface2      : gi0/2
      MAC           : 0001.7a54.5d71
      role          : second
      block-status  : unblock
      link-status   : UP
```

79 ULPP and Monitor Link

79.1 Overview

Dual-uplink networking mode is one of the frequently-used networking modes in core networks. This networking mode improves network reliability through redundant link. Generally, STP is used to remove redundant links. However, the convergence time of STP cannot meet the requirement of carrier Ethernet. In this circumstance, ULPP (UpLink Protect Protocol) was born.

ULPP means UpLink Protect Protocol. In addition to satisfying users' requirement for fast convergence of link, it achieves redundant backup of host and backup links and rapid switch of traffic, and effectively simplifies the configuration, making both deployment and maintenance more convenient and improving the working efficiency of deployment and maintenance staff.

Monitor Link provides coordination management technology for changes of link status. There are multiple uplink ports and multiple downlink ports in Monitor Link group. The uplink ports are monitored in real time. When their status changes, the downlink ports are coordinated to quickly notify the status of uplink device port to downlink device. This can help STP, ULPP and other modules rapidly respond to network changes and traffic switch.

79.2 ULPP Function Configuration

Table 79 ULPP Function Configuration List

Configuration Task	
Configure Basic Functions of ULPP	Configure ULPP Group
	Configure Uplink Port of ULPP
Configure ULPP Compatible Mode	Configure Compatible Mode of ULPP Group

Configuration Task	
	Configure Compatible Mode of ULPP Uplink Port
Configure Basic Functions of Monitor Link	Configure Monitor Link Group

79.2.1 Configure Basic Functions of ULPP

Configuration Condition

Before configuring the basic functions of ULPP, first complete the following tasks:

- Configure the spanning tree instance mapping relationship of ULPP group;
- This VLAN has been created when the control VLAN of ULPP group is configured;
- The member ports in ULPP group must be added to the VLAN.

Configure ULPP Group

There are two ports in ULPP group, i.e. master port and backup port. The ULPP group has two working modes: link backup and load sharing. In link backup mode, either master or backup port in the ULPP group can be in forwarding status, and the other is blocked, in standby state. When the port in normal forwarding status has any link failure, the ULPP group will automatically block this port, and switch the status of the originally blocked standby port to forwarding. In the load sharing mechanism, the ULPP group carries spanning tree instance traffic in different VLANs according to the binding relationship between the spanning tree instance configured on the master/backup port and the port.

Table 79 Configuring ULPP Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create ULPP group and enter the ULPP configuration mode	**ulpp-group** *group-id*	Mandatory By default, ULPP group is not created.
Configure the master port of ULPP group	**master** { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Mandatory

Step	Command	Description
		By default, master port of the ULPP group is not configured.
Configure backup port of ULPP group	**slave** { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Mandatory By default, backup port of the ULPP group is not configured.
Configure the stance carried by ULPP group	**instance group** *instance-number* { **master** | **slave** }	Mandatory By default, the stance carried by ULPP group is not configured. The spanning tree instances carried by master port and backup port shall not intersect with each other.
Configure the control VLAN of ULPP group	**control-vlan** *vlan-id*	Mandatory By default, control VLAN of the ULPP group is not configured.
Configure ULPP group enablement	**enable**	Mandatory By default, ULPP group enablement is not configured.
Enable the FLUSH packet sending function of ULPP group	**flush enable**	Optional By default, the FLUSH packet sending function of ULPP group is not enabled.
Configure the working mode of ULPP group	**mode** { **load-balance** | **backup** }	Optional By default, the ULPP group is in master/backup mode.
Configure role preemption	**preemption mode role**	Optional

Step	Command	Description
function for ULPP group		By default, the role preemption of ULPP group is not configured. Only when the working mode of ULPP group is link backup will the role preemption function be configured.

Note

- EIPS, STP and loopback detection functions must be disabled on the member ports of ULPP group.
- The member ports of ULPP group shall not be those of the ULPP group and Monitor Link group that have existed.
- The control VLAN in ULPP group shall not be used to forward service data.
- One ULPP group has one control VLAN only, and one control VLAN belongs to one ULPP group only.
- After the ULPP group is disabled, member ports are all blocked in all spanning tree instances.
- It is recommended that the instance should be referenced when the spanning tree mode is mstp. Otherwise, the ULPP protocol may become invalid.

Configure Uplink Port of ULPP

When the ULPP group has link switch, the ULPP group notifies other devices to refresh their address tables by sending FLUSH packet to them so as to ensure the rapid switch of service traffic in the network. In addition to receiving FLUSH packet, the uplink port forwards FLUSH packet within the control VLAN of the device.

Table 1 Configuring Control VLAN for Uplink Port of ULPP Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the port configuration mode	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure control VLAN for uplink port of ULPP group	**ulpp flush control-vlan** *vlan-list*	Mandatory By default, the control VLAN for uplink port of ULPP group is not configured.

79.2.2 Configure ULPP Compatible Mode

Configuration Condition

Before configuring ULPP compatible mode, ensure that:

- To configure ULPP compatible mode, basic functions of ULPP group need to be configured;
- To configure the ULPP uplink port configuration mode, the control VLAN of ULPP uplink port needs to be configured first.

Configure Compatible Mode of ULPP Group

ULPP group has three compatible modes, i.e. flexlink, smartlink, and smartlink multicast-mode.

Table 2 Configuring Compatible Mode of ULPP Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the ULPP configuration mode	**ulpp-group** *group-id*	-
Configure Compatible Mode of ULPP Group	**compatible** { **flexlink** | **smartlink** | **smartlink multicast-mode** }	Mandatory By default, the compatible mode

Step	Command	Description
		of ULPP group is not configured.

Configure Compatible Mode of ULPP Uplink Port

ULPP uplink port has three compatible modes, i.e. flexlink, smartlink, and smartlink multicast-mode.

Table 3 Configuring Compatible Mode of ULPP Uplink Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure compatible mode of ULPP uplink port	**ulpp compatible** { **flexlink** | **smartlink** | **smartlink multicast-mode** }	Mandatory By default, the compatible mode for uplink port of ULPP group is not configured.

Note

- Compatible mode can be configured only when the spanning tree of uplink port in ULPP group is closed.

79.2.3 Configure Basic Functions of Monitor Link Group

Configuration Condition

None

Configure Monitor Link Group

The Monitor Link group may have multiple uplink ports, such as general port, member port of aggregation group, aggregation group, VSL port or ULPP group. The Monitor Link group may have multiple downlink ports, such as general port, member port of aggregation group, and aggregation group. But ULPP group cannot serve as a downlink port.

Table 4 Configuring Creation of Monitor Link

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create Monitor Link group and enter the Monitor Link configuration mode	**mtlk-group** *group-id*	Mandatory By default, Monitor Link group is not created.
Configure the uplink port of Monitor Link group	**uplink** { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* | **ulpp-group** *group-id* }	Optional By default, uplink port of Monitor Link group is not configured.
Configure the downlink port of Monitor Link group	**downlink** { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Optional By default, downlink port of Monitor Link group is not configured.

79.2.4 ULPP Monitoring and Maintaining

Table 5 ULPP Monitoring and Maintaining

Command	Description
clear ulpp message flush { **receive | send group** *group-id* | **transmit** }	Clear the statistics of FLUSH packets of ULPP group
show ulpp group *group-id*	Show the configurations of ULPP group
show ulpp instance group *group-id*	Show the status of the spanning tree carried by master/backup member port in ULPP group
show ulpp message flush { **send group** *group-id* | **receive | transmit** }	Show the statistics of FLUSH packets processed by ULPP group
show ulpp assi	Show the configurations of uplink port of ULPP group
show mtlk group *group-id*	Show the configurations of Monitor Link group

79.3 Typical Configuration Example of ULPP and Monitor Link

79.3.1 Configure ULPP

Network Requirements

- Four devices constitute a dual-uplink network. In particular, uplink devices include Device1, Device2, and Device3, and Device4 is a downlink device.
- ULPP function is configured for the downlink device so that the port can normally carry or switch the services in associated spanning tree instance.

Network Topology

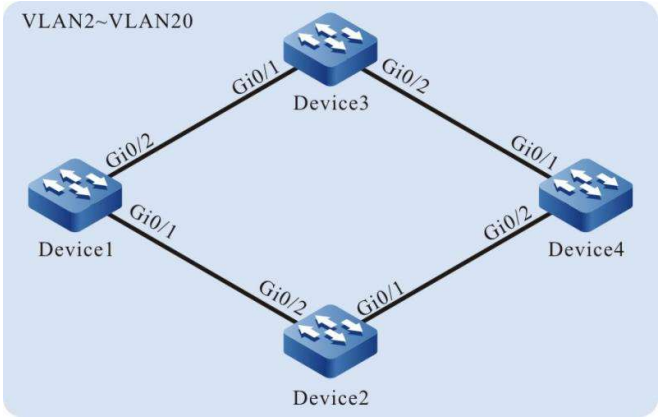


Figure 79 Configuring Network Topology of ULPP

Configuration Steps

Step 1: Configure VLANs and the link type of the ports.

#On Device1, create VLAN2-VLAN20, and configure the link type of ports gigabiteternet0/1 and gigabiteternet0/2 as Trunk to allow services of VLAN2-VLAN20 to pass.

```
Device1#configure terminal
Device1(config)#vlan 2-20
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#switchport mode trunk
Device1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2-20
Device1(config-if-gigabitethernet0/1)#exit
Device1(config)#interface gigabitethernet 0/2
Device1(config-if-gigabitethernet0/2)#switchport mode trunk
Device1(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2-20
Device1(config-if-gigabitethernet0/2)#exit
```

Note

- The VLAN and configuration of port link type on Device2, Device3, and Device 4 are the same as those on Device1. (Omitted)

Step 2: #Configure spanning tree instance on Device4.

#Configure spanning tree instance. Map instance 1 to VLAN3~VLAN10 and instance 2 to VLAN11~VLAN20.

```
Device4(config)#spanning-tree mst configuration
Device4(config-mst)#region-name admin
Device4(config-mst)#revision-level 1
Device4(config-mst)#instance 1 vlan 3-10
Device4(config-mst)#instance 2 vlan 11-20
```

#Enable the spanning tree instance.

```
Device4(config-mst)#active configuration pending
Device4(config-mst)#exit
```

Step 3: #Configure ULPP function on Device4.

#Create ULPP group.

```
Device4(config)#ulpp-group 1
```

#Configure the master port gigabitethernet0/1 and slave port gigabitethernet0/2 of ULPP group.

```
Device4(config-ulpp-1)#master interface gigabitethernet 0/1
Device4(config-ulpp-1)#slave interface gigabitethernet 0/2
```

#Configure associated spanning tree instance 1 of master port gigabitethernet0/1 and associated spanning tree instance 2 of slave port gigabitethernet0/2.

```
Device4(config-ulpp-1)#instance group 1 master
Device4(config-ulpp-1)#instance group 2 slave
```

#Configure the working mode of ULPP group as link backup.

```
Device4(config-ulpp-1)#mode backup
```

#Configure the control VLAN of ULPP group as VLAN2.

```
Device4(config-ulpp-1)#control-vlan 2
```

#Enable the Flush packet sending mechanism of ULPP.

```
Device4(config-ulpp-1)#flush enable
```

#Enable ULPP group.

```
Device4(config-ulpp-1)#enable
Device4(config-ulpp-1)#exit
```

Note

- After VLAN2 is configured as a control VLAN, it only permits Flush packet to pass.

Step 4: Configure uplink devices Device1, Device2, and Device3.

#Configure Flush packet receiving and forwarding mechanism on Device1.

```
Device1(config)#interface gigabitethernet 0/1-0/2
Device1(config-if-range)#ulpp flush control-vlan 2
Device1(config-if-range)#exit
```

Note

- The packet receiving and sending mechanism of Device2 and Device3, is the same as that of Device1. (Omitted)

Step 5: Check the results.

#View the status of ULPP group on Device4.

```
Device4#show ulpp group 1
---------------------------------------
ulpp-group 1 configuration information
---------------------------------------
Current status          : MASS
Work type               : Backup
Control vlan            : 2
Flush function          : Enable
Preemtion mode          : Disable
Master interface name       : gi0/1
Slave interface name        : gi0/2
Master interface status     : Active
Slave interface status      : Standby
Master interface instance   : 1
Slave interface instance    : 2
Flexlink compatible         : Disable
Smartlink compatible        : Disable
Smartlink mcast compatible  : Disable
Enable status           : Enable
```

#On Device4, view the status of associated spanning tree instances of master and slave ports.

```
Device4#show ulpp instance group 1
---------------------------------------
ulpp-group 1 instance status
---------------------------------------
Master forwarding instance  : 1-2
Master block instance       : None
Slave  forwarding instance  : None
Slave  block instance       : 1-2
```

#When the port gigabitethernet0/1 of Device4 fails, the status of ULPP group will be switched. View the status of ULPP group on Device4.

```
Device4#show ulpp group 1
----------------------------------------
ulpp-group 1 configuration information
----------------------------------------
Current status              : MNSA
Work type                   : Backup
Control vlan                : 2
Flush function              : Enable
Preemtion mode              : Disable
Master interface name       : gi0/1
Slave interface name        : gi0/2
Master interface status     : Down
Slave interface status      : Active
Master interface instance   : 1
Slave interface instance    : 2
Flexlink compatible         : Disable
Smartlink compatible        : Disable
Smartlink mcast compatible  : Disable
Enable status               : Enable
```

The master port gigabitethernet0/1 changes from Active to Down, and the slave port gigabitethernet0/2 changes from Standby to Active. The services in spanning tree instance are normally forwarded through gigabitethernet0/2.

#The uplink devices Device1 and Device2 will print the following information.

```
19:26:10: [tUlpp]%ULPP-ASSI: Receive flush message from gigabitethernet0/2 success, the receive sequence number is 1, vlan id is 2
```

This is the information of Flush packet received by uplink devices Device1 and Device2 when the status of ULPP group changes.

79.3.2 Configure Monitor Link

Network Requirements

- Four devices constitute a dual-uplink network. In particular, uplink devices include Device1, Device2, and Device3, and Device4 is a downlink device.
- Configure the Monitor Link function on Device3 to achieve link status monitoring.
- When the uplink port of Monitor Link group fails, the downlink port is closed, which

causes the ULPP group to switch between active and standby links to ensure network connectivity.

Network Topology

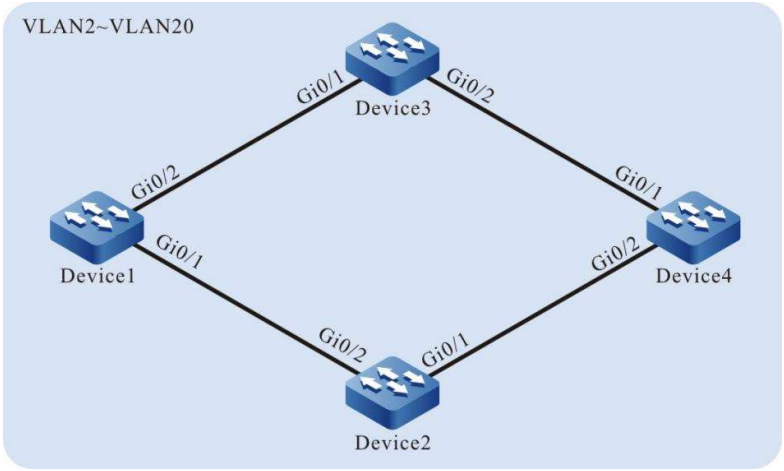


Figure 79 Configuring Network Topology of Monitor Link

Configuration Steps

Step 1: Configure VLANs and the link type of the ports.

#On Device1, create VLAN2-VLAN20, and configure the link type of ports gigabiteternet0/1 and gigabiteternet0/2 as Trunk to allow services of VLAN2-VLAN20 to pass.

```
Device1#configure terminal
Device1(config)#vlan 2-20
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#switchport mode trunk
Device1(config-if-gigabitethernet0/1)#switchport trunk allowed vlan add 2-20
Device1(config-if-gigabitethernet0/1)#exit
Device1(config)#interface gigabitethernet 0/2
Device1(config-if-gigabitethernet0/2)#switchport mode trunk
Device1(config-if-gigabitethernet0/2)#switchport trunk allowed vlan add 2-20
Device1(config-if-gigabitethernet0/2)#exit
```

Note

- The configuration of port and link type on Device2, Device3, and Device 4 is the same as that on Device1. (Omitted)

Step 2: #Configure spanning tree instance on Device4.

#Configure spanning tree instance. Map instance 1 to VLAN3~VLAN10 and instance 2 to VLAN11~VLAN20.

```
Device4(config)#spanning-tree mst configuration
Device4(config-mst)#region-name admin
Device4(config-mst)#revision-level 1
Device4(config-mst)#instance 1 vlan 3-10
Device4(config-mst)#instance 2 vlan 11-20
```

#Enable the spanning tree instance.

```
Device4(config-mst)#active configuration pending
Device4(config-mst)#exit
```

Step 3: #Configure ULPP function on Device4.

```
Device4(config)#ulpp-group 1
Device4(config-ulpp-1)#master interface gigabitethernet 0/1
Device4(config-ulpp-1)#slave interface gigabitethernet 0/2
Device4(config-ulpp-1)#instance group 1 master
Device4(config-ulpp-1)#instance group 2 slave
Device4(config-ulpp-1)#mode backup
Device4(config-ulpp-1)#control-vlan 2
Device4(config-ulpp-1)#flush enable
Device4(config-ulpp-1)#enable
Device4(config-ulpp-1)#exit
```

Note

- After VLAN2 is configured as a control VLAN, it only permits Flush packet to pass.

Step 4: Configure uplink devices Device1, Device2, and Device3.

#Configure Flush packet receiving and forwarding mechanism on Device1.

```
Device1(config)#interface gigabitethernet 0/1-0/2
Device1(config-if-range)#ulpp flush control-vlan 2
Device1(config-if-range)#exit
```

Note

- The packet receiving and sending mechanism of Device2 and Device3, is the same as that of Device1. (Omitted)

Step 5: Configure Monitor Link group.

#Configure Monitor Link group on Device3.

```
Device3(config)#mtlk-group 1
```

#On Device3, configure gigabitethernet0/1 as the uplink port of Monitor Link.

```
Device3(config-mtlk-1)#uplink interface gigabitethernet 0/1
```

#On Device3, configure gigabitethernet0/2 as the downlink port of Monitor Link.

```
Device3(config-mtlk-1)#downlink interface gigabitethernet 0/2
```

#View Monitor Link group.

```
Device3#show mtlk group 1
---------------------------------------
mtlk-group 1 configuration information
---------------------------------------
Uplink interface        : gi0/1
Uplink type             : no-ulpp
Uplink status           : up
Downlink interface      : gi0/2
```

Step 6: Check the result.

#When the uplink port gigabitethernet0/1 of the uplink device Device3 fails, the status of downlink port gigabitethernet0/2 coordinates with that of uplink port gigabitethernet 0/1, and the downlink port is forced to be closed.

#View the status of the downlink port gigabitethernet0/2.

```
Device3#show interface gigabitethernet 0/2
gigabitethernet0/2 configuration information
    Description     : downlink
    Status          : Enabled
    Link            : Down  (Err-disabled)
    Set Speed       : Auto
    Act Speed       : Unknown
```

```
Set Duplex       : Auto
Act Duplex       : Unknown
Set Flow Control : Off
Act Flow Control : Off
Mdix             : Auto
Mtu              : 1824
Port mode        : LAN
Port ability     : 10M HD,10M FD,100M HD,100M FD,1000M FD
Link Delay       : No Delay
Storm Control    : Unicast Disabled
Storm Control    : Broadcast Disabled
Storm Control    : Multicast Disabled
Storm Action     : None
Port Type        : Nni
Pvid             : 1
Set Medium       : Copper
Act Medium       : Copper
Mac Address      : 0001.7a58.000b
```

After the downlink port gigabitethernet0/2 is closed, the ULPP group of Device4 switches between active and standby links to ensure network connectivity.

80 Track

80.1 Overview

Track can be used to monitor some information when the system is operating. Other service modules can monitor the changes that occur during system operation by associating with Track. After the service module is associated with Track, when the information monitored by Track changes, Track will notify the service module which then process the changes accordingly. For example, in practical applications, VRRP and VBRP often monitor the status of uplink interface, network reachability and other information by associating with Track, and adjust their own priorities based on this information for the switch between active and standby devices.

80.2 Track Function Configuration

Table 80 Track Function Configuration List

Configuration Task	
Configure Track Group	Configure Track Group
Configure Monitoring Object	Configure Status of Monitoring Interface
	Configure Direct Route of Monitoring Interface
	Configure Bandwidth Utilization Rate Alarm in Incoming and Outgoing Directions of Monitoring Interface
	Configure Reachability of Monitoring Route
	Configure Status of Monitoring Aggregation Group

Configuration Task	
	Configure to Monitor Status of Layer-2 Ethernet Interface
	Configure Monitoring RTR Group

80.2.1 Configure Track Group

Configuration Condition

None

Configure Track Group

The system can be configured with multiple Track groups that are independent of each other, and a Track group may contain multiple monitoring objects.

The Track group has two logics, i.e. "and" and "or":

- When the logic of Track group is "and", the status of Track group will become up only when all monitoring objects therein are in up status; otherwise, it will be in down status;
- When the logic of Track group is "or", the status of Track group will become up only if one monitoring object therein is in up status; otherwise, it will be in down status.

Table 80 Configuring Track Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create a Track group	**track** *group-id*	Mandatory
Configure the logic of Track group	**logic { operator [AND | OR] | reverse }**	Optional AND: Logical "and" OR: Logical "or" Reverse: Logical reverse By default, the logic of Track group is "and"; the logical reverse function doesn't take effect.

Note

- When the service module needs to monitor some information through Track, in addition to configuring monitoring object in the Track group, you are also required to refer to relevant service module configuration manual to configure the service module to associate with the Track group command.

80.2.2 Configure Monitoring Object

Configuration Condition

Before configuring monitoring object, do the following:

- Configure Track group.

Configure Status of Monitoring Interface

The monitoring object to be configured in the Track group is interface status. When the network layer protocol of interface is up, the status of this monitoring object is up; when the network layer protocol of interface is down, the status of this monitoring object is down.

Table 1 Configuring to Monitor IPv4 Status of Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *track-id*	-
Configure Status of Monitoring Interface	**interface** *interface-name* **line-protocol**	Mandatory

Table 2 Configuring to Monitor IPv6 Status of Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *track-id*	-
Configure Status of Monitoring Interface	**interface** *interface-name* **line-ipv6-protocol**	Mandatory

Configure Direct Route of Monitoring Interface

The monitoring object to be configured in the Track group is direct route of interface. When the interface has an IP address and its status is up, the status of the monitoring object is up; when the interface doesn't have any IP address or its status is down, the status of the monitoring object is down.

Table 3 Configuring to Monitor Direct IPv4 Route of Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *track-id*	-
Configure Direct Route of Monitoring Interface	**interface** *interface-name* **ip-routing**	Mandatory

Table 4 Configuring to Monitor Direct IPv6 Route of Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *track-id*	-
Configure Direct Route of Monitoring Interface	**interface** *interface-name* **ipv6-routing**	Mandatory

Configure to Monitor Bandwidth Utilization Rate Alarm of Interface

In the Track group, the monitoring object can be configured with bandwidth utilization rate alarm in incoming and outgoing directions of interface. When the incoming traffic of an interface is higher than the bandwidth utilization rate alarm value in the incoming direction set for the interface, the status of the monitoring object is up; when the incoming traffic of the interface is lower than the bandwidth utilization alarm value in the incoming direction set for the interface, the status of the monitoring object is down; when the outgoing traffic of the interface is higher than the bandwidth utilization value in the outgoing direction set for the interface, the status of the monitoring object is up; when the outgoing traffic of the interface is lower than the bandwidth utilization alarm value in the outgoing direction set for the interface, the status of the monitoring object is down.

Table 5 Configuring to Monitor Bandwidth Utilization Rate Alarm of Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *track -id*	-
Configure bandwidth utilization rate of monitoring interface	**interface** *interface-name* **trap-threshold [input | output]**	Mandatory

Note

- For configurations related to bandwidth alarm value of interface, refer to the interface-related chapter in the User Manual.

Configure Reachability of Monitoring Route

The monitoring object to be configured in the Track group is route reachability. When there is a route leading to the network configured, the status of the monitoring object is up; otherwise, the status of the monitoring object is down.

Table 6 Configuring to Monitor IPv4 Route Reachability

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *track -id*	-
Configure Reachability of Monitoring Route	**ip-route** *ip-address network mask* [**vrf** *vrf-name*] [**metric** *metric-value*]	Mandatory If there are metric options, the status of the monitoring object is up only when the metric value of route leading to the network is less than the value configured.

Table 7 Configuring to Monitor IPv6 Route Reachability

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *track -id*	-
Configure Reachability of Monitoring Route	**ipv6-route** *ipv6-address/mask-length* [**vrf** *vrf-name*] [**metric** *metric-value*]	Mandatory If there are metric options, the status of the monitoring object is up only when the metric value of route leading to the network is less than the value configured.

Configure Status of Monitoring Aggregation Group

The monitoring object to be configured in the Track group is status of aggregation group. When the status of aggregation group is up, the status of the monitoring object is up; when status of aggregation group is down, the status of the monitoring object is down.

Table 8 Configuring to Monitor Status of Aggregation Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *group-id*	Mandatory
Configure Status of Monitoring Aggregation Group	**link-aggregation** *link-aggregation-id*	Mandatory

Configure to Monitor Status of Layer-2 Ethernet Interface

The monitoring object to be configured in the Track group is status of layer-2 Ethernet interface. When the layer-2 Ethernet interface is up, the status of the monitoring object is up; when the layer-2 Ethernet interface is down, the status of the monitoring object is down.

Table 9 Configuring to Monitor Status of Layer-2 Ethernet Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *group-id*	Mandatory
Configure to Monitor Status of Layer-2 Ethernet Interface	**switchport** *interface-name*	Mandatory

Configure Monitoring RTR Group

The monitoring object to be configured in the Track group is RTR group. When the status of RTR group is up, the status of the monitoring object is up; when status of RTR group is down, the status of the monitoring object is down. RTR (Response Time Reporter) is a network detection and monitoring tool. Track can indirectly monitor network communications by monitoring RTR group.

Table 10 Configuring to Monitor RTR Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Track configuration mode	**track** *track -id*	-
Configure Monitoring RTR Group	**rtr** *rtr-group-id*	Mandatory

Note

- For configurations related to RTR group, refer to the SLA-related chapter in the User Manual.

80.2.3 Track Monitoring and Maintaining

Table 11 Track Monitoring and Maintaining

Command	Description
show track object *group-id*	Show the information of Track group

81 EEP

81.1 Overview

EEP (Embedded Event Platform) is a extensible and customizable event detection and processing mechanism which is directly provided in the device. It provides a method which enables users to monitor specific event, obtain information and set actions when the event occurs.

81.2 EEP Function Configuration

Table 11-1 EEP Function Configuration List

Configuration Task	
Configure EEP Policy	Configure EEP Policy
Configure EEP Event	Configure EEP to Bind to Empty Event
	Configure EEP to Bind to Timer Event
	Configure EEP to Bind to TRACK Event
Configure EEP Action	Configure EEP Action

81.2.1 Configure EEP Policy

Configuration Condition

None

Configure EEP Policy

The system can be configured with multiple EEP policies that are independent of each other. In an EEP policy, only an EEP event and at most 50 EEP actions can be configured.

The EEP policy has three states, i.e. init, running and suspend:

- When the EEP policy is created for the first time, its status is init.
- In the EEP policy which has been created, configure EEP event and EEP action, and change the EEP policy status to running. In this status, after detecting the EEP event configured, the EEP policy will perform the EEP actions configured in turn.
- The user can suspend all EEP policies configured or a specified EEP policy with the command **event platform suspend** {**policy** *policy-name*}. The EEP policy state changes to suspend. In this status, after detecting the EEP event configured, the EEP policy will not perform the EEP actions configured.

Table 11-2 Configuring EEP Policy

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create EEP policy	**event platform applet** *policy-name*	Mandatory
Suspend EEP policy	**event platform suspend** {**policy** *policy-name*}	Optional

81.2.2 Configure EEP Event

Configuration Condition

Before configuring the EEP event, do the following:

- Configure EEP policy.

Configure EEP to Bind to Empty Event

Table 11-3 Configuring EEP to Bind to Empty Event

Step	Command	Description

Enter the global configuration mode.	**configure terminal**	-
Enter the EEP policy configuration mode	**event platform applet** *policy-name*	-
Configure EEP to Bind to Empty Event	**event none**	Mandatory

Note

- When EEP is bound to an empty event, the EEP policy will have no event to be monitored. Thus, the user can only trigger the EEP policy bound to empty event to perform EEP action with the command **event platform run** *policy- name.*

Configure EEP to Bind to Timer Event

The timer event bound to EEP has four types:

- Absolute timer: Trigger timer event when the specified time configured by the user is up.
- Calendar timer: Trigger timer event when the periodic time configured by the user is up.
- Countdown timer: Trigger timer event when the countdown time configured by the user is up.
- Watchdog timer: Trigger timer event when the watchdog time configured by the user is up.

Table 11-4 Configuring EEP to Bind to Timer Event

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the EEP policy configuration mode	**event platform applet** *policy-name*	-

Configure EEP to bind to absolute timer event	**event timer absolute** *year month day hour:minute*[*:second*]	Optional
Configure EEP to bind to calendar timer event	**event timer calendar** { **per-day** *hour:minute*[*:second*] **| per-hour** *minute* | **per-month** *day hour:minute*[*:second*] | **per-week** *week hour:minute*[*:second*] }	Optional Value range of *minute*: 0~59 Value range of *day*: 1~28 Value range of *week*: 0~6, 0 means Sunday
Configure EEP to bind to countdown timer event	**event timer countdown** *time-value*	Optional Value range of *time-value*: 1~107374182, in second
Configure EEP to bind to watchdog timer event	**event timer watchdog** *time-value*	Optional Value range of *time-value*: 1~107374182, in second

Configure EEP to Bind to TRACK Event

Table 11-5 Configuring EEP to Bind to TRACK Event

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the EEP policy configuration mode	**event platform applet** *policy-name*	-
Configure EEP to Bind to TRACK Event	**event track** *track-id* {*up-to-down*| *down-to-up*}	Optional Value range of *track-id*: 1~500

81.2.3 Configure EEP Action

Table 11-6 Configuring EEP Actions

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the EEP policy configuration mode	**event platform applet** *policy-name*	-
Configure EEP to perform command line actions	**action** *action-number* {**cli-command** *cli-command-string* | **force-switchover | reload** [**master | slave**] **| syslog** [**msg** *message-text* | **priority** *priority-value* **msg** *message-text*]}	Optional Value range of *action-number*: 1~1000

Note

- EEP policy performs command line actions by *action-number* (from small to large).
- The command line *cli-command-string* is performed in the configured mode by default.

81.2.4 EEP Monitoring and Maintaining

Table 11-7 EEP Monitoring and Maintaining

Command	Description
show eep policy registered { *detail* **|** *INEXIST-EVENT* **|** *NONE-EVENT* **|** *TIMER-EVENT* **|** *TRACK-EVENT* }	View the information of all EEP policy states

81.3 Typical Configuration Example of EEP

81.3.1 Configure EEP Policy and PBR Coordination

Network Requirements

- The OSPF protocol is run on all devices, and PBR is configured on Device1.
- By configuring PBR, PC can access the server 2.2.2.2 through Device1 and Device2.

- After EEP is associated with PBR, when the interface of Device1 connecting Device2 is down, EEP quickly notifies PBR to delete the next-hop configuration so that the PC can access the server 2.2.2.2 through Device1 and Device3; when the link between Device1 and Device2 returns to normal, EEP notifies PBR to add the next-hop configuration so that PC can access the server 2.2.2.2 through Device1 and Device2.

Network Topology

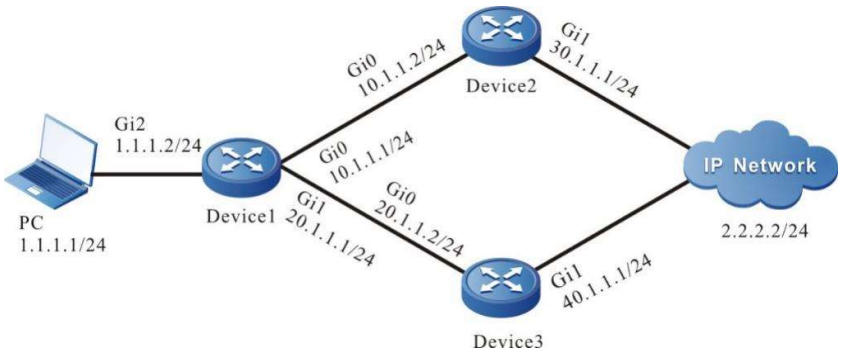


Figure 11-1 Network Topology for Configuring EEP Policy and PBR Coordination

Configuration Steps

Step 1: Configures IP addresses for the ports. (Omitted)

Step 2: Enable the unicast routing protocol OSPF, so that all devices in the network can communicate with each other.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#router-id 1.1.1.1
Device1(config-ospf)#network 1.1.1.0 0.0.0.255 area 0
Device1(config-ospf)#network 10.1.1.0 0.0.0.255 area 0
Device1(config-ospf)#network 20.1.1.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device1(config-ospf)#router-id 2.2.2.2
Device2(config-ospf)#network 10.1.1.0 0.0.0.255 area 0
Device2(config-ospf)#network 30.1.1.0 0.0.0.255 area 0
Device2(config-ospf)#exit
```

#Configure Device3.

```
Device3#configure terminal
```

```
Device3(config)#router ospf 100
Device1(config-ospf)#router-id 3.3.3.3
Device3(config-ospf)#network 20.1.1.0 0.0.0.255 area 0
Device3(config-ospf)#network 40.1.1.0 0.0.0.255 area 0
Device3(config-ospf)#exit
```

#It can be seen from the routing table of Device1 that there are two next hops that can reach the network 2.2.2.0/24.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
      O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.1.1.0/24 is directly connected, 22:14:53, gigabitethernet2
L   1.1.1.1/32 is directly connected, 22:14:53, gigabitethernet2
O   2.2.2.0/24 [110/3] via 10.1.1.2, 00:00:09, gigabitethernet0
              [110/3] via 20.1.1.2, 00:00:09, gigabitethernet1
C   10.1.1.0/24 is directly connected, 21:41:21, gigabitethernet0
L   10.1.1.1/32 is directly connected, 21:41:21, gigabitethernet0
C   20.1.1.0/24 is directly connected, 15:19:15, gigabitethernet1
L   20.1.1.1/32 is directly connected, 15:19:15, gigabitethernet1
O   30.1.1.0/24 [110/2] via 10.1.1.2, 18:55:36, gigabitethernet0
O   40.1.1.0/24 [110/2] via 20.1.1.2, 00:22:08, gigabitethernet1
C   127.0.0.0/8 is directly connected, 87:42:47, lo0
L   127.0.0.1/32 is directly connected, 87:42:47, lo0
```

#On Device1, change the cost value of interface gigabitethernet0 to 100 so that the route leading to the network 2.2.2.0/24 prefers the interface gigabitethernet1.

```
Device1(config)#interface gigabitethernet0
Device1(config-if-gigabitethernet0)#ip ospf cost 100
Device1(config-if-gigabitethernet0)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
       U - Per-user Static route
       O - OSPF, OE-OSPF External, M - Management, E - IRMP, EX - IRMP external

C   1.1.1.0/24 is directly connected, 23:27:34, gigabitethernet2
L   1.1.1.1/32 is directly connected, 23:27:34, gigabitethernet2
O   2.2.2.0/24 [110/3] via 20.1.1.2, 01:12:50, gigabitethernet1
C   10.1.1.0/24 is directly connected, 22:54:03, gigabitethernet0
```

```
L   10.1.1.1/32 is directly connected, 22:54:03, gigabitethernet0
C   20.1.1.0/24 is directly connected, 16:31:57, gigabitethernet1
L   20.1.1.1/32 is directly connected, 16:31:57, gigabitethernet1
O   30.1.1.0/24 [110/3] via 20.1.1.2, 00:31:42, gigabitethernet0
O   40.1.1.0/24 [110/2] via 20.1.1.2, 01:34:50, gigabitethernet1
C   127.0.0.0/8 is directly connected, 88:55:28, lo0
L   127.0.0.1/32 is directly connected, 88:55:28, lo0
#On the PC, view with Traceroute the paths through which the server 2.2.2.2 can be reached.
C:\Documents and Settings\Administrator>tracert 2.2.2.2

Tracing route to 2.2.2.2 over a maximum of 30 hops

  1    1 ms    1 ms    1 ms  1.1.1.2
 2   <1 ms   <1 ms   <1 ms  20.1.1.2
 ……
 n   <1 ms   <1 ms   <1 ms  2.2.2.2
Trace complete.
```

It is indicated that PC can access the server 2.2.2.2 through Device1 and Device3.

Step 3: Configure policy route on Device1.

#Configure the access control list 1001 and permit PC to access the network 2.2.2.0/24.

```
Device1(config)#ip access-list extended 1001
Device1(config-ext-nacl)#permit ip any 2.2.2.0 0.0.0.255
Device1(config-ext-nacl)#exit
```

#Configure the policy route aaa, associate with the access control list 1001, and specify the next hop as 10.1.1.2.

```
Device1(config)#route-policy aaa permit 10
Device1(config-pbr)#match ip address acl 1001
Device1(config-pbr)#set ip next-hop 10.1.1.2
Device1(config-pbr)#exit
```

#View the information of the policy route aaa of Device1.

```
Device1#show route-policy aaa
route-policy aaa
  sequence 10 permit:
    match ip address acl 1001
    set ip next-hop 10.1.1.2
```

Step 4: Apply the policy route.

#Apply the policy route aaa on the interface gigabitethernet2 of Device1.

```
Device1(config)#interface gigabitethernet2
Device1(config-if-gigabitethernet2)#ip policy aaa
Device1(config-if-gigabitethernet2)#exit
```

#On the PC, view with Traceroute the paths through which the server 2.2.2.2 can be reached.

```
C:\Documents and Settings\Administrator>tracert 2.2.2.2

Tracing route to 2.2.2.2 over a maximum of 30 hops

  1    1 ms    1 ms    1 ms  1.1.1.2
 2   <1 ms   <1 ms   <1 ms  10.1.1.2
 ……
 n   <1 ms   <1 ms   <1 ms  2.2.2.2
Trace complete.
```

It is indicated that after the policy route is applied on the interface gigabitethernet2, PC can access the server 2.2.2.2 through Device1 and Device2.

Step 5: Configure EEP policy to associate with PBR.

#Configure TRACK 1 to monitor the status of interface gigabitethernet 0.

```
Device1(config)#track 1
Device1(config-track)#interface gigabitethernet0 line-protocol
Device1(config-track)#exit
```

#Configure EEP policy e1 on Device1 to bind to track group 1 to monitor the status of interface gigabitethernet0. When the interface gigabitethernet0 of Device1 is down, notify PBR to delete corresponding next-hop configuration.

```
Device1(config)#event platform applet e1
Device1(config-eep)#event track 1 up-to-down
Device1(config-eep)#action 1 cli-command route-policy aaa permit 10
Device1(config-eep)#action 2 cli-command no set ip next-hop 10.1.1.2
Device1(config-eep)#exit
```

#Configure EEP policy e2 on Device1 to bind to track group 1 to monitor the status of interface gigabitethernet0. When the interface gigabitethernet0 of Device1 is up, notify PBR to add corresponding next-hop configuration.

```
Device1(config)#event platform applet e2
Device1(config-eep)#event track 1 down-to-up
Warning:
Configuring event track 1 down-to-up is risky, are you sure to configure?(Yes/No)yes
Device1(config-eep)#action 1 cli-command route-policy aaa permit 10
Device1(config-eep)#action 2 cli-command set ip next-hop 10.1.1.2
```

```
Device1(config-eep)#exit
```

Step 6: Check the result.

#When interface gigabitethernet0 of Device1 is down, EEP will quickly notify PBR to delete the next-hop configuration, and PC will access the server 2.2.2.2 through Device3.

```
Device1#show route-policy aaa
route-policy aaa
  sequence 10 permit:
   match ip address acl 1001
#On the PC, view with Traceroute the paths through which the server 2.2.2.2 can be reached.
C:\Documents and Settings\Administrator>tracert 2.2.2.2

Tracing route to 2.2.2.2 over a maximum of 30 hops

  1    1 ms    1 ms    1 ms  1.1.1.2
 2   <1 ms   <1 ms   <1 ms  20.1.1.2
 ……
 n   <1 ms   <1 ms   <1 ms  2.2.2.2
Trace complete.
```

It is indicated that after interface gigabitethernet2 becomes down, PC can access the server 2.2.2.2 through Device1 and Device3.

#When interface gigabitethernet0 of Device1 is up, EEP will notify PBR to add the next-hop configuration, and PC will access the server 2.2.2.2 through Device2.

```
Device1#show route-policy aaa
route-policy aaa
  sequence 10 permit:
match ip address acl 1001
set ip next-hop 10.1.1.2
```

#On the PC, view with Traceroute the paths through which the server 2.2.2.2 can be reached.

```
C:\Documents and Settings\Administrator>tracert 2.2.2.2

Tracing route to 2.2.2.2 over a maximum of 30 hops

  1    1 ms    1 ms    1 ms  1.1.1.2
 2   <1 ms   <1 ms   <1 ms  10.1.1.2
 ……
 n   <1 ms   <1 ms   <1 ms  2.2.2.2
Trace complete.
```

It is indicated that after interface gigabitethernet2 becomes up, PC can access the server 2.2.2.2 through Device1 and Device2.

82 ERPS

82.1 Overview

In the Ethernet layer-2 network, STP (Spanning Tree Protocol) is generally used for network reliability. However, the convergence time of STP, in second, is long when there is a large network diameter. In order to reduce the convergence time and eliminate the influence of network size, ERPS (Ethernet Ring Protection Switching) technology is born. ERPS is a layer-2 damage protocol standard defined by ITU-T, with a protocol standard number of ITU-T G.8032/Y1344. It is also called G.8032 which is a reliable and stable Ethernet link layer technology. When the Ethernet ring network is complete, it can prevent the broadcast storm caused by data loop. When the Ethernet ring network link fails, with a high convergence speed, it can quickly restore the communication path between the nodes on the ring network. At the same time, if the manufacturer's devices within the ring network all support this protocol, interconnection can be achieved.

Definitions of ERPS-related concepts:

- ERPS ring, a basic unit of ERPS protocol, is a group of interconnected network devices configured with the same control VLAN (Virtual Local Area Network). It has main ring and subring. The former is closed, while the latter is not closed. The attributes of main ring and subring are determined by users.
- Port role: According to the ERPS protocol, there are three types of port roles, i.e. RPL owner port, RPL neighbor port, and general port. In particular, RPL neighbor port is supported by ERPSv2 only.
- RPL owner port: An ERPS ring has one RPL owner port only, specified by users. The ERPS protocol prevents link loops by blocking the forwarding state of the RPL owner port. The link where the RPL owner port is located is the RPL (Ring Protection Link).
- RPL neighbor port means the node port directly connected to the RPL owner port. Normally, both RPL owner port and RPL neighbor port will be blocked to prevent loops. When the ERPS ring network fails, both RPL owner port and RPL neighbor port will be unblocked.
- General port: In the ERPS ring, all ports except RPL owner and RPL neighbor are general ports. They are responsible for monitoring the status of their own direct links and notify other node ports of the changes in a timely manner.

- ERPS control VLAN is used to transmit ERPS protocol packets. Control VLAN is specified by users. ERPS control VLAN (Virtual Local Area Network) cannot be used for other services. Each ERPS ring has a different control VLAN.
- ERPS data instance is a data instance mapped by data VLAN which requires ERPS ring protection.

82.2 ERPS Function Configuration

Table 82 ERPS Function Configuration List

Configuration Task	
Configure ERPS Ring	Configure ERPS Ring
	Enable ERPS Protocol
Configure ERPS Ring Timer	Configure ERPS Ring Timer
Configure ERPS Network Optimization	Configure ERPS Port Block Switch Mode
	Clear Blocking Point Configured for ERPS
	Configure ERPS Topology Change Advertisement
	Configure ERPS TC Limiting Function
Configure Coordination of ERPS with CFM	Configure ERPS to Coordinate with CFM

82.2.1 Configure ERPS Ring

When configuring ERPS ring, you are required to configure the ports accessing ERPS ring on each node and the nodes on the ring.

Configuration Condition

Before configuring ERPS ring, do the following:

- Create control VLAN;

- Close the ring network protocol of ring port;
- Configure the ring port as trunk mode;
- Add the ring port to the control VLAN to which the ring belongs;
- Configure the mapping relationship between MSTP instance and the VLAN to be included.

Configure ERPS Ring

Configure basic functions of ERPS ring

Table 82 Configuring ERPS Ring

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create ERPS ring	**erps ring** *ring-id*	Mandatory By default, no ERPS ring is created, and the value range of the ring is 1~64.
Configure the control VLAN of ERPS ring	**control vlan** *vlan-id*	Mandatory By default, no control VLAN of ERPS ring is configured.
Configure the data instance of ERPS ring	**instance** *instance-list*	Mandatory By default, no data instance of ERPS ring is configured.
Configure port PORT0 of ERPS ring	**port0** { **interface** *interface-name* |interface **link-aggregation** *link-aggregation-id* } [**rpl** { **owner** | **neighbour** }]	Mandatory By default, no port PORT0 of ERPS ring is configured. **rpl owner**: owner port, the port of which is RPL

		rpl neighbour: neighbour port, the port of which is RPL It is a general port if no rpl is configured.
Configure port PORT1 of ERPS ring	**port1** { **interface** *interface-name* | interface **link-aggregation** *link-aggregation-id* } [**rpl** { **owner** | **neighbour** }]	Mandatory By default, ERPS port1 is not configured. **rpl owner**: owner port, the port of which is RPL **rpl neighbour**: neighbour port, the port of which is RPL It is a general port if no rpl is configured.
Configure ERPS ring version	**version** { *v1* | *v2* }	Optional By default, the version is version v2.
Configure the mel value of ERPS ring packet	**mel** *level-id*	Optional By default, the mel value is 7, and the value range is 0~7.
Configure the ERPS ring as a subring	**sub-ring**	Optional By default, the ERPS ring is a main ring.
Configure the non-revertive mode of ERPS ring	**revertive disable**	Optional By default, ERPS is in revertive mode.
Configure the virtual channel of ERPS subring	**virtual-channel enable**	Optional By default, ERPS has a non-virtual channel.

Note

- ERPS control VLAN is used to transmit ERPS protocol packets only rather than for other services. All the nodes in the same ERPS ring need to be configured with the same mel value.
- In the networking environment with intersecting rings, virtual channel of subring is not recommended for networking.

Enable ERPS Protocol

Upon completion of the configuration mentioned above, use this command to enable ERPS protocol.

Table 1 Enabling Protocol on ERPS Ring

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the ERPS configuration mode	**erps ring** *ring-id*	-
Enable ERPS Protocol	**erps enable**	Mandatory By default, the ERPS protocol is not enabled on the ring.

82.2.2 Configure ERPS Ring Timer

Configuration Condition

Before configuring ERPS timer, do the following:

- Configure ERPS ring.

Configure ERPS Ring Timer

After the node device or link failure in the ERPS ring is recovered, in order to prevent network flapping, the ERPS ring timer will be enabled to reduce the interruption time of service traffic.

Table 82 Configuring ERPS Ring Timer

Step	Command	Description

Enter the global configuration mode.	**configure terminal**	-
Enter the ERPS configuration mode	**erps ring** *ring-id*	-
Configure Guard timer of ERPS ring	**guard-timer** *time-value*	Mandatory By default, the timeout period of the Guard timer is 500 milliseconds, and the range of the Guard timer is 10 to 2000 milliseconds.
Configure Hold-off timer of ERPS ring	**holdoff-timer** *time-value*	Mandatory By default, the timeout period of the Hold-off timer is 0 millisecond, and the range of the Guard timer is 0 ~ 10000 milliseconds.
Configure WTR timer of ERPS ring	**wtr-timer** *time-value*	Mandatory By default, the timeout period of the Guard timer is 5 minutes, and the range of the WTR timer is 1 ~ 12 minutes.

82.2.3 Configure ERPS Network Optimization

Configuration Condition

Before configuring ERPS network optimization, ensure that:

- Configure ERPS ring.

Configure ERPS Port Block Switch Mode

Since the bandwidth of the link where the RPL owner port is located may carry more user traffic, you may consider blocking the link with a low bandwidth so that the user traffic can go back to RPL for transmission.

Table 82 Configuring ERPS Port Block Switch Mode

Step	Command	Description
Configure ERPS Port Block Switch Mode	**erps ring** *ring-id* { **interface** *interface-name* | interface **link-aggregation** *link-aggregation-id* } **switch** { **force | manual** }	Mandatory By default, the ERPS port blocking point switch mode is not configured.

Clear Blocking Point Configured for ERPS

Clear the blocking point switch operation configured for ERPS ring.

Table 82 Clearing Blocking Point Configured for ERPS

Step	Command	Description
Clear Blocking Point Configured for ERPS	**clear erps ring** *ring-id*	Mandatory

Configure ERPS Topology Change Advertisement

When the topology of the ERPS ring changes without notifying layer-2 network in time, the MAC address entries before the downstream network topology changes still remain in the MAC address table of layer-2 network, which will cause interruption of user traffic. In order to ensure the normal communication of user traffic, you are required to select the topology change notifcation object of the ERPS ring according to the user's actual network.

Table 82 Configuring ERPS Ring Topology Change Advertisement

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the ERPS configuration mode	**erps ring** *ring-id*	-
Configure ERPS ring topology change advertisement	**tc-notify erps ring** *ring-list*	Mandatory By default, the ERPS topology change is not notified.

Configure ERPS TC Limiting Function

Frequent topology change notifications will result in a decrease in CPU processing capacity and the frequent refreshing of Flush-FDB packets on the ERPS ring to occupy network bandwidth. To avoid this situation, topology change notification packets should be suppressed. The device is protected by configuring the ERPS topology change protection interval and the maximum threshold value for processing topology change packets within the topology change protection interval, and avoiding frequent deletion of MAC address entries and ARP entries.

Table 82 Configuring ERPS TC Limiting Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the ERPS configuration mode	**erps ring** *ring-id*	-
Configure to enable the ERPS topology change TC limiting function	**tc-limit enable**	Mandatory By default, the TC limiting function is not enabled.
Configure the timer interval of ERPS topology change TC limit	**tc-limit interval** *interval-value*	Optional By default, the time interval is 2 seconds, and the value range is 1~500 seconds.
Configure the threshold value of ERPS topology change TC limit	**tc-limit threshold** *threshold-value*	Optional The default value is 3, and the value range is 1~64.

82.2.4 Configure Coordination of ERPS with CFM

Configuration Condition

Before configuring the coordination of ERPS with CFM (Connectivity Fault Management), do the following:

- Configure basic ERPS functions.

- Configure CFM function

Configure Coordination of ERPS with CFM

After configuring the Ethernet CFM coordination function on the ring port added to ERPS ring, you can accelerate the detection of failures to realize the fast convergence of topology and reduce the interruption time of traffic.

Table 82 Configuring Coordination of ERPS with CFM

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure Coordination of ERPS with CFM	**erps ring** *ring-id* **track cfm domain** *domain-name* **service-instance** *ser-name* **mep** *mep-id* **remote-mep** *rmep-id*	Mandatory By default, the port is not coordinated with CFM.

82.2.5 ERPS Monitoring and Maintaining

Table 2 ERPS Monitoring and Maintaining

Command	Description
clear erps [**ring** *ring-id*] **statistics**	Clear ERPS-related statistics
show erps [**ring** *ring-id*] **config**	Show the ERPS configuration information
show erps [ring *ring-id***] detail**	Show the detailed information of ERPS
show erps [**ring** *ring-id*] **statistics**	Show the ERPS statistics

82.3 Typical Configuration Example of ERPS

82.3.1 Configure Basic Functions of ERPS

Network Requirements

- All Devices are within the same layer-2 network.
- ERPS is enabled on all Devices and used to disconnect the link loop in the network.

Network Topology

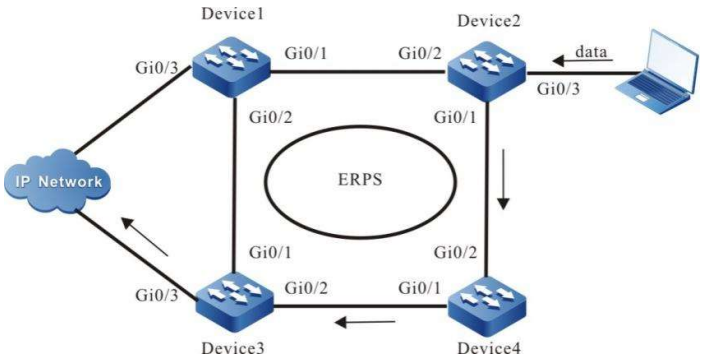


Figure 82 Configuring Basic Functions of ERPS

Configuration Steps

Step 1: Configure VLANs, and configure the link type of the ports.

#On Device1, create VLAN2 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN100~VLAN200 to pass, and disable the spanning tree and storm suppression under the port.

```
Device1#configure terminal
Device1(config)#vlan 2,100-200
```

```
Device1(config)# interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#shutdown
Device1(config-if-gigabitethernet0/1)# switchport mode trunk
Device1(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device1(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device1(config-if-gigabitethernet0/1)# no storm-control unicast
Device1(config-if-gigabitethernet0/1)# no storm-control broadcast
Device1(config-if-gigabitethernet0/1)# no storm-control multicast
Device1(config-if-gigabitethernet0/1)# no spanning-tree enable
Device1(config-if-gigabitethernet0/1)#exit
Device1(config)# interface gigabitethernet 0/2
Device1(config-if-gigabitethernet0/2)# switchport mode trunk
Device1(config-if-gigabitethernet0/2)# no switchport trunk allowed vlan all
Device1(config-if-gigabitethernet0/2)# switchport trunk allowed vlan add 2,100-200
Device1(config-if-gigabitethernet0/2)# no storm-control unicast
Device1(config-if-gigabitethernet0/1)# no storm-control broadcast
Device1(config-if-gigabitethernet0/1)# no storm-control multicast
Device1(config-if-gigabitethernet0/2)# no spanning-tree enable
Device1(config-if-gigabitethernet0/2)#end
```

#On Device2, create VLAN2 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN100~VLAN200 to pass, and disable the spanning tree and storm suppression under the port.

```
Device2#configure terminal
Device2 (config)#vlan 2,100-200
Device2 (config)# interface gigabitethernet 0/1
Device2 (config-if-gigabitethernet0/1)#shutdown
Device2 (config-if-gigabitethernet0/1)# switchport mode trunk
Device2 (config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device2 (config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device2 (config-if-gigabitethernet0/1)# no storm-control unicast
Device2(config-if-gigabitethernet0/1)# no storm-control broadcast
Device2(config-if-gigabitethernet0/1)# no storm-control multicast
Device2 (config-if-gigabitethernet0/1)# no spanning-tree enable
Device2 (config-if-gigabitethernet0/1)#exit
Device2 (config)# interface gigabitethernet 0/2
Device2 (config-if-gigabitethernet0/2)# switchport mode trunk
Device2 (config-if-gigabitethernet0/2)# no switchport trunk allowed vlan all
Device2 (config-if-gigabitethernet0/2)# switchport trunk allowed vlan add 2,100-200
Device2 (config-if-gigabitethernet0/2)# no storm-control unicast
Device2(config-if-gigabitethernet0/1)# no storm-control broadcast
```

```
Device2(config-if-gigabitethernet0/1)# no storm-control multicast
Device2 (config-if-gigabitethernet0/2)# no spanning-tree enable
Device2 (config-if-gigabitethernet0/2)#end
```

#On Device3, create VLAN2 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN100~VLAN200 to pass, and disable the spanning tree and storm suppression under the port.

```
Device3#configure terminal
Device3 (config)#vlan 2,100-200
Device3 (config)# interface gigabitethernet 0/1
Device3 (config-if-gigabitethernet0/1)#shutdown
Device3 (config-if-gigabitethernet0/1)# switchport mode trunk
Device3 (config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device3 (config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device3 (config-if-gigabitethernet0/1)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3 (config-if-gigabitethernet0/1)# no spanning-tree enable
Device3 (config-if-gigabitethernet0/1)#exit
Device3 (config)# interface gigabitethernet 0/2
Device3 (config-if-gigabitethernet0/2)# switchport mode trunk
Device3 (config-if-gigabitethernet0/2)# no switchport trunk allowed vlan all
Device3 (config-if-gigabitethernet0/2)# switchport trunk allowed vlan add 2,100-200
Device3 (config-if-gigabitethernet0/2)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3 (config-if-gigabitethernet0/2)# no spanning-tree enable
Device3 (config-if-gigabitethernet0/2)#end
```

#On Device4, create VLAN2 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN100~VLAN200 to pass, and disable the spanning tree and storm suppression under the port.

```
Device4#configure terminal
Device4 (config)#vlan 2,100-200
Device4 (config)# interface gigabitethernet 0/1
Device4 (config-if-gigabitethernet0/1)#shutdown
Device4 (config-if-gigabitethernet0/1)# switchport mode trunk
Device4 (config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device4 (config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device4 (config-if-gigabitethernet0/1)# no storm-control unicast
Device4(config-if-gigabitethernet0/1)# no storm-control broadcast
Device4(config-if-gigabitethernet0/1)# no storm-control multicast
```

```
Device4 (config-if-gigabitethernet0/1)# no spanning-tree enable
Device4 (config-if-gigabitethernet0/1)#exit
Device4 (config)# interface gigabitethernet 0/2
Device4 (config-if-gigabitethernet0/2)# switchport mode trunk
Device4 (config-if-gigabitethernet0/2)# no switchport trunk allowed vlan all
Device4 (config-if-gigabitethernet0/2)# switchport trunk allowed vlan add 2,100-200
Device4 (config-if-gigabitethernet0/2)# no storm-control unicast
Device4(config-if-gigabitethernet0/1)# no storm-control broadcast
Device4(config-if-gigabitethernet0/1)# no storm-control multicast
Device4 (config-if-gigabitethernet0/2)# no spanning-tree enable
Device4 (config-if-gigabitethernet0/2)#end
```

Step 2: Configure MST instance.

#On Device1, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device1#configure terminal
Device1(config)# spanning-tree mst configuration
Device1(config-mst)# instance 1 vlan 100-200
Device1(config-mst)# active configuration pending
Device1(config-mst)#end
```

#On Device2, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device2#configure terminal
Device2 (config)# spanning-tree mst configuration
Device2 (config-mst)# instance 1 vlan 100-200
Device2 (config-mst)# active configuration pending
Device2 (config-mst)#end
```

#On Device3, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device3#configure terminal
Device3 (config)# spanning-tree mst configuration
Device3 (config-mst)# instance 1 vlan 100-200
Device3 (config-mst)# active configuration pending
Device3 (config-mst)#end
```

#On Device4, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device4#configure terminal
Device4 (config)# spanning-tree mst configuration
Device4 (config-mst)# instance 1 vlan 100-200
Device4 (config-mst)# active configuration pending
Device4 (config-mst)#end
```

Step 3: Configure ERPS.

#On Device1, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the owner port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device1# configure terminal
Device1(config)#erps ring 1
Device1(config-erps1)# control vlan 2
Device1(config-erps1)# port0 interface g0/1
Device1(config-erps1)# port1 interface g0/2 rpl owner
Device1(config-erps1)# instance 1
Device1(config-erps1)# erps enable
Device1(config-erps1)# exit
Device1(config)# interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#no shutdown
Device1(config-if-gigabitethernet0/1)# end
```

#On Device2, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device2# configure terminal
Device2(config)#erps ring 1
Device2(config-erps1)# control vlan 2
Device2(config-erps1)# port0 interface g0/2
Device2(config-erps1)# port1 interface g0/1
Device2(config-erps1)# instance 1
Device2(config-erps1)# erps enable
Device2(config-erps1)# exit
Device2(config)# interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#no shutdown
Device2(config-if-gigabitethernet0/1)# end
```

#On Device3, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the neighbor port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device3# configure terminal
Device3(config)#erps ring 1
Device3(config-erps1)# control vlan 2
Device3(config-erps1)# port0 interface g0/1 rpl neighbor
Device3(config-erps1)# port1 interface g0/2
Device3(config-erps1)# instance 1
```

```
Device3(config-erps1)# erps enable
Device3(config-erps1)# exit
Device3(config)# interface gigabitethernet 0/1
Device3(config-if-gigabitethernet0/1)#no shutdown
Device3(config-if-gigabitethernet0/1)# end
```

#On Device4, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device4# configure terminal
Device4(config)#erps ring 1
Device4(config-erps1)# control vlan 2
Device4(config-erps1)# port0 interface g0/1
Device4(config-erps1)# port1 interface g0/2
Device4(config-erps1)# instance 1
Device4(config-erps1)# erps enable
Device4(config-erps1)# exit
Device4(config)# interface gigabitethernet 0/1
Device4(config-if-gigabitethernet0/1)#no shutdown
Device4(config-if-gigabitethernet0/1)# end
```

Step 4: Check the result.

#After the network topology is stable, check the ERPS information of the Device. Take Device1 as an example.

#View the ERPS information of Device1.

```
Device1# show erps ring 1 detail
Ring ID      : 1
Version      : v2
R-APS mel    : 7
Instance     : 1  vlans mapped : 100-200
Control VLAN  : 2
Node role    : Owner
Node state   : idle
Guard timer  :  500 ms       Running : 0 ms
Holdoff timer :    0 ms      Running : 0 ms
WTR timer    :    5 min      Running : 0 s
WTB timer    :    7 s        Running : 0 s
Subring      : No
Tc-limit enable   : No
```

Tc-limit Interval : 2

Tc-limit Threshold : 3

Revertive operation : Revertive

R-APS channel : Non-Virtual channel

Enable status : Enable

Gigabitethernet0/1 Flush Logic

Remote Node ID : 0000-0000-0000

Remote BPR : 0

Gigabitethernet0/1 track CFM

MD Name :

MA Name :

MEP ID : 0

RMEP ID : 0

CFM State : 0

Gigabitethernet0/2 Flush Logic

Remote Node ID : 0000-0000-0000

Remote BPR : 0

Gigabitethernet0/2 track CFM

MD Name :

MA Name :

MEP ID : 0

RMEP ID : 0

CFM State : 0

Port	Name	PortRole	SwitchType	PortStatus	SignalStatus
Port0	gigabitethernet0/1	Normal	--	Forwarding	Non-failed
Port1	gigabitethernet0/2	Owner	--	Blocking	Non-failed

Note

- Before configuring ERPS, ensure the link status of at least one point in the ring network is down. Otherwise, there will be loops.

82.3.2 Configure ERPS load

Network Requirements

- All devices are within the same layer-2 network.

- The data traffic of Data1 is transmitted through Device2-Device1, and that of Data2 is transmitted through Device4-Device3 to achieve load sharing and provide link backup.

Network Topology

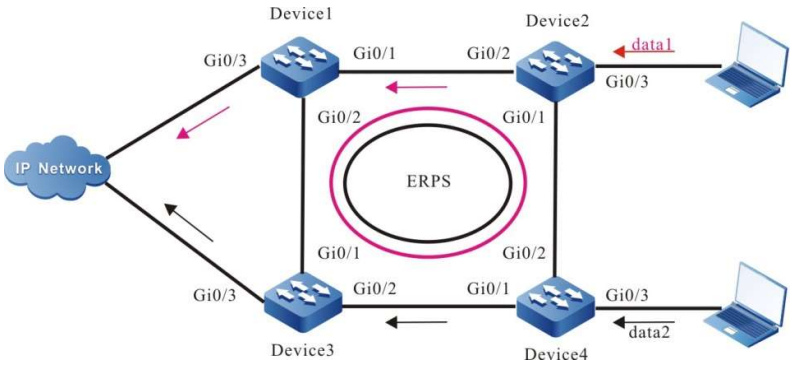


Figure 82 Configuring ERPS Load

Configuration Steps

Step 1: Configure VLANs, and configure the link type of the ports.

#On Device1, create VLAN2~VLAN3, VLAN100~VLAN200 and VLAN300~VLAN400, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2~VLAN3, VLAN100~VLAN200 and VLAN300~VLAN400 to pass, and disable the spanning tree and storm suppression under the port.

```
Device1#configure terminal
Device1(config)#vlan 2-3,100-200,300-400
Device1(config)# interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#shutdown
Device1(config-if-gigabitethernet0/1)# switchport mode trunk
Device1(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device1(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device1(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,300-400
Device1(config-if-gigabitethernet0/1)# no storm-control unicast
Device1(config-if-gigabitethernet0/1)# no storm-control broadcast
Device1(config-if-gigabitethernet0/1)# no storm-control multicast
Device1(config-if-gigabitethernet0/1)# no spanning-tree enable
Device1(config-if-gigabitethernet0/1)#exit
Device1(config)# interface gigabitethernet 0/2
Device1(config-if-gigabitethernet0/1)# switchport mode trunk
Device1(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device1(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device1(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,300-400
```

```
Device1(config-if-gigabitethernet0/1)# no storm-control unicast
Device1(config-if-gigabitethernet0/1)# no storm-control broadcast
Device1(config-if-gigabitethernet0/1)# no storm-control multicast
Device1(config-if-gigabitethernet0/1)# no spanning-tree enable
Device1(config-if-gigabitethernet0/1)#end
```

#On Device2, create VLAN2~VLAN3, VLAN100~VLAN200 and VLAN300~VLAN400, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2~VLAN3, VLAN100~VLAN200 and VLAN300~VLAN400 to pass, and disable the spanning tree and storm suppression under the port.

```
Device2#configure terminal
Device2(config)# vlan 2-3,100-200,300-400
Device2(config)# interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#shutdown
Device2(config-if-gigabitethernet0/1)# switchport mode trunk
Device2(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device2(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device2(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,300-400
Device2(config-if-gigabitethernet0/1)# no storm-control unicast
Device2(config-if-gigabitethernet0/1)# no storm-control broadcast
Device2(config-if-gigabitethernet0/1)# no storm-control multicast
Device2(config-if-gigabitethernet0/1)# no spanning-tree enable
Device2(config-if-gigabitethernet0/1)#exit
Device2(config)# interface gigabitethernet 0/2
Device2(config-if-gigabitethernet0/1)# switchport mode trunk
Device2(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device2(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device2(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,300-400
Device2(config-if-gigabitethernet0/1)# no storm-control unicast
Device2(config-if-gigabitethernet0/1)# no storm-control broadcast
Device2(config-if-gigabitethernet0/1)# no storm-control multicast
Device2(config-if-gigabitethernet0/1)# no spanning-tree enable
Device2(config-if-gigabitethernet0/1)#end
```

#On Device3, create VLAN2~VLAN3, VLAN100~VLAN200 and VLAN300~VLAN400, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2~VLAN3, VLAN100~VLAN200 and VLAN300~VLAN400 to pass, and disable the spanning tree and storm suppression under the port.

```
Device3#configure terminal
Device3(config)# vlan 2-3,100-200,300-400
Device3(config)# interface gigabitethernet 0/1
Device3(config-if-gigabitethernet0/1)#shutdown
```

```
Device3(config-if-gigabitethernet0/1)# switchport mode trunk
Device3(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,300-400
Device3(config-if-gigabitethernet0/1)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3(config-if-gigabitethernet0/1)# no spanning-tree enable
Device3(config-if-gigabitethernet0/1)#exit
Device3(config)# interface gigabitethernet 0/2
Device3(config-if-gigabitethernet0/1)# switchport mode trunk
Device3(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,300-400
Device3(config-if-gigabitethernet0/1)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3(config-if-gigabitethernet0/1)# no spanning-tree enable
Device3(config-if-gigabitethernet0/1)#end
```

#On Device4, create VLAN2~VLAN3, VLAN100~VLAN200 and VLAN300~VLAN400, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2~VLAN3, VLAN100~VLAN200 and VLAN300~VLAN400 to pass, and disable the spanning tree and storm suppression under the port.

```
Device4#configure terminal
Device4(config)# vlan 2-3,100-200,300-400
Device4(config)# interface gigabitethernet 0/1
Device4(config-if-gigabitethernet0/1)#shutdown
Device4(config-if-gigabitethernet0/1)# switchport mode trunk
Device4(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device4(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device4(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,300-400
Device4(config-if-gigabitethernet0/1)# no storm-control unicast
Device4(config-if-gigabitethernet0/1)# no storm-control broadcast
Device4(config-if-gigabitethernet0/1)# no storm-control multicast
Device4(config-if-gigabitethernet0/1)# no spanning-tree enable
Device4(config-if-gigabitethernet0/1)#exit
Device4(config)# interface gigabitethernet 0/2
Device4(config-if-gigabitethernet0/1)# switchport mode trunk
Device4(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device4(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
```

```
Device4(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,300-400
Device4(config-if-gigabitethernet0/1)# no storm-control unicast
Device4(config-if-gigabitethernet0/1)# no storm-control broadcast
Device4(config-if-gigabitethernet0/1)# no storm-control multicast
Device4(config-if-gigabitethernet0/1)# no spanning-tree enable
Device4(config-if-gigabitethernet0/1)#end
```

Step 2: Configure MST instance.

#On Device1, configure MST instance 1 to map vlan100-200 and MST instance 2 to map vlan300-400, and activate the instance.

```
Device1#configure terminal
Device1(config)# spanning-tree mst configuration
Device1(config-mst)# instance 1 vlan 100-200
Device1(config-mst)# instance 2 vlan 300-400
Device1(config-mst)# active configuration pending
Device1(config-mst)#end
```

#On Device2, configure MST instance 1 to map vlan100-200 and MST instance 2 to map vlan300-400, and activate the instance.

```
Device2#configure terminal
Device2(config)# spanning-tree mst configuration
Device2(config-mst)# instance 1 vlan 100-200
Device2(config-mst)# instance 2 vlan 300-400
Device2(config-mst)# active configuration pending
Device2(config-mst)#end
```

#On Device3, configure MST instance 1 to map vlan100-200 and MST instance 2 to map vlan300-400, and activate the instance.

```
Device3#configure terminal
Device3(config)# spanning-tree mst configuration
Device3(config-mst)# instance 1 vlan 100-200
Device3(config-mst)# instance 2 vlan 300-400
Device3(config-mst)# active configuration pending
Device3(config-mst)#end
```

#On Device4, configure MST instance 1 to map vlan100-200 and MST instance 2 to map vlan300-400, and activate the instance.

```
Device4#configure terminal
Device4(config)# spanning-tree mst configuration
Device4(config-mst)# instance 1 vlan 100-200
Device4(config-mst)# instance 2 vlan 300-400
```

```
Device4(config-mst)# active configuration pending
Device4(config-mst)#end
```

Step 3: Configure ERPS.

#On Device1, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device1# configure terminal
Device1(config)#erps ring 1
Device1(config-erps1)# control vlan 2
Device1(config-erps1)# port0 interface g0/1
Device1(config-erps1)# port1 interface g0/2
Device1(config-erps1)# instance 1
Device1(config-erps1)# erps enable
Device1(config-erps1)# end
```

#On Device1, configure ERPS ring2. Configure vlan3 as the control vlan of ring2, gigabitethernet0/1 as the normal port of ring2, gigabitethernet0/2 as the normal port of ring2, and instance 2 as the data vlan of ring2; enable the ERPS function of ring2.

```
Device1# configure terminal
Device1(config)#erps ring 2
Device1(config-erps1)# control vlan 3
Device1(config-erps1)# port0 interface g0/1
Device1(config-erps1)# port1 interface g0/2
Device1(config-erps1)# instance 2
Device1(config-erps1)# erps enable
Device1(config-erps1)# exit
Device1(config)# interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#no shutdown
Device1(config-if-gigabitethernet0/1)# end
```

#On Device2, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the owner port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device2# configure terminal
Device2(config)#erps ring 1
Device2(config-erps1)# control vlan 2
Device2(config-erps1)# port0 interface g0/1 rpl owner
Device2(config-erps1)# port1 interface g0/2
Device2(config-erps1)# instance 1
Device2(config-erps1)# erps enable
```

```
Device2(config-erps1)# exit
```

#On Device2, configure ERPS ring2. Configure vlan3 as the control vlan of ring2, gigabitethernet0/1 as the neighbor port of ring2, gigabitethernet0/2 as the normal port of ring2, and instance 2 as the data vlan of ring2; enable the ERPS function of ring2.

```
Device2# configure terminal
Device2(config)#erps ring 2
Device2(config-erps1)# control vlan 3
Device2(config-erps1)# port0 interface g0/1 rpl neighbor
Device2(config-erps1)# port1 interface g0/2
Device2(config-erps1)# instance 2
Device2(config-erps1)# erps enable
Device2(config-erps1)# exit
Device2(config)# interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#no shutdown
Device2(config-if-gigabitethernet0/1)# end
```

#On Device3, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device3# configure terminal
Device3(config)#erps ring 1
Device3(config-erps1)# control vlan 2
Device3(config-erps1)# port0 interface g0/1
Device3(config-erps1)# port1 interface g0/2
Device3(config-erps1)# instance 1
Device3(config-erps1)# erps enable
Device3(config-erps1)# exit
```

#On Device3, configure ERPS ring2. Configure vlan3 as the control vlan of ring2, gigabitethernet0/1 as the normal port of ring2, gigabitethernet0/2 as the normal port of ring2, and instance 2 as the data vlan of ring2; enable the ERPS function of ring2.

```
Device3# configure terminal
Device3(config)#erps ring 2
Device3(config-erps1)# control vlan 3
Device3(config-erps1)# port0 interface g0/1
Device3(config-erps1)# port1 interface g0/2
Device3(config-erps1)# instance 2
Device3(config-erps1)# erps enable
Device3(config-erps1)# exit
Device3(config)# interface gigabitethernet 0/1
Device3(config-if-gigabitethernet0/1)#no shutdown
```

```
Device3(config-if-gigabitethernet0/1)# end
```

#On Device4, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the neighbor port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device4# configure terminal
Device4(config)#erps ring 1
Device4(config-erps1)# control vlan 2
Device4(config-erps1)# port0 interface g0/1
Device4(config-erps1)# port1 interface g0/2 rpl neighbour
Device4(config-erps1)# instance 1
Device4(config-erps1)# erps enable
Device4(config-erps1)# exit
```

#On Device4, configure ERPS ring2. Configure vlan3 as the control vlan of ring2, gigabitethernet0/1 as the normal port of ring2, gigabitethernet0/2 as the owner port of ring2, and instance 2 as the data vlan of ring2; enable the ERPS function of ring2.

```
Device4# configure terminal
Device4(config)#erps ring 2
Device4(config-erps1)# control vlan 3
Device4(config-erps1)# port0 interface g0/1
Device4(config-erps1)# port1 interface g0/2 rpl owner
Device4(config-erps1)# instance 2
Device4(config-erps1)# erps enable
Device4(config-erps1)# exit
Device4(config)# interface gigabitethernet 0/1
Device4(config-if-gigabitethernet0/1)#no shutdown
Device4(config-if-gigabitethernet0/1)# end
```

Step 4: Check the result.

#After the network topology is stable, check the ERPS information of the Device. Take Device2 as an example.

#View the ERPS information of Device2.

```
Device2# show erps ring 1 detail
Ring ID      : 1
Version      : v2
R-APS mel    : 7
Instance     :  1  vlans mapped : 100-200
Control VLAN  : 2
Node role    : Owner
Node state   : idle
```

Guard timer : 500 ms Running : 0 ms

Holdoff timer : 0 ms Running : 0 ms

WTR timer : 5 min Running : 0 s

WTB timer : 7 s Running : 0 s

Subring : No

Tc-limit enable : No

Tc-limit Interval : 2

Tc-limit Threshold : 3

Revertive operation : Revertive

R-APS channel : Non-Virtual channel

Enable status : Enable

Gigabitethernet0/1 Flush Logic

Remote Node ID : 0000-0000-0000

Remote BPR : 0

Gigabitethernet0/1 track CFM

MD Name :

MA Name :

MEP ID : 0

RMEP ID : 0

CFM State : 0

Gigabitethernet0/2 Flush Logic

Remote Node ID : 0000-0000-0000

Remote BPR : 0

Gigabitethernet0/2 track CFM

MD Name :

MA Name :

MEP ID : 0

RMEP ID : 0

CFM State : 0

Port	Name	PortRole	SwitchType	PortStatus	SignalStatus
Port0	gigabitethernet0/1	Owner	--	Blocking	Non-failed
Port1	gigabitethernet0/2	Normal	--	Forwarding	Non-failed

Device2# show erps ring 2 detail

Ring ID : 2

Version : v2

R-APS mel : 7

Instance : 2 vlans mapped : 300-400

Control VLAN : 3

Node role : Neighbour

Node state : idle

Guard timer : 500 ms Running : 0 ms

Holdoff timer : 0 ms Running : 0 ms

WTR timer : 5 min Running : 0 s

WTB timer : 7 s Running : 0 s

Subring : No

Tc-limit enable : No

Tc-limit Interval : 2

Tc-limit Threshold : 3

Revertive operation : Revertive

R-APS channel : Non-Virtual channel

Enable status : Enable

Gigabitethernet0/1 Flush Logic

Remote Node ID : 0000-0000-0000

Remote BPR : 0

Gigabitethernet0/1 track CFM

MD Name :

MA Name :

MEP ID : 0

RMEP ID : 0

CFM State : 0

Gigabitethernet0/2 Flush Logic

Remote Node ID : 0000-0000-0000

Remote BPR : 0

Gigabitethernet0/2 track CFM

MD Name :

MA Name :

MEP ID : 0

RMEP ID : 0

CFM State : 0

Port	Name	PortRole	SwitchType	PortStatus	SignalStatus
Port0	gigabitethernet0/1	Neighbour	--	Blocking	Non-failed
Port1	gigabitethernet0/2	Normal	--	Forwarding	Non-failed

Note

- When loading, the logical rings on the same physical ring cannot be configured with the same data instance.

82.3.3 Configure ERPS Intersecting Rings

Network Requirements

- All devices are within the same layer-2 network.
- Device1-Device2-Device4-Device3 and Device3-Device5-Device6-Device4 form two physical loops respectively. ERPS is enabled on all Devices to disconnect the link loop.

Network Topology

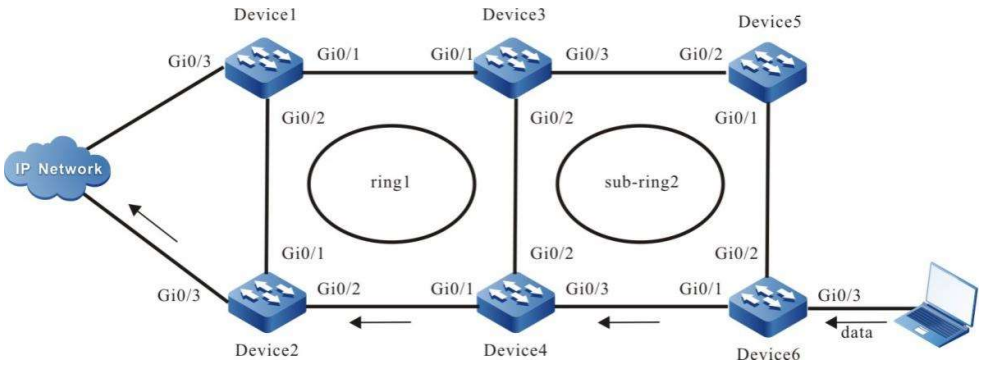


Figure 82 Configuring ERPS Intersecting Rings

Configuration Steps

Step 1: Configure VLANs, and configure the link type of the ports.

#On Device1, create VLAN2 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN100~VLAN200 to pass, and disable the spanning tree and storm suppression under the port.

```
Device1#configure terminal
Device1(config)#vlan 2,100-200
Device1(config)# interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#shutdown
Device1(config-if-gigabitethernet0/1)# switchport mode trunk
Device1(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device1(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device1(config-if-gigabitethernet0/1)# no storm-control unicast
Device1(config-if-gigabitethernet0/1)# no storm-control broadcast
Device1(config-if-gigabitethernet0/1)# no storm-control multicast
```

```
Device1(config-if-gigabitethernet0/1)# no spanning-tree enable
Device1(config-if-gigabitethernet0/1)#exit
Device1(config)# interface gigabitethernet 0/2
Device1(config-if-gigabitethernet0/1)# switchport mode trunk
Device1(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device1(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device1(config-if-gigabitethernet0/1)# no storm-control unicast
Device1(config-if-gigabitethernet0/1)# no storm-control broadcast
Device1(config-if-gigabitethernet0/1)# no storm-control multicast
Device1(config-if-gigabitethernet0/1)# no spanning-tree enable
Device1(config-if-gigabitethernet0/1)#end
```

#On Device2, create VLAN2 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN100~VLAN200 to pass, and disable the spanning tree and storm suppression under the port.

```
Device2#configure terminal
Device2(config)#vlan 2,100-200
Device2(config)# interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#shutdown
Device2(config-if-gigabitethernet0/1)# switchport mode trunk
Device2(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device2(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device2(config-if-gigabitethernet0/1)# no storm-control unicast
Device2(config-if-gigabitethernet0/1)# no storm-control broadcast
Device2(config-if-gigabitethernet0/1)# no storm-control multicast
Device2(config-if-gigabitethernet0/1)# no spanning-tree enable
Device2(config-if-gigabitethernet0/1)#exit
Device2(config)# interface gigabitethernet 0/2
Device2(config-if-gigabitethernet0/1)# switchport mode trunk
Device2(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device2(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device2(config-if-gigabitethernet0/1)# no storm-control unicast
Device2(config-if-gigabitethernet0/1)# no storm-control broadcast
Device2(config-if-gigabitethernet0/1)# no storm-control multicast
Device2(config-if-gigabitethernet0/1)# no spanning-tree enable
Device2(config-if-gigabitethernet0/1)#end
```

#On Device3, create VLAN2~VLAN3 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN100~VLAN200 to pass; configure the link type of port gigabitethernet0/3 as Trunk, permitting services of VLAN3 and VLAN100~VLAN200, and disable the spanning tree and storm suppression under the port.

```
Device3#configure terminal
```

```
Device3(config)#vlan 2-3,100-200
Device3(config)# interface gigabitethernet 0/1
Device3(config-if-gigabitethernet0/1)#shutdown
Device3(config-if-gigabitethernet0/1)# switchport mode trunk
Device3(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device3(config-if-gigabitethernet0/1)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3(config-if-gigabitethernet0/1)# no spanning-tree enable
Device3(config-if-gigabitethernet0/1)#exit
Device3(config)# interface gigabitethernet 0/2
Device3(config-if-gigabitethernet0/1)# switchport mode trunk
Device3(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device3(config-if-gigabitethernet0/1)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3(config-if-gigabitethernet0/1)# no spanning-tree enable
Device3(config-if-gigabitethernet0/1)#end
Device3(config)# interface gigabitethernet 0/3
Device3(config-if-gigabitethernet0/1)#shutdown
Device3(config-if-gigabitethernet0/1)# switchport mode trunk
Device3(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,100-200
Device3(config-if-gigabitethernet0/1)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3(config-if-gigabitethernet0/1)# no spanning-tree enable
Device3(config-if-gigabitethernet0/1)#exit
```

#On Device4, create VLAN2~VLAN3 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN2 and VLAN100~VLAN200 to pass; configure the link type of port gigabitethernet0/3 as Trunk, permitting services of VLAN3 and VLAN100~VLAN200, and disable the spanning tree and storm suppression under the port.

```
Device4#configure terminal
Device4(config)#vlan 2-3,100-200
Device4(config)# interface gigabitethernet 0/1
Device4(config-if-gigabitethernet0/1)#shutdown
Device4(config-if-gigabitethernet0/1)# switchport mode trunk
```

```
Device4(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device4(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device4(config-if-gigabitethernet0/1)# no storm-control unicast
Device4(config-if-gigabitethernet0/1)# no storm-control broadcast
Device4(config-if-gigabitethernet0/1)# no storm-control multicast
Device4(config-if-gigabitethernet0/1)# no spanning-tree enable
Device4(config-if-gigabitethernet0/1)#exit
Device4(config)# interface gigabitethernet 0/2
Device4(config-if-gigabitethernet0/1)# switchport mode trunk
Device4(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device4(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 2,100-200
Device4(config-if-gigabitethernet0/1)# no storm-control unicast
Device4(config-if-gigabitethernet0/1)# no storm-control broadcast
Device4(config-if-gigabitethernet0/1)# no storm-control multicast
Device4(config-if-gigabitethernet0/1)# no spanning-tree enable
Device4(config-if-gigabitethernet0/1)#end
Device4(config)# interface gigabitethernet 0/3
Device4(config-if-gigabitethernet0/1)#shutdown
Device4(config-if-gigabitethernet0/1)# switchport mode trunk
Device4(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device4(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,100-200
Device4(config-if-gigabitethernet0/1)# no storm-control unicast
Device4(config-if-gigabitethernet0/1)# no storm-control broadcast
Device4(config-if-gigabitethernet0/1)# no storm-control multicast
Device4(config-if-gigabitethernet0/1)# no spanning-tree enable
Device4(config-if-gigabitethernet0/1)#exit
```

#On Device5, create VLAN3 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN3 and VLAN100~VLAN200 to pass, and disable the spanning tree and storm suppression under the port.

```
Device5#configure terminal
Device5(config)#vlan 3,100-200
Device5(config)# interface gigabitethernet 0/1
Device5(config-if-gigabitethernet0/1)#shutdown
Device5(config-if-gigabitethernet0/1)# switchport mode trunk
Device5(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device5(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,100-200
Device5(config-if-gigabitethernet0/1)# no storm-control unicast
Device5(config-if-gigabitethernet0/1)# no storm-control broadcast
Device5(config-if-gigabitethernet0/1)# no storm-control multicast
Device5(config-if-gigabitethernet0/1)# no spanning-tree enable
```

```
Device5(config-if-gigabitethernet0/1)#exit
Device5(config)# interface gigabitethernet 0/2
Device5(config-if-gigabitethernet0/1)# switchport mode trunk
Device5(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device5(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,100-200
Device5(config-if-gigabitethernet0/1)# no storm-control unicast
Device5(config-if-gigabitethernet0/1)# no storm-control broadcast
Device5(config-if-gigabitethernet0/1)# no storm-control multicast
Device5(config-if-gigabitethernet0/1)# no spanning-tree enable
Device5(config-if-gigabitethernet0/1)#end
```

#On Device6, create VLAN3 and VLAN100~VLAN200, configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 as Trunk, permitting services of VLAN3 and VLAN100~VLAN200 to pass, and disable the spanning tree and storm suppression under the port.

```
Device3#configure terminal
Device3(config)#vlan 3,100-200
Device3(config)# interface gigabitethernet 0/1
Device3(config-if-gigabitethernet0/1)#shutdown
Device3(config-if-gigabitethernet0/1)# switchport mode trunk
Device3(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,100-200
Device3(config-if-gigabitethernet0/1)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3(config-if-gigabitethernet0/1)# no spanning-tree enable
Device3(config-if-gigabitethernet0/1)#exit
Device3(config)# interface gigabitethernet 0/2
Device3(config-if-gigabitethernet0/1)# switchport mode trunk
Device3(config-if-gigabitethernet0/1)# no switchport trunk allowed vlan all
Device3(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3,100-200
Device3(config-if-gigabitethernet0/1)# no storm-control unicast
Device3(config-if-gigabitethernet0/1)# no storm-control broadcast
Device3(config-if-gigabitethernet0/1)# no storm-control multicast
Device3(config-if-gigabitethernet0/1)# no spanning-tree enable
Device3(config-if-gigabitethernet0/1)#end
```

Step 2: Configure MST instance.

#On Device1, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device1#configure terminal
Device1(config)# spanning-tree mst configuration
```

```
Device1(config-mst)# instance 1 vlan 100-200
Device1(config-mst)# active configuration pending
Device1(config-mst)#end
```

#On Device2, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device2#configure terminal
Device2(config)# spanning-tree mst configuration
Device2(config-mst)# instance 1 vlan 100-200
Device2(config-mst)# active configuration pending
Device2(config-mst)#end
```

#On Device3, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device3#configure terminal
Device3(config)# spanning-tree mst configuration
Device3(config-mst)# instance 1 vlan 100-200
Device3(config-mst)# active configuration pending
Device3(config-mst)#end
```

#On Device4, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device4#configure terminal
Device4(config)# spanning-tree mst configuration
Device4(config-mst)# instance 1 vlan 100-200
Device4(config-mst)# active configuration pending
Device4(config-mst)#end
```

#On Device5, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device5#configure terminal
Device5(config)# spanning-tree mst configuration
Device5(config-mst)# instance 1 vlan 100-200
Device5(config-mst)# active configuration pending
Device5(config-mst)#end
```

#On Device6, configure MST instance 1 to map vlan100-200, and activate the instance.

```
Device6#configure terminal
Device6(config)# spanning-tree mst configuration
Device6(config-mst)# instance 1 vlan 100-200
Device6(config-mst)# active configuration pending
Device6(config-mst)#end
```

Step 3: Configure ERPS.

#On Device1, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the owner port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device1# configure terminal
Device1(config)#erps ring 1
Device1(config-erps1)# control vlan 2
Device1(config-erps1)# port0 interface g0/1
Device1(config-erps1)# port1 interface g0/2 rpl owner
Device1(config-erps1)# instance 1
Device1(config-erps1)# erps enable
Device1(config-erps1)# end
Device1(config)# interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#no shutdown
Device1(config-if-gigabitethernet0/1)# end
```

#On Device2, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the neighbor port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device2# configure terminal
Device2(config)#erps ring 1
Device2(config-erps1)# control vlan 2
Device2(config-erps1)# port0 interface g0/1 rpl neighbour
Device2(config-erps1)# port1 interface g0/2
Device2(config-erps1)# instance 1
Device2(config-erps1)# erps enable
Device2(config-erps1)# exit
Device2(config)# interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#no shutdown
Device2(config-if-gigabitethernet0/1)# end
```

#On Device3, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device3# configure terminal
Device3(config)#erps ring 1
Device3(config-erps1)# control vlan 2
Device3(config-erps1)# port0 interface g0/1
Device3(config-erps1)# port1 interface g0/2
Device3(config-erps1)# instance 1
Device3(config-erps1)# erps enable
Device3(config-erps1)# exit
```

```
Device2(config)# interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#no shutdown
Device2(config-if-gigabitethernet0/1)# end
```

#On Device3, configure ERPS ring2. Configure vlan3 as the control vlan of ring2, gigabitethernet0/3 as the normal port of ring2, instance 1 as the data vlan of ring2, and ring2 as a subring; enable the ERPS function of ring2.

```
Device3# configure terminal
Device3(config)#erps ring 2
Device3(config-erps1)# control vlan 3
Device3(config-erps1)# port0 interface g0/3
Device3(config-erps1)# instance 1
Device3(config-erps1)# sub-ring
Device3(config-erps1)# erps enable
Device3(config-erps1)# exit
Device3(config)# interface gigabitethernet 0/3
Device3(config-if-gigabitethernet0/1)#no shutdown
Device3(config-if-gigabitethernet0/1)# end
```

#On Device4, configure ERPS ring1. Configure vlan2 as the control vlan of ring1, gigabitethernet0/1 as the normal port of ring1, gigabitethernet0/2 as the normal port of ring1, and instance 1 as the data vlan of ring1; enable the ERPS function of ring1.

```
Device4# configure terminal
Device4(config)#erps ring 1
Device4(config-erps1)# control vlan 2
Device4(config-erps1)# port0 interface g0/1
Device4(config-erps1)# port1 interface g0/2
Device4(config-erps1)# instance 1
Device4(config-erps1)# erps enable
Device4(config-erps1)# exit
Device4(config)# interface gigabitethernet 0/1
Device4(config-if-gigabitethernet0/1)#no shutdown
Device4(config-if-gigabitethernet0/1)# end
```

#On Device4, configure ERPS ring2. Configure vlan3 as the control vlan of ring2, gigabitethernet0/3 as the normal port of ring2, instance 1 as the data vlan of ring2, and ring2 as a subring; enable the ERPS function of ring2.

```
Device4# configure terminal
Device4(config)#erps ring 2
Device4(config-erps1)# control vlan 3
Device4(config-erps1)# port0 interface g0/3
Device4(config-erps1)# instance 1
```

```
Device4(config-erps1)# sub-ring
Device4(config-erps1)# erps enable
Device4(config-erps1)# exit
Device4(config)# interface gigabitethernet 0/3
Device4(config-if-gigabitethernet0/1)#no shutdown
Device4(config-if-gigabitethernet0/1)# end
```

#On Device5, configure ERPS ring2. Configure vlan3 as the control vlan of ring2, gigabitethernet0/2 as the normal port of ring2, gigabitethernet0/1 as the owner port of ring2, instance 1 as the data vlan of ring2, and ring2 as a subring; enable the ERPS function of ring2.

```
Device4# configure terminal
Device4(config)#erps ring 2
Device4(config-erps1)# control vlan 3
Device4(config-erps1)# port0 interface g0/1 rpl owner
Device4(config-erps1)# port0 interface g0/2
Device4(config-erps1)# instance 1
Device4(config-erps1)# sub-ring
Device4(config-erps1)# erps enable
Device4(config-erps1)# exit
Device4(config)# interface gigabitethernet 0/1
Device4(config-if-gigabitethernet0/1)#no shutdown
Device4(config-if-gigabitethernet0/1)# end
```

#On Device6, configure ERPS ring2. Configure vlan3 as the control vlan of ring2, gigabitethernet0/2 as the neighbor port of ring2, gigabitethernet0/1 as the normal port of ring2, instance 1 as the data vlan of ring2, and ring2 as a subring; enable the ERPS function of ring2.

```
Device4# configure terminal
Device4(config)#erps ring 2
Device4(config-erps1)# control vlan 3
Device4(config-erps1)# port0 interface g0/1
Device4(config-erps1)# port0 interface g0/2 rpl neighbour
Device4(config-erps1)# instance 1
Device4(config-erps1)# sub-ring
Device4(config-erps1)# erps enable
Device4(config-erps1)# exit
Device4(config)# interface gigabitethernet 0/1
Device4(config-if-gigabitethernet0/1)#no shutdown
Device4(config-if-gigabitethernet0/1)# end
```

Step 4: Check the result.

#After the network topology is stable, check the ERPS information of the Device. Take Device3 as an example.

#View the ERPS information of Device3.

```
Device3# show erps ring 1 detail
Ring ID       : 1
Version       : v2
R-APS mel     : 7
Instance      :  1  vlans mapped : 100-200
Control VLAN  : 2
Node role     : Normal
Node state    : idle
Guard timer   :   500 ms         Running : 0 ms
Holdoff timer :     0 ms         Running : 0 ms
WTR timer     :     5 min        Running : 0 s
WTB timer     :     7 s          Running : 0 s
Subring       : No
Tc-limit enable    : No
Tc-limit Interval  : 2
Tc-limit Threshold : 3
Revertive operation : Revertive
R-APS channel : Non-Virtual channel
Enable status : Enable
Gigabitethernet0/1 Flush Logic
   Remote Node ID : 0000-0000-0000
   Remote BPR     : 0
Gigabitethernet0/1 track CFM
   MD Name   :
   MA Name   :
   MEP ID    : 0
   RMEP ID   : 0
   CFM State : 0
Gigabitethernet0/2 Flush Logic
   Remote Node ID : 0000-0000-0000
   Remote BPR     : 0
Gigabitethernet0/2 track CFM
   MD Name   :
   MA Name   :
   MEP ID    : 0
   RMEP ID   : 0
```

CFM State : 0

Port Name PortRole SwitchType PortStatus SignalStatus

Port0 gigabitethernet0/1 Normal -- Forwarding Non-failed

Port1 gigabitethernet0/2 Normal -- Forwarding Non-failed

Device3# show erps ring 2 detail

Ring ID : 2

Version : v2

R-APS mel : 7

Instance : 1 vlans mapped : 100-200

Control VLAN : 3

Node role : Normal

Node state : idle

Guard timer : 500 ms Running : 0 ms

Holdoff timer : 0 ms Running : 0 ms

WTR timer : 5 min Running : 0 s

WTB timer : 7 s Running : 0 s

Subring : No

Tc-limit enable : No

Tc-limit Interval : 2

Tc-limit Threshold : 3

Revertive operation : Revertive

R-APS channel : Non-Virtual channel

Enable status : Enable

Gigabitethernet0/3 Flush Logic

Remote Node ID : 0000-0000-0000

Remote BPR : 0

Gigabitethernet0/1 track CFM

MD Name :

MA Name :

MEP ID : 0

RMEP ID : 0

CFM State : 0

Port Name PortRole SwitchType PortStatus SignalStatus

Port0 gigabitethernet0/3 Normal -- Forwarding Non-failed

83 Network Test and Fault Diagnosis

83.1 Overview

With the network test and fault diagnosis tool, we can check the network connection status and diagnose the system fault. In daily maintenance, when it is necessary to check the network connection, we can use the ping function and traceroute function. When it is necessary to diagnose the system fault, we can open the system debugging information to diagnose the system fault.

83.2 Network Test and Fault Diagnosis Application

Table 83 Application List of Network Test and Fault Diagnosis

Application functions	
Ping function	ping
	ping ip
	Interactive ping
	groupping
Traceroute function	traceroute
	Interactive traceroute
System debugging function	System debugging

83.2.1 Ping Function

The ping function is used to check the network connection status and the availability of hosts. The ping function sends the ICMP echo request packet to the host and waits for the ICMP echo response, used to judge whether the destination is reachable. ping can also measure the round trip time from the source to the destination.

Configuration Condition

None

ping

Table 1 ping

Step	Command	Description
Check whether the specified destination address is reachable	**ping** [**vrf** *vrf-name*] {[**ip** *host-name* | *ip-address*] | [**ipv6** *host-name* | *ipv6-address*] | *host-name* | *ip-address* | *ipv6-address* } [**-l** *packet-length*] [**-w** *wait-time*] [**-n** *packet-number* | **-t**]	Mandatory

Interactive ping

If you need to use options such as loose source routing options, strict source routing options, logging routes, logging timestamps, or need to know the maximum ICMP packet size supported by the peer device, you can use interactive ping to achieve this.

Table 2 Interactive Ping

Step	Command	Description
Enter the interactive ping mode.	**ping** [**vrf** *vrf-name*]	Mandatory Execute this command in privileged user mode to enter ping interactive mode.
Configure Network Protocol Types	**Protocol** [**ip**]：[**ip** | **ipv6**]	Optional By default, the IPv4 protocol is used.

Step	Command	Description
Configure the destination IP address or host name.	**Target IP address or hostname**：{ *ip-address* | *host-name* }	Mandatory
Configure the number of attempts to send ICMP request packet.	**Repeat count** [**5**]：[*repeat-count*]	Optional By default, the number is 5.
Configure the length of the ICMP request packet.	**Datagram size** [**76**]：[*datagram-size*]	Optional The length of the packet is the length of the entire IP packet. By default, the packet length is 76 bytes.
Configure the timeout time for ICMP responses.	**Timeout in seconds** [**2**]：[*timeout*]	Optional By default, the timeout is 2 seconds.
Enable extended options.	**Extended commands** [**no**]：[**yes** | **no**]	Optional The configuration commands for the extended options are visible only after the extended options are enabled. By default, the extension option is not enabled.
Configure the extended option, source IP address or output interface for ICMP request packets.	**Source address or interface**：{ *ip-address* | *interfacename* }	Optional The command can only be configured if the extended option is enabled. By default, the source address and output interface of the request packets are not specified.

Step	Command	Description
Configure extended selection, service type of ICMP request packet.	**Type of service** [**0**]: [*tos*]	Optional. This command is supported only for IPv4 protocol. The command can only be configured after the extended option is enabled. By default, the TOS value is 0.
Configure extended options to ban reassembly.	**Set DF bit in IP header?** [**no**]: [**yes** / **no**]	Optional. This command is supported only for IPv4 protocol. The command can only be configured after the extended option is enabled. By default, no DF flag is set and reassembly is permitted.
Configure extended options to verify the data content of the response packet.	**Validate reply data?** [**no**]: [**yes** / **no**]	Optional. This command is supported only for IPv4 protocol. The command can only be configured after the extended option is enabled. By default, no data content is verified.
Configure extended options to enable ICMP request data content of the packet.	**Data pattern** [**abcd**]: [*data-pattern*]	Optional The command can only be configured after the extended option is enabled. By default, the data content template is set as "abcd".

Step	Command	Description
Configure extended options, loose source routing options, strict source routing options, logging routes, logging timestamps, and display details.	**Loose, Strict, Record, Timestamp, Verbose**[**none**]：[**l | s**] [**r / t / v**]	Optional. This command is supported only for IPv4 protocol. The command can only be configured after the extended option is enabled. By default, the extended option is not configured.
Enable sweep of the ICMP request packet.	**Sweep range of sizes** [**no**]：[**yes** / **no**]	Optional. This command is supported only for IPv4 protocol. By default, the sweep option is disabled.
Configure the sweep start value.	**Sweep min size** [**36**]：[*min-szie*]	Optional. This command is supported only for IPv4 protocol. This command can only be configured after sweep is enabled. By default, the sweep start value is 36.
Configure sweep end value.	**Sweep max size** [**18024**]：[*max-size*]	Optional. This command is supported only for IPv4 protocol. This command can only be configured after sweep is enabled. By default, the end value of sweep is 18024.
Configure sweep increment.	**Sweep interval** [**1**]：[*interval*]	Optional. This command is supported only for IPv4 protocol.

Step	Command	Description
		This command can only be configured after sweep is enabled. By default, the sweep increment is 1.

groupping

The device supports sending multiple ICMP echo requests at once to get a more accurate network connection status based on the number of ICMP reply packets returned by the destination host.

Table 3 Groupping

Step	Command	Description
Send multiple ICMP request packets to check if the specified destination address is reachable.	**groupping** [**vrf** *vrf-name*] { *hostname* | *ip-address* } [[**-l** *packet-length*] [**-g** *packet-group*] [**-w** *wait-time*] [**-n** *packet-number*] [**-t**]	Mandatory

Note

- When pinging the destination host name, first configure the DNS function. Otherwise, ping fails. For DNS configuration, refer to "DNS Configuration" in "IP Network Protocol Configuration".

83.2.2 Traceroute Function

The traceroute function is used to view the gateway through which a packet passes from the source to the destination. It is mainly used to detect whether the destination is reachable and to analyze the faulty network nodes. The executing process of traceroute is: First send one IP packet with TTL 1 to the destination host; the first-hop gateway drops the packet and returns one ICMP timeout error packet. In this way, traceroute gets the first gateway address in the path. And then traceroute sends one packet with TTL 2. In this way, get the address of the second-hop gateway. Continue the process until reaching the destination host. The UDP port number of the traceroute packet is the port number of the destination that cannot be used by any application program. After the destination receives the packet, return one error packet of the port unreachable. In this way, get all gateway addresses on the path.

Configuration Condition

None

traceroute

Table 4 Traceroute

Step	Command	Description
View the gateway through which the data packet travels from the source to the destination.	**traceroute** [**vrf** *vrf-name*] {{**ip** *host-name* | *ip-address*} | {**ipv6** *host-name* | *ipv6-address*} | *host-name* | *ip-address* | *ipv6-address* } [-f start-ttl] [-w wait-time] [-m max-ttl]	Mandatory

Interactive traceroute

Table 5 Interactive Traceroute

Step	Command	Description
Enter interactive traceroute mode.	**traceroute** [**vrf** *vrf-name*]	Mandatory Execute this command in privileged user mode to enter interactive traceroute mode.
Configure Network Protocol Types	**Protocol** [**ip**]：[**ip** | **ipv6**]	Optional By default, the IPv4 protocol is used.
Configure the destination IP address or host name.	**Target IP address or hostname**：{ *ip-address* | *host-name* }	Mandatory
Configure the source IP address or output interface for traceroute packets.	**Source address or interface**：{ *ip-address* | *interface-name* }	Optional By default, the source IP address or output interface of the

Step	Command	Description
		packet is not specified.
Configure the timeout period for each inspection packet response.	**Timeout in seconds** [**3**]：*timeout*	Optional By default, the timeout is 3 seconds.
Configure the number of attempts to send inspection packets with the same TTL value.	**Probe count** [**3**]：*probe-count*	Optional By default, the number is 3.
Configure the minimum TTL value for inspection packets.	**Minimum Time to Live** [**1**]：*min-ttl*	Optional By default, the minimum TTL value is 1.
Configure the maximum TTL value for inspection packets.	**Maximum Time to Live** [**30**]：*max-ttl*	Optional By default, the maximum TTL value is 30.
Configure the destination UDP port number of the inspection packets.	**Port Number** [**33434**]：*port-number*	Optional By default, the destination port number is 33434.
Configure loose source routing options, strict source routing options, logging routes, logging timestamps, and display details.	**Loose, Strict, Record, Timestamp, Verbose**[**none**]：[**l | s**] [**r / t / v**]	Optional. This command is supported only for IPv4 protocol. By default, the option is not configured.

83.2.3 System Debugging Function

To help the user diagnose the problem, the most function modules of the device provide the debugging function.

The debugging function has two switch controls:

- The debugging switch of the module, controlling whether to generate the debugging information of the module
- The output switch of the screen, controlling whether to output the debugging information to the terminal

Configuration Condition

None

System Debugging

Table 6 System Debugging

Step	Command	Description
Turn on the system debugging screen output switch for remote login.	**terminal monitor**	Optional Remote login includes telnet, ssh and other methods. By default, the switch is off.
Enter the global configuration mode.	**configure terminal**	-
Turn on the system debugging screen output switch in the console.	**logging console**	Optional By default, the switch is on.
Exit global configuration mode	**exit**	-
Turn on the debugging switch of the system function module.	**debug** { **all** | *module-name* [*option*] }	Optional By default, the debugging switches of all functional modules of the system are off.

Note

- The debugging information can be displayed on the terminal only after configuring debug module-name option, terminal monitor or logging console at the same time.
- The generating and output of the debugging information affect the system performance, so when it is necessary, had better use the debug module-name option command to open the specified debugging switch. The debug all command opens all debugging switches, so we

had better not use. After debugging ends, close the corresponding debugging switch in time or use the no debug all command to close all debugging switches.

83.2.4 Network Test and Fault Diagnosis Monitoring and Maintaining

Table 7 System Test and Fault Diagnosis Monitoring and Maintaining

Command	Description
show debugging	Display information about the function modules in the system for which the debugging switch is turned on.

83.3 Typical Configuration Example of Network Test and Fault Diagnosis

83.3.1 Application of Ping

Network Requirements

- Device1 failed to log into Device3 using telnet IP address, now you need to confirm whether IP route is reachable between Device1 and Device3.
- Device1 failed to log into Device3 using telnet IPv6 address, now you need to confirm whether IPv6 route is reachable between Device1 and Device3.

Network Topology

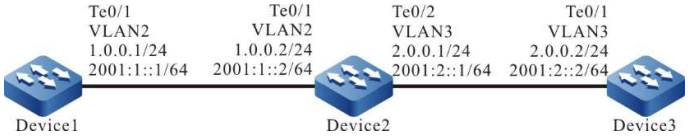


Figure 83 Network Topology for the Application of Ping

Configuration Steps

Step 1: Configure the IP address and IPv6 global unicast address of each interface. (Omitted)

Step 2: Use the ping command to see if Device1 and Device3 are reachable to each other.

#Check whether Device1 ping Device3's IP address 2.0.0.2 can be pinged through.

```
Device1#ping 2.0.0.2
```

```
Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to 2.0.0.2 , timeout is 2 seconds:
.....
Success rate is 0% (0/5).
```

#Check whether Device1 ping Device3's IPv6 address 2001:2::2 can be pinged through.

```
Device1#ping 2001:2::2

Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to 2001:2::2 , timeout is 2 seconds:
.....
Success rate is 0% (0/5).
```

Step 3: Use the ping command to see if Device1 and Device2 are reachable to each other.

#Check whether Device1 ping Device2's IP address 1.0.0.2 can be pinged through.

```
Device1#ping 1.0.0.2


Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to 1.0.0.2 , timeout is 2 seconds:
!!!!!
Success rate is 100% (5/5). Round-trip min/avg/max = 0/0/0 ms.
```

#Check whether Device1 ping Device2's IPv6 address 2001:1::2 can be pinged through.

```
Device1#ping 2001:1::2

Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to 2001:1::2 , timeout is 2 seconds:
!!!!!
Success rate is 100% (5/5). Round-trip min/avg/max = 0/0/0 ms.
```

Step 4: Use the ping command to see if Device2 and Device3 are reachable to each other.

#Check whether Device2 ping Device3's IP address 2.0.0.2 can be pinged through.

```
Device2#ping 2.0.0.2


Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to 2.0.0.2 , timeout is 2 seconds:
!!!!!
Success rate is 100% (5/5). Round-trip min/avg/max = 0/0/0 ms.
```

#Check whether Device2 ping Device3's IPv6 address 2001:2::2 can be pinged through.

```
Device2#ping 2001:2::2

Press key (ctrl + shift + 6) interrupt it.
Sending 5, 76-byte ICMP Echos to 2001:2::2 , timeout is 2 seconds:
!!!!!
Success rate is 100% (5/5). Round-trip min/avg/max = 0/176/883 ms.
```

From the above troubleshooting results, we can see that Device1 can communicate with Device2, and Device2 can communicate with Device3. The problem appears between Device1 and Device3. You can view the routing and other configurations subsequently, or use the **debug ip icmp** command and **debug ipv6 icmp** command to check whether the contents of ICMP packets and ICMPv6 packets are correct respectively, or you can use the traceroute command introduced in the following section to confirm the faulty network node.

83.3.2 Application of Traceroute

Network Requirements

- Device1 failed to log in to Device3 using telnet IP address, now you need to confirm whether the IP route between Device1 and Device3 is reachable, if the route is not reachable, then you need to identify the faulty network node.
- Device1 failed to log in to Device3 using telnet IPv6 address, now you need to confirm whether the IPv6 route between Device1 and Device3 is reachable, if the route is not reachable, then you need to identify the faulty network node.

Network Topology

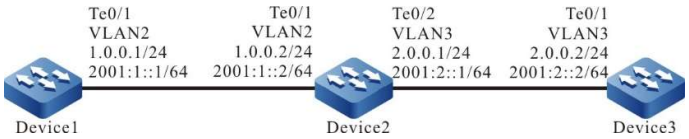


Figure 1 Network Topology for the Application of Traceroute

Configuration Steps

Step 1: Configure the IP address and IPv6 global unicast address of each interface. (Omitted)

Step 2: Use the traceroute command to identify the faulty node between Device1 and Device3.

#Use the traceroute command to identify the IPv4 faulty node between Device1 and Device3.

```
Device1#traceroute  2.0.0.2
Type escape sequence to abort.
Tracing the route to 2.0.0.2 , min ttl = 1, max ttl = 30 .

 1  1.0.0.2   0 ms   0 ms   0 ms
 2  *  *      *
 3  *  *      *
 4  *  *      *
 5  *  *      *
 6
```

Use the traceroute command to identify the IPv6 faulty node between Device1 and Device3.

```
Device1#traceroute 2001:2::2

Type escape sequence to abort.
Tracing the route to 2001:2::2 , min ttl = 1, max ttl = 30 .

 1  2001:1::2 0 ms   0 ms   0 ms
 2  *   *   *
 3  *   *   *
 4  *   *   *
 5  *   *   *
 6
```

From the above troubleshooting results, the traceroute packet from Device1 can reach Device2, and the traceroute packet from Device2 cannot reach Device3. Subsequently, you need to check the route

configuration and lines of Device2 and Device3, or use the **debug ip icmp** command and **debug ipv6 icmp** command to check whether the content of ICMP packet and ICMPvv6 packet is correct, and you can use the ping command in the previous section to check the connectivity between Device2 and Device3.

84 Keepalive Gateway

84.1 Overview

Keepalive gateway sets the Ethernet interface to send the keepalive packet to the specified gateway address, used to monitor the reachability of the destination gateway. When the gateway is unreachable, close the interface IP protocol layer.

After configuring the keepalive gateway on one interface, the interface regularly sends the ARP request packet to the configured gateway address. When the interface does not receive the ARP response packet for successive N times (N is the retry times configured for the user), close the interface IP protocol layer. Until receiving the ARP response packet again, enable the interface IP protocol layer.

84.2 Keepalive Gateway Function Configuration

Table 84 Keepalive Gateway Function Configuration List

Configuration Task	
Configure keepalive gateway.	Configure keepalive gateway basic functions.
	Configure the parameters for sending keepalive packets.
	Configure keepalive IPv6 associated gateway.

84.2.1 Configure Keepalive Gateway.

Configuration Condition

Before configuring the keepalive gateway function, do the following:

- Configure interface IP address.

Configure Keepalive Gateway Basic Functions

Table 84 Configuring Keepalive Gateway Basic Functions

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Configure keepalive gateway function.	**keepalive gateway** *ip-address* [*interval* | **msec** *interval*] [*retry-count*]	Mandatory By default, the keepalive gateway function is not enabled on the interface.

Configure the Parameters for Sending Keepalive Packets

Configure the parameters for sending keepalive packets to control the sending rate of the keepalive gateway packets. When the sending rate of keepalive packets reaches the configured value, you can continue to send keepalive packets after the configured time is paused.

Table 1 Configuring Parameters for Sending Keepalive Packet

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the sending rate of keepalive packets.	**keepalive gateway disperse pkt-rate** *packet-rate*	Optional By default, the maximum sending rate of keepalive packets is 100pps.
Configure the time for sending keepalive packets.	**keepalive gateway disperse pause-time** *pause-time*	Optional By default, the time for sending keepalive packets is 100 milliseconds.

Configure Keepalive IPv6 Associated Gateway

When keepalive IPv6 associated gateway is configured, the IPv6 protocol layer of the interface will be turned off at the same time when the gateway is unreachable.

Table 2 Configuring Keepalive IPv6 Associated Gateway

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the sending rate of keepalive packets.	**keepalive gateway ipv6-respond-ipv4**	Optional By default, keepalive the IPv6 associated gateway is disabled.

84.2.2 Keepalive Gateway Monitoring and Maintaining

Table 3 Keepalive Gateway Monitoring and Maintaining

Command	Description
clear keepalive gateway statistics [*interface-name*]	Clear the incoming and inbound and outbound statistics of keepalive gateway.
show keepalive gateway [*interface-name*]	View interfaces with keepalive gateway enabled, and their configurations.
show keepalive gateway disperse	View the configuration of the sending parameters of the keepalive packets.
show keepalive gateway statistics [*interface-name*]	View statistics on gateway activities.

84.3 Typical Configuration Example of Keepalive Gateway

84.3.1 Configure Keepalive Gateway Function

Network Requirements

- As a connecting device, Device 4 transmits the data in a transparent way.
- Device1, Device2, and Device3 are running the OSPF protocol for routing interactions.
- Device3 is preferred for the data flow from Device1 to the 201.0.0.0/24 network segment.
- The line between Device1 and Device3 has the enabled keepalive gateway. When the line between Device1 and Device3 fails, the keepalive gateway function will quickly detect the failure and modify the state of the relevant interface to down, and OSPF will switch the route to Device2 for communication after it senses the state change of the interface.

Network Topology

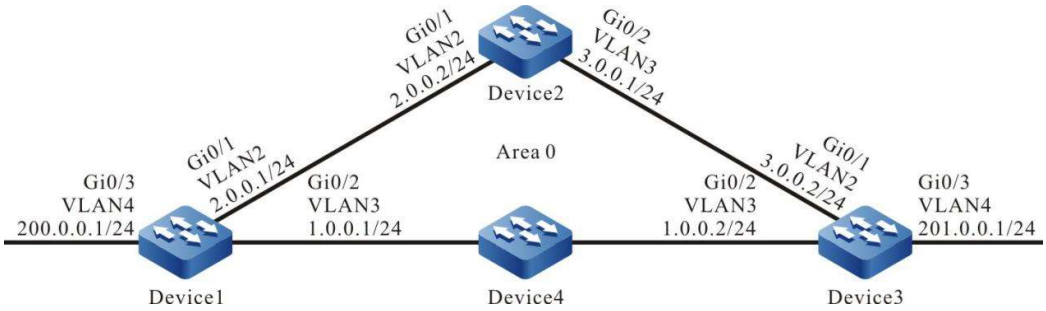


Figure 84 Network Topology for Configuring Keepalive Gateway

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure OSPF process.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#router ospf 100
Device1(config-ospf)#network 1.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#network 2.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#network 200.0.0.0 0.0.0.255 area 0
Device1(config-ospf)#exit
```

#Configure Device2.

```
Device2#configure terminal
Device2(config)#router ospf 100
Device2(config-ospf)#network 2.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#network 3.0.0.0 0.0.0.255 area 0
Device2(config-ospf)#exit
```

#Configure Device3.

```
Device3#configure terminal
Device3(config)#router ospf 100
```

```
Device3(config-ospf)#network 1.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#network 3.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#network 201.0.0.0 0.0.0.255 area 0
Device3(config-ospf)#exit
```

#View the routing table of Device1.

```
Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
     D - Redirect, E - IRMP, Ex - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   1.0.0.0/24 is directly connected, 00:20:17, vlan3
C   2.0.0.0/24 is directly connected, 13:01:32, vlan2
O   3.0.0.0/24 [110/2] via 2.0.0.2, 01:11:40, vlan2
          [110/2] via 1.0.0.2, 00:02:00, vlan3
C   200.0.0.0/24 is directly connected, 01:31:58, vlan4
O   201.0.0.0/24 [110/2] via 1.0.0.2, 00:02:00, vlan3
```

#Device3 is preferred for the data flow from Device1 to the 201.0.0.0/24 network segment.

Note

- Device2 and Device3 are viewed in the same way as Device1, and the viewing process is omitted.

Step 4: Configure keepalive gateway.

#Configure Device1.

```
Device1(config)#interface vlan 3
Device1(config-if-vlan3)#keepalive gateway 1.0.0.2
Device1(config-if-vlan3)#exit
```

#Configure Device3.

```
Device3(config)#interface vlan 3
Device3(config-if-vlan3)#keepalive gateway 1.0.0.1
Device3(config-if-vlan3)#exit
```

#View the keepalive gateway information of Device1.

```
Device1#show keepalive gateway
interface vlan3 gateway 1.0.0.2 time 10s retry 3 remain 3 now UP
```

#View the keepalive gateway information of Device3.

```
Device3#show keepalive gateway
interface vlan3 gateway 1.0.0.1 time 10s retry 3 remain 3 now UP
```

Step 5: Check the result.

#When the line between Device1 and Device3 fails, the keepalive gateway function will quickly detect the failure and change the state of interface VLAN3 to down.

```
Device1#show keepalive gateway
interface vlan3 gateway 1.0.0.2 time 10s retry 3 remain 0 now DOWN
```

#OSPF senses the state change of interface VLAN3 and switches the route to Device2 for communication.

```
Device1# show ip ospf interface vlan3
VLAN3 is down, line protocol is down
  OSPF is enabled, but not running on this interface

Device1#show ip route
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, Ex - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

C   2.0.0.0/24 is directly connected, 13:16:40, vlan2
O   3.0.0.0/24 [110/2] via 2.0.0.2, 00:01:25, vlan2
C   200.0.0.0/24 is directly connected, 00:10:53, vlan4
O   201.0.0.0/24 [110/3] via 2.0.0.2, 00:00:18, vlan2
```

It is indicated that Device2 is preferred for the data flow from Device1 to the 201.0.0.1/24 network segment.

85 SLA

85.1 Overview

SLA (Service Level Agreements) calculates the related parameters according to the packet transmission and outputs the report at last. SLA, also called RTR (Response Time Reporter), is one network detection and monitoring tool. SLA regularly sends the packets of the specified protocol to detect and monitor the network communication. SLA can diagnose different network applications and output the test result by configuring different types of RTR entities and adjusting.

SLA basic concepts:

- RTR Entity: RTR Entity is one universal concept and not related with the specific type of RTR entity. The current RTR entity types of the system include: the ICMP-echo entity, ICMP-path-echo entity, ICMP-path-jitter entity, and UDP-echo entity used to detect the network communication; the VoIP-jitter entity used to detect the network transmitting the VoIP packets; the FLOW-statistics entity used to detect the interface traffic; the MAC-ping entity used to detect the Ethernet link communication service quality.
- RTR Group: One RTR entity group is the set of one or multiple entities;
- RTR responder: The RTR responder is configured at the destination, mainly used to set up the connection with the source and respond the detection packet sent by the source. Most entities do not need to configure the responder, but when using the UDP-echo entity and VoIP-jitter entity, we should configure the responder.
- RTR Schedule: If only configuring the RTR entity or RTR entity group, we cannot detect, but should initiate the scheduling so that the detection can be completed.

85.2 SLA Function Configuration

Table 85 SLA Function Configuration List

Configuration Task	
Enable RTR.	Enable RTR.

Configuration Task	
Configure an RTR entity.	Create an RTR entity.
	Configure ICMP-echo Entity
	Configure an ICMPv6-echo entity.
	Configure ICMP-path-echo Entity
	Configure ICMP-path-jitter Entity
	Configure VoIP-jitter Entity
	Configure UDP-echo Entity
	Configure FLOW-statistics Entity
	Configure entity common configuration.
Configure RTR Entity Group	Configure RTR Entity Group
Configure RTR Responder	Configure RTR Responder
Configure RTR Scheduler	Configure RTR Scheduler
Configure Pausing Scheduling Entity	Configure Pausing Scheduling Entity
Configure Restoring Scheduling Entity	Configure Restoring Scheduling Entity

85.2.1 Enable RTR.

Among the various configuration tasks of RTR, it must be enabled first before the configuration of other functional features can take effect.

Configuration Condition

None

Enable RTR.

Table 1 Enabling RTR

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable RTR.	**rtr enable**	Mandatory By default, RTR is not enabled.

85.2.2 Configure an RTR entity.

Configuration Condition

Before configuring an RTR entity, do the following:

Enable RTR.

Create an RTR Entity

There is one type of detection for each type of entity. After creating an RTR entity and entering the configuration mode for that entity, you can configure the specific parameters of the entity.

Table 2 Creating a RTR Entity

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create an RTR entity.	**rtr** *entity-id entity-type*	Mandatory

Configure ICMP-echo Entity

The ICMP-echo entity is to detect the network communication. It regularly sends the ICMP echo request packet to one destination address in the network, so as to get the delay and packet loss of the packet transmission from the detection end to the destination end. In one detection period, as long as the ICMP-echo entity receives one ICMP echo request response packet, the entity status is reachable.

The general network devices all support ping, so the entity can take effect in detecting the network communication. With the rich scheduling policies and log recording function, we can let the network administrator get to know the network communication status and history information in time and reduce inputting the common ping command frequently at the same time.

Table 3 Configuring an ICMP-Echo Entity

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the ICMP-echo entity configuration mode.	**rtr** *entity-id* [**icmpecho**]	-
Configure the detection attributes.	**set** [**vrf** *vrf-name*] *target-ip-address* [*npacket*] [*data-size*] [*timeout*] [*frequency-value*] [**extend** *source-ip-address* [*tos*] [*set-DF*] [*verify-data*]]	Mandatory By default, no detection attribute of the entity is configured.
Configure to set the rtt value as the basis for determining whether the entity is reachable.	**status-care rtt**	Optional By default, the rtt value is not used to determine whether the entity is reachable.
Configure entity common configuration.	Please refer to the section on configuring entity common configuration.	Optional

Note

- The schedule interval (frequency-value) of the ICMP-echo entity needs to satisfy the following requirements: schedule interval > npacket * timeout.
- If a scheduler is configured for the entity, the aging time of the scheduler must be greater than the schedule interval for the entity.

Configuring ICMPv6-Echo Entities

The role of an ICMPV6-echo entity is to detect the network communication. It regularly sends the ICMP echo request packet to one destination address in the network, so as to get the delay and packet loss of the packet transmission from the detection end to the destination end. In one detection period, as long as the ICMPV6-echo entity receives one ICMP echo request response packet, the entity status is reachable.

The general network devices all support ping, so the entity can take effect in detecting the network communication. With the rich scheduling policies and log recording function, we can let the network

administrator get to know the network communication status and history information in time and reduce inputting the common ping command frequently at the same time.

Table 4 Configuring an ICMPV6-Echo Entity

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the ICMP-echo entity configuration mode.	**rtr** *entity-id* [**icmpv6echo**]	-
Configure the detection attributes.	**set** [**vrf** *vrf-name*] *target-ip-address* [*npacket*] [*data-size*] [*timeout*] [*frequency-value*] [**extend** *source-ip-address* [*tos*] [*verify-data*]]	Mandatory By default, no detection attribute of the entity is configured.
Configure to set the rtt value as the basis for determining whether the entity is reachable.	**status-care rtt**	Optional By default, the rtt value is not used to determine whether the entity is reachable.
Configure entity common configuration.	Please refer to the section on configuring entity common configuration.	Optional

Note

- The schedule interval (frequency-value) of the ICMPV6-echo entity needs to satisfy the following requirements: schedule interval > npacket * timeout.
- If a scheduler is configured for the entity, the aging time of the scheduler must be greater than the schedule interval for the entity.

Configure ICMP-path-echo Entity

The ICMP-path-echo entity is to detect the network communication. It regularly sends the ICMP echo request packet to one destination address in the network, so as to get the delay and packet loss of the

packet transmission from the detection end to the destination end, as well as the delay and packet loss between the detection end and the intermediate devices from the detection end to the destination. In one detection period, as long as the ICMP-path-echo entity receives one ICMP echo request response packet, the entity status is reachable.

The general network devices all support ping, so the entity can take effect in detecting the network communication. With the rich scheduling policies and log recording function, we can let the network administrator get to know the network communication status (for example, which network device on the path has serious delay) and history information in time.

Table 5 Configuring an ICMP-Path-Echo Entity

Step	Command	Description
Enter the system configuration mode	**configure terminal**	-
Enter the ICMP-path-echo entity configuration mode.	**rtr** *entity-id* [**icmp-path-echo**]	-
Configure the detection attributes.	**set dest-ipaddr** *target-ip-address* [**source-ipaddr** *source-ip-address*]	Mandatory
Configure loose source station routing.	**lsr-path** [*hop-ip-address-list* | **none**]	Optional By default, no loose source station routing is configured.
Configure to detect only the network conditions from the source to the destination.	**targetOnly** [**true** | **false**]	Optional By default, targetOnly is true to detect only the network conditions from the source to the destination. If targetOnly is configured to false, it will detect the network conditions from the source to the destination hop by hop.
Configure whether to verify the data content of the response packet.	**verify-data** [**true** | **false**]	Optional By default, no data content is verified.

Step	Command	Description
Configure entity common configuration.	Please refer to the section on configuring entity common configuration.	Optional

Configure ICMP-path-jitter Entity

The ICMP-path-jitter entity is to detect the network communication. It regularly sends the ICMP echo request packet to one destination address in the network, so as to get the delay, jitter, and packet loss of the packet transmission from the detection end to the destination end, as well as the delay, jitter and packet loss between the detection end and the intermediate devices from the detection end to the destination. In one detection period, as long as the ICMP-path-jitter entity receives one ICMP echo request response packet, the entity status is reachable.

The general network devices all support ping, so the entity can take effect in detecting the network communication. With the rich scheduling policies and log recording function, we can let the network administrator get to know the network communication status (for example, which network device on the path has serious delay) and history information in time.

Table 6 Configuring an ICMP-Path-Jitter Entity

Step	Command	Description
Enter the system configuration mode	**configure terminal**	-
Enter the ICMP-path-jitter entity configuration mode.	**rtr** *entity-id* [**icmp-path-jitter**]	-
Configure the detection attributes.	**set dest-ipaddr** *target-ip-address* [*pkt-number*] [*pkt-interval*] [**source-ipaddr** *source-ip-address*]	Mandatory
Configure the IP address of the loose source station routing.	**lsr-path** [*hop-ip-address-list* | **none**]	Optional By default, no source station routing is configured.
Configure to detect only the network conditions from the source to the destination.	**targetOnly** [**true** | **false**]	Optional By default, targetOnly is true to detect only the network conditions from the source to the destination.

Step	Command	Description
		If targetOnly is configured to false, it will detect the network conditions from the source to the destination hop by hop.
Configure the jitter threshold and the overrun rule.	**threshold-jitter** *jitter* **direction** { **be** | **se** }	Optional By default, the jitter threshold is 6000 milliseconds and the overrun rule is be.
Configure whether to verify the data content of the response packet.	**verify-data** [**true** | **false**]	Optional By default, no data content is verified.
Configure entity common configuration.	Please refer to the section on configuring entity common configuration.	Optional

Note

- When the over-limit rule is be and the actual value is larger than or equal to the threshold, it judged as over-limit; when the over-limit rule is se and the actual value is smaller than or equal to the threshold, it is judged as over-limit.

Configure VoIP-jitter Entity

The VoIP-jitter entity is the RTR entity used to measure the transmission quality of the VoIP packet in the general IP network.

The VoIP-jitter entity can simulate the G.711 A Law, G.711 mu Law, and G.729A codec or the customized codes to send the UDP packet with the corresponding rate, packet interval and size from the source device to the destination device, measure the turnaround time, uni-directional packet loss and uni-directional delay of the packet, and calculates the ICPIF value based on the statistics information. At last, estimate the MOS value according to the ICPIF value. In the detection period, as long as the VoIP-jitter entity receives one detection response packet, the status of the entity is reachable.

Table 7 Configuring a VoIP-jitter Entity

Step	Command	Description
Enter the system configuration mode	**configure terminal**	-
Enter the VoIP-jitter entity configuration mode.	**rtr** *entity-id* [**jitter**]	Mandatory If the entity already exists, go directly to entity configuration mode.
Configure the detection attributes.	**set dest-ipaddr** *target-ip-address* **dest-port** *target-port* { **g711alaw** | **g711ulaw** | **g729a** | **user_defined** *packet-size packet-number packet-interval schedule-interval* } [**source-ipaddr** *source-ip-address*] [**source-port** *source-port*]	Mandatory
Configure the source-to-destination one-way delay threshold and the overrun rule.	**threshold-sd-delay** *sd-delay* **direction** { **be** | **se** }	Optional By default, the source-to-destination delay threshold is 5000 milliseconds and the overrun rule is be.
Configure the source-to-destination one-way jitter threshold and the overrun rule.	**threshold-sd-jitter** *sd-jitter* **direction** { **be** | **se** }	Optional By default, the source-to-destination one-way jitter threshold is 6000 milliseconds, and the overrun rule is be.
Configure the source-to-destination packet loss threshold and the overrun rule.	**threshold-sd-pktloss** *sd-packet* **direction** { **be** | **se** }	Optional By default, the source-to-destination packet loss threshold is 60000, and the overrun rule is be.
Configure the destination-to-source one-way delay threshold and the overrun rule.	**threshold-ds-delay** *ds-delay* **direction** { **be** | **se** }	Optional By default, the destination-to-source delay threshold is 5000 milliseconds and the overrun rule is be.

Step	Command	Description
Configure the destination-to-source one-way jitter threshold and the overrun rule.	**threshold-ds-jitter** *ds-jitter* **direction** { be | se }	Optional By default, the destination-to-source one-way jitter threshold is 6000 milliseconds, and the overrun rule is be.
Configure the destination-to-source packet loss threshold and the overrun rule.	**threshold-ds-pktloss** *ds-packet* **direction** { **be** | **se** }	Optional By default, the destination-to-source packet loss threshold is 60000, and the overrun rule is be.
Configure the threshold and the overrun rule for icpif value.	**threshold-icpif** *icpif-value* **direction** { **be** | **se** }	Optional By default, the icpif threshold is 100000000, and the overrun rule is be.
Configure the threshold and the overrun rule for mos value.	**threshold-mos** *mos-value* **direction** { **be** | **se** }	Optional By default, the mos threshold value is 10000000 and the overrun rule is be.
Configure entity common configuration.	Please refer to the section on configuring entity common configuration.	Optional

Note

- When using the VoIP-jitter entity detection, besides configuring the VoIP-jitter entity, we also need to configure the RTR responder at the destination.
- By default, the VoIP-jitter entity sends many packets, which occupy the network bandwidth, so when configuring the entity exceeds one hour, the shell prompts.
- When the VoIP-jitter entity detects the network transmitting the VoIP packet, the clocks of the source and the destination need to be consistent, so before scheduling the VoIP-jitter entity, we also need to configure the NTP server at the destination and NTP client at the source. After the clocks are synchronized, configure the RTR responder, and at last, configure the scheduler. For the configuration of NTP, refer to NTP configuration-related chapter.
- When the over-limit rule is be and the actual value is larger than or equal to the threshold, it judged as over-limit; when the over-limit rule is se and the actual value is smaller than or equal

to the threshold, it is judged as over-limit.

Configure UDP-echo Entity

The UDP-echo entity mainly detects the UDP packet transmitted in the IP network. In the entity, we need to specify the destination address and port of the sent packet. We can monitor the transmission of the UDP packet in the IP network by scheduling the entity. In one detection period, as long as the UDP-echo entity receives one detection response packet, the entity status is reachable.

The UDP-echo entity can monitor efficiently to record the turnaround delay, packet loss and other information of the UDP packet in the IP network, even record the monitored history information by logs so that the network administrator can get to know the network communication and fix the fault.

Table 8 Configuring a UDP-echo Entity

Step	Command	Description
Enter the system configuration mode	**configure terminal**	-
Enter the UDP-echo entity configuration mode.	**rtr** *entity-id* [udpecho]	Mandatory If the entity already exists, go directly to entity configuration mode.
Configure the detection attributes.	**set dest-ipaddr** *target-ip-address* **dest-port** *target-port* [**source-ipaddr** *source-ip-address*] [**source-port** *source-port*]	Mandatory By default, the detection attribute of an UDP-echo entity is not configured.
Configure packet padding content.	**data-pattern** *pad*	Optional By default, the padding content is "ABCD".
Configure entity common configuration.	Please refer to the section on configuring entity common configuration.	Optional

Note

- When using the UDP-echo entity detection, besides configuring the UDP-echo entity, we also need to configure the RTR responder at the destination.

Configure FLOW-statistics Entity

The FLOW-statistics entity is to detect the interface traffic and one entity corresponds to one interface. We can monitor the traffic on the interface by scheduling the entity. In one detection period, as long as there are packets passing the interface monitored by the FLOW-statistics entity, the entity status is reachable.

The interval of the FLOW-statistics entity monitoring the interface traffic is 10s-10min. We can record the traffic peak value information on the interface by monitoring, even can record the history information of the traffic statistics during each monitoring, so as to make the network administrator get to know the network communication status and fix the fault.

Table 9 Configuring a FLOW-statistics Entity

Step	Command	Description
Enter the system configuration mode	**configure terminal**	-
Enter the FLOW-statistics entity configuration mode.	**rtr** *entity-id* [**flow-statistics**]	Mandatory If the entity already exists, go directly to entity configuration mode.
Configure the detection attributes.	**flow-statistics interface** *interface-name* **interval** *interval*	Mandatory
Configure the inflow threshold and the overrun rule for the interface.	**threshold-inflow** *flow-value* **direction** { **be** | **se** }	Optional By default, the inflow threshold of the interface is 200000000bps (bits/sec), and the overrun rule is be.
Configure the threshold for the number of packets received by the interface and the overrun rule.	**threshold-inpacket** *packet-value* **direction** { **be** | **se** }	Optional By default, the threshold for the number of packets received by the interface is 200000000, and the overrun rule is be.
Configure the outflow threshold and the overrun rule for the interface.	**threshold-outflow** *flow-value* **direction** { **be** | **se** }	Optional By default, the interface outflow threshold is 200000000 bps (bits per

Step	Command	Description
		second), and the overrun rule is be.
Configure the threshold for the number of packets sent by the interface and the overrun rule.	**threshold-outpacket** *packet-value* **direction** { **be** | **se** }	Optional By default, the threshold for the number of packets sent by the interface is 200000000, and the overrun rule is be.
Configure entity common configuration.	Please refer to the section on configuring entity common configuration.	Optional

Note

- When the over-limit rule is be and the actual value is larger than or equal to the threshold, it judged as over-limit; when the over-limit rule is se and the actual value is smaller than or equal to the threshold, it is judged as over-limit.

Entity Common Configuration

Table 10 Entity Common Configuration

Step	Command	Description
Configure alarm types.	**alarm-type** [**log** | **log-and-trap** | **trap** | **none**]	Optional By default, the alarm mode is none, i.e. no alarm.
Configure the number of history records to be saved.	**number-of-history-kept** *history-number*	Optional By default, 1 history record is saved.
Configure the period for saving history.	**periods** *periods*	Optional By default, 1 history record is saved at the end of each schedule.
Configure timeout.	**timeout** *timeout*	Optional

Step	Command	Description
		By default, the timeout is: For ICMP-path-echo entity, the timeout is 5000 milliseconds. For ICMP-path-jitter entity, the timeout is 5000 milliseconds. For VoIP-jitter entity, the timeout is 50000 milliseconds. For UDP-echo entity, the timeout is 5000 milliseconds. Entities that do not support the common command: ICMP-echo entity ICMPv6-echo entity FLOW-statistics entity
Configure the TOS value of a packet.	**tos** *tos-value*	Optional By default, the TOS value is 0. Entities that do not support the common command: ICMP-echo entity ICMPv6-echo entity FLOW-statistics entity
Configure the VRF attribute of an entity.	**vrf** *vrf-name*	Optional By default, the VRF attribute of entity is not configured. Entities that do not support the common command: ICMP-echo entity ICMPv6-echo entity FLOW-statistics entity
Configure the schedule interval for the entity.	**frequency** *seconds*	Optional By default, the schedule interval is:

Step	Command	Description
		For ICMP-path-echo entity, the interval is 60 seconds. For ICMP-path-jitter entity, the interval is 60 seconds. For UDP-echo entity, the interval is 60 seconds. Entities that do not support the common command: ICMP-echo entity ICMPv6-echo entity VoIP-jitter entity FLOW-statistics entity
Configure the length of the detection packet.	**request-data-size** *data-size*	Optional By default, the length of a detection packet is: For ICMP-path-echo entity, the length is 70 bytes. For ICMP-path-jitter entity, the length is 70 bytes. For UDP-echo entity, the length is 16 bytes. Entities that do not support the common command: ICMP-echo entity ICMPv6-echo entity VoIP-jitter entity FLOW-statistics entity
Configure the packet loss threshold and the overrun rule.	**threshold-pktloss** *pktloss* **direction** { **be | se** }	Optional By default, the packet loss threshold is: For ICMP-echo entity, the threshold is 150. For ICMPv6-echo entity, the threshold is 150.

Step	Command	Description
		For ICMP-path-echo entity, the threshold is 1. For ICMP-path-jitter entity, the threshold is 100. For UDP-echo entity, the threshold is 1. The overrun rule is be. Entities that do not support the common command: VoIP-jitter entity FLOW-statistics entity
Configure the bi-directional delay threshold and the overrun rule.	**threshold-rtt** *rtt* **direction** { **be** | **se** }	Optional By default, the bi-directional delay threshold is: For ICMP-echo entity, the threshold is 9000 milliseconds. For ICMPv6-echo entity, the threshold is 9000 milliseconds. For ICMP-path-echo entity, the threshold is 9000 milliseconds. For ICMP-path-jitter entity, the threshold is 9000 milliseconds. For VoIP-jitter entity, the threshold is 9000 milliseconds. For UDP-echo entity, the threshold is 9000 milliseconds. The overrun rule is be. Entities that do not support the common command: FLOW-statistics entity

Note

- If the RTR entity already exists and the entity is in the un-scheduled state, execute the rtr

entity-id command to enter the entity configuration mode directly.

- When the over-limit rule is be and the actual value is larger than or equal to the threshold, it judged as over-limit; when the over-limit rule is se and the actual value is smaller than or equal to the threshold, it is judged as over-limit.
- The schedule interval of the ICMP-path-echo entity needs to meet the following requirement: schedule interval > timeout.
- The schedule interval of the ICMP-path-jitter entity needs to meet the following requirements: schedule interval > timeout; timeout needs to meet the following requirements: timeout > pkt-number * pkt-interval; For the pkt-number parameter and the pkt-interval parameter, refer to the **set** command of the ICMP-path-echo entity.
- When the schedule interval of the VoIP-jitter entity selects simulating G.711ALaw, G.711muLaw, and G.729A codec, it is necessary to meet the following requirement: schedule interval > timeout + 5; when selecting the customized codec, it is necessary to meet the following requirement: schedule interval > schedule-interval + 5; schedule-interval needs to meet the following requirement: schedule-interval > packet-number * packet-interval; for the schedule-interval, packet-number and packet-interval parameters, refer to the **set** command of the VoIP-jitter entity.
- The schedule interval of the UDP-echo entity needs to meet the following requirement: schedule interval > timeout + 5.

85.2.3 Configure RTR Entity Group

One RTR entity group is the set of one or multiple RTR entity groups. One RTR entity can belong to multiple RTR entity groups and the group cannot become the member of the group. One group can only contain one member once. The RTR entity group is identifies by the group ID uniquely and the group name is automatically generated by the system.

The RTR entity group is mainly to schedule one RTR set. The scheduling for the RTR entity group is equivalent to the scheduling for all RTR entities in the RTR entity group. The detection result is saved in the history records of the RTR entity.

Configuration Condition

Before configuring an RTR entity group, do the following:

Enable RTR.

Configure RTR Entity Group

Table 11 Configure RTR Entity Group

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the configuration mode of an RTR entity group.	**rtr group** *group-id*	Mandatory If no corresponding RTR entity group exist, it will be created automatically.
Add members to an RTR entity group.	**member** *entity-list*	Optional By default, an RTR entity group does not contain any members.
Configure options of an RTR entity group.	**option** {**or** | **and** }	Optional By default, the status option of an RTR entity group is and (the group status is showed as reachable when all entities in the group are reachable).
Configure the schedule interval between members within the RTR entity group.	**interval** *interval*	Optional By default, the schedule interval for group members is 0 seconds.
Configure the RTR entity group to automatically generate a scheduler.	**group probe**	Optional By default, the RTR entity group is not configured to auto-generate a scheduler.

Note

- One VoIP-jitter entity or UDP-echo entity cannot be added to multiple groups for scheduling. Otherwise, the scheduling result may be wrong.
- The calculation method for the scheduling interval of the RTR entity group is as follows: scheduling interval = the maximum of all member scheduling intervals + (member quantity – 1) * scheduling interval between the members.

85.2.4 Configure RTR Responder

The RTR responder is mainly used to set up the connection with the source end and respond the detection packets sent by the source end, so as to ensure that the detection result is correct. The VoIP-jitter entity and the UDP-echo entity need to set up the connection with the destination end, so we should configure the RTR responder at the destination end.

Configuration Condition

Before configuring an RTR entity responder, do the following:

Enable RTR.

Configure RTR Responder

Table 12 Configuring RTR Transponder

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure RTR Responder	**rtr responder**	Mandatory By default, no RTR responder is configured.

85.2.5 Configure RTR Scheduler

The RTR scheduler is the policy of the scheduling detection for the RTR entity or group. The RTR scheduler can take one entity member as the object and also can take one RTR entity group as the object, but cannot take the group and entity as the object together. The RTR scheduler is identified by the schedule ID uniquely and not related with the RTR entity type, but the scheduling interval should consider the attributes of the scheduled RTR entity or the members in the RTR entity group. The RTR scheduler provides rich scheduling policies and can select to schedule at once or start to schedule after some time, even can set the absolute time of starting the scheduling. Besides, the scheduler can automatically demise after the set scheduling times and also can always exist.

Configuration Condition

Before configuring an RTR scheduler, do the following:

Configure the RTR entity or RTR entity group that need to be scheduled.

Configure RTR Scheduler

Table 13 Configuring RTR Dispatcher

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure an RTR scheduler to schedule an entity or group.	**rtr schedule** *schedule-id* { **entity** *entity-id* | **group** *group-id* } **start** { *hh:mm* [:*ss*] *date month year* | **after** *hh:mm* [:*ss*] | **now** } **ageout** *ageout-time* **life** { **forever** | *life-time* **repeat** *repeat-times* }	Mandatory By default, no RTR scheduler is configured.

Note

- The age time of the RTR scheduler should be larger than the scheduling interval of the scheduling object. Otherwise, after one scheduling, the scheduler is deleted because of aging and timeout.

85.2.6 Configure Pausing Scheduling Entity

For an entity undergoing scheduling, you can configure to suspend schedule of that entity.

Configuration Condition

Before configuring to suspend entity schedule, do the following:

The entity is in scheduling.

Configure Pausing Scheduling Entity

Table 14 Configuring Pause Entity Scheduling

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Pausing Scheduling Entity	**rtr** *entity-id* **halt**	Optional By default, an entity in schedule is not suspended.

Note

- Only one entity can configure rtr halt. If the entity is the member of the RTR entity group, we cannot configure rtr halt.
- After configuring rtr halt and if still not configuring rtr resume before the scheduling period ends, the scheduler of scheduling the entity is deleted because of aging and timeout.

85.2.7 Configure Restoring Scheduling Entity

For entities that are suspended from scheduling, you can configure to resume scheduling of that entity.

Configuration Condition

Before configuring to recover schedule of an entity, do the following:

- The entity is suspended from scheduling.

Configure Restoring Scheduling Entity

Table 15 Configuring Recovery Entity Scheduling

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Restoring Scheduling Entity	**rtr** *entity-id* **resume**	Optional

85.2.8 SLA Monitoring and Maintaining

Table 16 SLA Monitoring and Maintaining

Command	Description
show rtr entity [*entity-id*]	Display information about an RTR entity.
show rtr group [*group-id*]	Display information about an RTR entity group.
show rtr history *entity-id*	Display history records of a specified RTR entity.
show rtr schedule [*schedule-id*]	Display information about an RTR scheduler.

85.3 Typical Configuration Example of SLA

85.3.1 Configure an ICMP-echo entity to detect the network communication.

Network Requirements

- The ICMP-echo entity is used on Device1 to detect the network communication from Device1 to Device3.

Network Topology

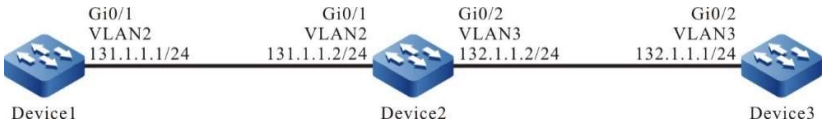


Figure 85 Network Topology for Configuring an ICMP-echo Entity

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure the IP address and route of each interface to enable communication between Device1 and Device3. (Omitted)

Step 3: Configure an ICMP-echo-type entity and add attribute parameters.

#Configure Device1.

```
Device1#config terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 icmpecho
Device1(config-rtr-icmpecho)#set 132.1.1.1 5 70 2 12 extend 131.1.1.1 0 TRUE FALSE
Device1(config-rtr-icmpecho)#alarm-type log
Device1(config-rtr-icmpecho)#number-of-history-kept 255
Device1(config-rtr-icmpecho)#threshold-pktLoss 10 direction be
Device1(config-rtr-icmpecho)#threshold-rtt 1000  direction be
Device1(config-rtr-icmpecho)#exit
```

#View the parameters of an ICMP-echo entity.

```
Device1#show rtr entity 1
-----------------------------------------------------------------
ID:1          name:IcmpEcho1        Created:TRUE
***************type:ICMPECHO****************
CreatedTime:WED OCT 31 14:49:31 2012
LatestModifiedTime:WED OCT 31 14:53:53 2012
Times-of-schedule:0
TargetIp:132.1.1.1
Transmit-packets:5
Totally-send-packets:0
Packet-size:70
Timeout:2(s)
Alarm-type:log
Threshold-of-rtt:1000(ms) direction:be
Threshold-of-packet-loss:10 direction:be
Number-of-history-kept:255
```

```
Periods:1
Extend parameters:
sourceIp:131.1.1.1      tos:0   DF(DON'T FRAG):TRUE     Verify-data:FALSE
In-scheduling:FALSE
Schedule frequency:12(s)
Status:DEFAULT
```

The results show that the entity parameters are consistent with the configuration.

In-scheduling:FALSE indicates that the entity is not scheduled.

Status:DEFAULT indicates that the entity status is DEFAULT.

Note

- When an entity is not scheduled, its status is DEFAULT; when an entity is scheduled, if the entity is reachable, its status is REACHABLE, if it is unreachable, its status is UNREACHABLE.

Step 4: Schedule a defined ICMP-echo entity, and define attribute parameters of the schedule.

#Configure Device1

```
Device1(config)#rtr schedule 1 entity 1 start now ageout 100 life forever
```

Step 5: Check the result.

1) When the network communication from Device1 to Device3 is normal.

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1            name:IcmpEcho1          Created:TRUE
****************type:ICMPECHO*****************
CreatedTime:WED OCT 31 14:49:31 2012
LatestModifiedTime:WED OCT 31 14:53:53 2012
Times-of-schedule:1
Time-of-last-schedule:WED OCT 31 14:54:07 2012
TargetIp:132.1.1.1
Transmit-packets:5
Totally-send-packets:5
Packet-size:70
Timeout:2(s)
Alarm-type:log
Threshold-of-rtt:1000(ms) direction:be
Threshold-of-packet-loss:10 direction:be
Number-of-history-kept:255
Periods:1
Extend parameters:
sourceIp:131.1.1.1      tos:0   DF(DON'T FRAG):TRUE     Verify-data:FALSE
In-scheduling:TRUE
Schedule frequency:12(s)
Status:REACHABLE
```

In-scheduling:TRUE indicates that the entity is in scheduling.

Status: REACHABLE means that the entity status is reachable, that is, the network communication from Device1 to Device3 is normal.

1) When the network communication from Device1 to Device3 fails.

Since the entity parameters are configured with the alarm mode as log, the alarm message is printed on the device when the network is down, as follows:

```
Oct 31 14:54:46: [tRtrIcmpRcv]Rtr 1 (ICMPECHO) rtt [9000ms] was exceeded(>=) threshold [1000ms].
```

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1            name:IcmpEcho1          Created:TRUE
***************type:ICMPECHO***************
CreatedTime:WED OCT 31 14:49:31 2012
LatestModifiedTime:WED OCT 31 14:53:53 2012
Times-of-schedule:4
Time-of-last-schedule:WED OCT 31 14:54:43 2012
TargetIp:132.1.1.1
Transmit-packets:5
Totally-send-packets:20
Packet-size:70
Timeout:2(s)
Alarm-type:log
Threshold-of-rtt:1000(ms) direction:be
Threshold-of-packet-loss:10 direction:be
Number-of-history-kept:255
Periods:1
Extend parameters:
sourceIp:131.1.1.1      tos:0   DF(DON'T FRAG):TRUE     Verify-data:FALSE
In-scheduling:TRUE
Schedule frequency:12(s)
Status:UNREACHABLE
```

In-scheduling:TRUE indicates that the entity is in scheduling.

Status: UNREACHABLE means that the entity status is unreachable, that is, the network communication from Device1 to Device3 fails.

#View the history records.

```
Device1#show rtr history 1
----------------------------------------------------------------
ID:1    Name:IcmpEcho1  CurHistorySize:4        MaxHistorysize:255
History recorded as following:
WED OCT 31 14:54:46 2012
       PktLoss:5        ,Rtt:invalid
WED OCT 31 14:54:32 2012
       PktLoss:0        ,Rtt:11       (ms)
WED OCT 31 14:54:20 2012
       PktLoss:0        ,Rtt:2        (ms)
WED OCT 31 14:54:07 2012
        PktLoss:0       ,Rtt:2        (ms)
```

The history records provide details about the packet loss and latency of each schedule; an invalid Rtt indicates that there is a failure in the network causing the network to be unreachable.

85.3.2 Configure an ICMP-path-echo Entity to Detect Network Communication

Network Requirements

- An ICMP-path-echo entity is used on Device1 to detect the network communication of the path from Device1 to Device3.

Network Topology

Figure 1 Network Topology for Configuring an ICMP-Path-Echo Entity

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure the IP address and route of each interface to enable communication between Device1, Device2 and Device3. (Omitted)

Step 3: Configure an ICMP-path-echo-type entity and add attribute parameters.

#Configure Device1.

```
Device1#config terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 icmp-path-echo
Device1(config-rtr-icmppathecho)#set dest-ipaddr 192.0.0.2 source-ipaddr 110.1.0.1
Device1(config-rtr-icmppathecho)#number-of-history-kept 255
Device1(config-rtr-icmppathecho)#targetOnly false
Device1(config-rtr-icmppathecho)#exit
```

#View the parameters of an ICMP-path-echo entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1            name:IcmpPathEcho1              Created:TRUE
****************type:ICMPPATHECHO****************
CreatedTime:WED OCT 24 10:18:02 2012
LatestModifiedTime:WED OCT 24 10:19:09 2012
Times-of-schedule:0
TargetIp:192.0.0.2
SourceIp:110.1.0.1
Transmit-packets:1 (each hop)
Request-data-size:70
Timeout:5000(ms)
Frequency:60(s)
TargetOnly:FALSE
Verify-data:FALSE
Alarm-type:none
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-pktloss:1 direction:be
Number-of-history-kept:255
Periods:1
In-scheduling:FALSE
Status:DEFAULT
----------------------------------------------------------------
```

The results show that the entity parameters are consistent with the configuration.

In-scheduling:FALSE indicates that the entity is not scheduled.

Status:DEFAULT indicates that the entity status is DEFAULT.

Step 4: Schedule a defined ICMP-path-echo entity, and define attribute parameters of the schedule.

#Configure Device1.

```
Device1(config)#rtr schedule 1 entity 1 start now ageout 100 life 600 repeat 10
```

Step 5: Check the result.

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:IcmpPathEcho1            Created:TRUE
***************type:ICMPPATHECHO***************
CreatedTime:WED OCT 24 10:18:02 2012
LatestModifiedTime:WED OCT 24 10:19:09 2012
Times-of-schedule:1
Time-of-last-schedule:WED OCT 24 10:20:01 2012
TargetIp:192.0.0.2
SourceIp:110.1.0.1
Transmit-packets:1 (each hop)
Request-data-size:70
Timeout:5000(ms)
Frequency:60(s)
TargetOnly:FALSE
Verify-data:FALSE
Alarm-type:none
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-pktloss:1 direction:be
Number-of-history-kept:255
Periods:1
In-scheduling:TRUE
Status:REACHABLE
```

In-scheduling:TRUE indicates that the entity is in scheduling.

Status: REACHABLE means that the entity status is reachable, that is, the network communication of the path from Device1 to Device3 is normal.

#View the history records.

```
Device1#show rtr history 1
----------------------------------------------------------------
ID:1    Name:IcmpPathEcho1
History of hop-by-hop:
 110.1.0.2      PktLoss:0      ,Rtt:2        (ms)
 192.0.0.2      PktLoss:0      ,Rtt:1        (ms)
History of record from source to dest:
CurHistorySize:1       MaxHistorysize:255
WED OCT 24 10:20:01 2012
       PktLoss:0      ,Rtt:1        (ms)
```

The history records provide details about the packet loss and latency of each schedule.

#Wait for a while and view the entity status after 10 schedule sessions.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:IcmpPathEcho1          Created:TRUE
***************type:ICMPPATHECHO***************
CreatedTime:WED OCT 24 10:18:02 2012
LatestModifiedTime:WED OCT 24 10:19:09 2012
Times-of-schedule:10
Time-of-last-schedule:WED OCT 24 10:29:01 2012
TargetIp:192.0.0.2
SourceIp:110.1.0.1
Transmit-packets:1 (each hop)
Request-data-size:70
Timeout:5000(ms)
Frequency:60(s)
TargetOnly:FALSE
Verify-data:FALSE
Alarm-type:none
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-pktloss:1 direction:be
Number-of-history-kept:255
Periods:1
In-scheduling:FALSE
Status:DEFAULT
```

After 10 scheduling sessions, the scheduling stops and the entity status is DEFAULT.

85.3.3 Configure an ICMP-path-jitter Entity to Detect Network Communication

Network Requirements

- An ICMP-path-jitter entity is used on Device1 to detect the network communication of the path from Device1 to Device3.

Network Topology

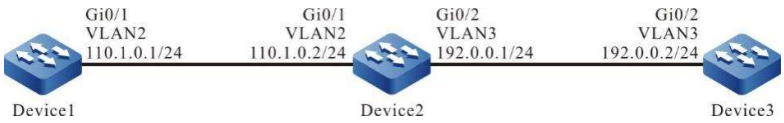


Figure 2 Network Topology for Configuring an ICMP-Path-Jitter Entity

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure the IP address and route of each interface to enable communication between Device1, Device2 and Device3. (Omitted)

Step 3: Configure an ICMP-path-jitter-type entity and add attribute parameters.

#Configure Device1.

```
Device1#config terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 icmp-path-jitter
Device1(config-rtr-icmppathjitter)#set dest-ipaddr 192.0.0.2 10 20 source-ipaddr 110.1.0.1
```

```
Device1(config-rtr-icmppathjitter)#number-of-history-kept 255
Device1(config-rtr-icmppathjitter)#targetOnly false
Device1(config-rtr-icmppathjitter)#exit
```

#View the parameters of an ICMP-path-jitter.

```
Device1#show rtr entity 1
---------------------------------------------------------------
ID:1          name:IcmpPathJitter1          Created:TRUE
***************type:ICMPPATHJITTER***************
CreatedTime:WED OCT 24 10:54:31 2012
LatestModifiedTime:WED OCT 24 10:56:12 2012
Times-of-schedule:0
TargetIp:192.0.0.2
SourceIp:110.1.0.1
Transmit-packets:10 (each hop)
Packets-interval:20(ms)
Request-data-size:70
Timeout:5000(ms)
Frequency:60(s)
TargetOnly:FALSE
Verify-data:FALSE
Alarm-type:none
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-pktLoss: 200000000  direction:be
Threshold-of-jitter:6000(ms) direction:be
Number-of-history-kept:255
Periods:1
In-scheduling:FALSE
Status:DEFAULT
---------------------------------------------------------------
```

The results show that the entity parameters are consistent with the configuration.

In-scheduling:FALSE indicates that the entity is not scheduled.

Status:DEFAULT indicates that the entity status is DEFAULT.

Step 4: Schedule a defined ICMP-path-jitter entity, and define attribute parameters of the schedule.

#Configure Device1.

```
Device1(config)#rtr schedule 1 entity 1 start now ageout 100 life foreve
```

Step 5: Check the result.

#View the status of an entity.

```
Device1#show rtr entity 1
---------------------------------------------------------------
ID:1          name:IcmpPathJitter1          Created:TRUE
***************type:ICMPPATHJITTER***************
CreatedTime:WED OCT 24 10:54:31 2012
LatestModifiedTime:WED OCT 24 10:56:12 2012
Times-of-schedule:4
Time-of-last-schedule:WED OCT 24 11:00:25 2012
TargetIp:192.0.0.2
SourceIp:110.1.0.1
Transmit-packets:10 (each hop)
Packets-interval:20(ms)
Request-data-size:70
Timeout:5000(ms)
```

```
Frequency:60(s)
TargetOnly:FALSE
Verify-data:FALSE
Alarm-type:none
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-pktLoss: 200000000 direction:be
Threshold-of-jitter:6000(ms) direction:be
Number-of-history-kept:255
Periods:1
In-scheduling:TRUE
Status:REACHABLE
----------------------------------------------------------------
```

In-scheduling:TRUE indicates that the entity is in scheduling.

Status: REACHABLE means that the entity status is reachable, that is, the network communication from Device1 to Device2 is normal.

#View the history records.

```
Device1#show rtr history 1
----------------------------------------------------------------
ID:1    Name:IcmpPathJitter1
History of hop-by-hop:
 110.1.0.2      PktLoss:0       Rtt:1       (ms),Jitter:0       (ms)
 192.0.0.2      PktLoss:0       Rtt:0       (ms),Jitter:0       (ms)
History of record from source to dest:
CurHistorySize:4       MaxHistorysize:255
WED OCT 24 11:00:25 2012
      PktLoss:0       ,Rtt:1       (ms),Jitter:0       (ms)
WED OCT 24 10:59:25 2012
      PktLoss:0       ,Rtt:0       (ms),Jitter:0       (ms)
WED OCT 24 10:58:25 2012
      PktLoss:0       ,Rtt:0       (ms),Jitter:0       (ms)
WED OCT 24 10:57:25 2012
      PktLoss:0       ,Rtt:0       (ms),Jitter:0       (ms)
----------------------------------------------------------------
```

The history records provide details about the packet loss, latency and jitter of each schedule.

85.3.4 Configure a VoIP-jitter Entity to Detect Network Transmission of Voice Packets

Network Requirements

- A VoIP-jitter entity is used on Device1 to detect the transmission of voice packets from Device1 to Device3.

Network Topology

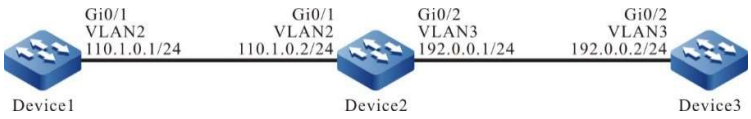


Figure 3 Network Topology for Configuring VoIP-Jitter Entities

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure the IP address and route of each interface to enable communication between Device1 and Device3. (Omitted)

Step 3: Configure ntp for clock synchronization.

#Configure Device3.

```
Device3#config terminal
Device3(config)#ntp master
```

#Configure Device1.

```
Device1(config)#ntp server 192.0.0.2
```

#View if Device3 has been successfully specified as the clock server, indicating that the clock has been synchronized.

```
Device3#show ntp status
Current NTP status information
Clock is synchronized, stratum 8, reference is 127.127.8.10
reference time is D4321EF4.7BBBBB68 (08:01:56.483 Wed Oct 24 2012)
```

#View if Device1 has been successfully specified as a clock client, indicating that the clock has been synchronized with the server address displayed.

```
Device1#show ntp status
Current NTP status information
Clock is synchronized, stratum 9, reference is 192.0.0.2
reference time is D43222C1.91110F31 (08:18:09.566 Wed Oct 24 2012)
```

Step 4: Configure a responder on Device3 as the responder.

#Configure Device3

```
Device3(config)#rtr enable
Device3(config)#rtr responder
```

Step 5: Configure the VoIP-jitter entity on Device1 and add the attribute parameters.

#Configure Device1.

```
Device1#config terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 jitter
Device1(config-rtr-jitter)#set dest-ipaddr 192.0.0.2 dest-port 1234 g711alaw source-ipaddr 110.1.0.1 source-port 1234
Device1(config-rtr-jitter)#number-of-history-kept 255
Device1(config-rtr-jitter)#exit
```

#View the entity parameters.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:Jitter1          Created:TRUE
***************type:JITTER****************
CreatedTime:WED OCT 24 16:02:32 2012
LatestModifiedTime:WED OCT 24 16:02:58 2012
```

```
Times-of-schedule:0
Entry-state:Pend
TargetIp:192.0.0.2      targetPort:1234
Codec:G.711 A-Law       Packet-size:172 Packet-number:1000
Packet-transmit-interval:20(ms)
frequency:60(s)
SourceIp:110.1.0.1      Soure-port:1234
TimeOut:50000(ms)
Alarm-type:none
Threshold-of-dsDelay:5000(ms) direction:be
Threshold-of-dsJitter:6000(ms) direction:be
Threshold-of-dsPktLoss:200000000 direction:be
Threshold-of-sdDelay:5000(ms) direction:be
Threshold-of-sdJitter:6000(ms) direction:be
Threshold-of-sdPktLoss:200000000 direction:be
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-mos:10000000 direction:be
Threshold-of-icpif:100000000 direction:be
Number-of-history-kept:255
Periods:1
Status:DEFAULT
----------------------------------------------------------------
```

The results show that the entity parameters are consistent with the configuration.

Status:DEFAULT indicates that the entity status is DEFAULT.

Step 6: Invoke the defined VoIP-jitter entity and define attribute parameters of the schedule.

#Configure Device1.

```
Device1(config)#rtr schedule 1 entity 1 start now ageout 100 life 600 repeat 10
```

Step 7: Check the result.

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1            name:Jitter1            Created:TRUE
****************type:JITTER*****************
CreatedTime:WED OCT 24 16:02:32 2012
LatestModifiedTime:WED OCT 24 16:06:02 2012
Times-of-schedule:3
Time-of-last-schedule:WED OCT 24 16:08:29 2012
Entry-state:Transmit
TargetIp:192.0.0.2      targetPort:1234
Codec:G.711 A-Law       Packet-size:172 Packet-number:1000
Packet-transmit-interval:20(ms)
frequency:60(s)
SourceIp:110.1.0.1      Soure-port:1234
TimeOut:50000(ms)
Alarm-type:none
Threshold-of-dsDelay:5000(ms) direction:be
Threshold-of-dsJitter:6000(ms) direction:be
Threshold-of-dsPktLoss:200000000 direction:be
Threshold-of-sdDelay:5000(ms) direction:be
Threshold-of-sdJitter:6000(ms) direction:be
Threshold-of-sdPktLoss:200000000 direction:be
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-mos:10000000 direction:be
Threshold-of-icpif:100000000 direction:be
Number-of-history-kept:255
Periods:1
```

```
Status:REACHABLE
----------------------------------------------------------------
```

Entry-state:Transmit indicates that the entity is in scheduling.

Status: REACHABLE means that the entity is reachable, indicating that the network from Device1 to Device3 is transmitting voice packets normally.

#View the history records.

```
Device1#show rtr history 1
----------------------------------------------------------------
ID:1    Name:Jitter1    CurHistorySize:3        MaxHistorysize:255
History recorded as following:
WED OCT 24 16:08:46 2012
      SdPktLoss:0          ,DsPktLoss:0          ,Rtt:185       (ms),
      SdDelay:14       (ms),DsDelay:178      (ms),SdJitter:8         (ms),DsJitter:183       (ms),
      Mos:5.000000         ,icpif:0.000000
WED OCT 24 16:07:45 2012
      SdPktLoss:0          ,DsPktLoss:0          ,Rtt:14        (ms),
      SdDelay:16       (ms),DsDelay:7        (ms),SdJitter:10        (ms),DsJitter:13        (ms),
      Mos:5.000000         ,icpif:0.000000
WED OCT 24 16:06:46 2012
      SdPktLoss:0          ,DsPktLoss:0          ,Rtt:17        (ms),
      SdDelay:16       (ms),DsDelay:9        (ms),SdJitter:11        (ms),DsJitter:13        (ms),
      Mos:5.000000         ,icpif:0.000000
----------------------------------------------------------------
```

The history records provide details about one-way packet loss, round-trip delay, one-way delay, and one-way jitter for each schedule.

Note

- Before a VoIP-jitter entity is configured, the NTP service needs to be configured to achieve network clock synchronization and the rtr responder command needs to be configured on the destination end to set it as the responder. Note that the scheduling result will be incorrect if the clock is not synchronized or the responder is not configured.

85.3.5 Configure a UDP-echo Entity to Detect Network Transmission of UDP Packets

Network Requirements

- A UDP-echo entity is used on Device1 to detect the transmission of UDP packets from Device1 to Device3.

Network Topology

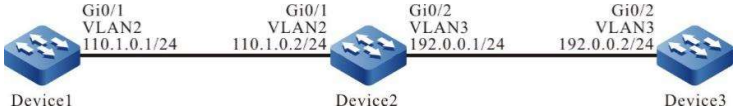


Figure 85 Network Topology for Configuring UDP-echo Entities

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure the IP address and route of each interface to enable communication between Device1 and Device3. (Omitted)

Step 3: Configure a responder on Device3 as the responder.

#Configure Device3

```
Device3#config terminal
Device3(config)#rtr enable
Device3(config)#rtr responder
```

Step 4: Configure the UDP-echo entity on Device1 and add the attribute parameters.

#Configure Device1.

```
Device1#config terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 udpecho
Device1(config-rtr-udpecho)#set dest-ipaddr 192.0.0.2 dest-port 1001 source-ipaddr 110.1.0.1 source-port 1001
Device1(config-rtr-udpecho)#number-of-history-kept 255
Device1(config-rtr-udpecho)#frequency 10
Device1(config-rtr-udpecho)#exit
```

#View the entity parameters.

```
Device1#show rtr entity 1
---------------------------------------------------------------------
ID:1            name:UdpEcho1           Created:TRUE
****************type:UDPECHO****************
CreatedTime:WED OCT 24 16:36:45 2012
LatestModifiedTime:WED OCT 24 16:37:44 2012
Times-of-schedule:0
Entry-state:Pend
TargetIp:192.0.0.2      TargetPort:1001
SourceIp:110.1.0.1      SourePort:1001
TimeOut:5000(ms)
request-data-size:16
Frequecy:10(s)
Alarm-type:none
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-pktloss:1 direction:be
Number-of-history-kept:255
Periods:1
Status:DEFAULT
---------------------------------------------------------------------
```

The results show that the entity parameters are consistent with the configuration.

Status:DEFAULT indicates that the entity status is DEFAULT.

Step 5: Call the defined UDP-echo entity and define attribute parameters of the schedule.

#Configure Device1.

```
Device1(config)#rtr schedule 1 entity 1 start now ageout 100 life forever
```

Step 6: Check the result.

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1            name:UdpEcho1           Created:TRUE
****************type:UDPECHO*****************
CreatedTime:WED OCT 24 16:36:45 2012
LatestModifiedTime:WED OCT 24 16:37:44 2012
Times-of-schedule:5
Time-of-last-schedule:WED OCT 24 16:39:50 2012
Entry-state:Pend
TargetIp:192.0.0.2      TargetPort:1001
SourceIp:110.1.0.1      SourePort:1001
TimeOut:5000(ms)
request-data-size:16
Frequecy:10(s)
Alarm-type:none
Threshold-of-rtt:9000(ms) direction:be
Threshold-of-pktloss:1 direction:be
Data-pattern:ABCD
Number-of-history-kept:255
Periods:1
Status:REACHABLE
----------------------------------------------------------------
```

Status: REACHABLE means that the entity is reachable, that is, the network from Device1 to Device3 is transmitting UDP packets normally.

#View the history records.

```
Device1#show rtr history 1
----------------------------------------------------------------
ID:1    Name:UdpEcho1   CurHistorySize:5       MaxHistorysize:255
History recorded as following:
WED OCT 24 16:39:54 2012
      PktLoss:0       ,Rtt:1        (ms)
WED OCT 24 16:39:44 2012
      PktLoss:0       ,Rtt:1        (ms)
WED OCT 24 16:39:33 2012
      PktLoss:0       ,Rtt:2        (ms)
WED OCT 24 16:39:23 2012
      PktLoss:0       ,Rtt:2        (ms)
WED OCT 24 16:39:13 2012
      PktLoss:0       ,Rtt:2        (ms)
----------------------------------------------------------------
```

The history records provide details about the packet loss and latency of each schedule.

Note

- Before a UDP-echo entity is configured, the rtr responder command needs to be configured on the destination end to set it as the responder. Note that the scheduling result will be incorrect if the responder is not configured.

85.3.6 Configure an FLOW-statistics Entity to Detect Interface Traffic Flow

Network Requirements

- A FLOW-statistics entity is used on Device1 to detect interface vlan2 traffic flow.

Network Topology

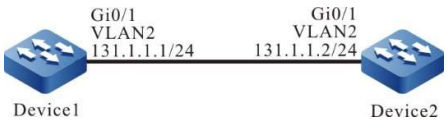


Figure 4 Network Topology for Configuring a FLOW-Statistics Entity

Configuration Steps

Step 1: Configure IP addresses for the ports. (Omitted)

Step 2: Configure the FLOW-statistics entity on Device1 and add the attribute parameters.

#Configure Device1.

```
Device1#config terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 flow-statistics
Device1(config-rtr-flowsta)#flow-statistics interface vlan 2 interval 60
Device1(config-rtr-flowsta)#number-of-history-kept 255
Device1(config-rtr-flowsta)#exit
```

#View the entity parameters.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:flow-statistics1          Created:TRUE
***************type:FLOWSTATISTICS***************
CreatedTime:THU OCT 25 09:57:43 2012
LatestModifiedTime:THU OCT 25 09:58:03 2012
Times-of-schedule:0
Alarm-type:none
Threshold-of-inputPkt:200000000 direction:be
Threshold-of-inputFlow:200000000 direction:be
Threshold-of-outputPkt:200000000 direction:be
Threshold-of-outputFlow:200000000 direction:be
Interface: vlan2
Statistics-interval:60(s)
Number-of-history-kept:255
Periods:1
Status:DEFAULT
----------------------------------------------------------------
```

The results show that the entity parameters are consistent with the configuration.

Status: DEFAULT indicates that the entity status is DEFAULT.

Step 3: Invoke the defined FLOW-statistics entity and define attribute parameters of the schedule.

#Configure Device1.

```
Device1(config)#rtr schedule 1 entity 1 start now ageout 100 life 600 repeat 10
```

Step 4: Check the result.

1) When there is received data traffic on interface vlan2.

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:flow-statistics1          Created:TRUE
***************type:FLOWSTATISTICS***************
CreatedTime:THU OCT 25 09:57:43 2012
LatestModifiedTime:THU OCT 25 09:58:03 2012
Times-of-schedule:2
Time-of-last-schedule:THU OCT 25 10:02:11 2012
Alarm-type:none
Threshold-of-inputPkt:200000000 direction:be
Threshold-of-inputFlow:200000000 direction:be
Threshold-of-outputPkt:200000000 direction:be
Threshold-of-outputFlow:200000000 direction:be
Interface: vlan 2
Statistics-interval:60(s)
Number-of-history-kept:255
Periods:1
Status:REACHABLE
----------------------------------------------------------------
```

Status: REACHABLE indicates that the entity is reachable, i.e., there are data packets in/out of the vlan2 interface.

2) When there is no input/output data traffic on interface vlan2.

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:flow-statistics1          Created:TRUE
***************type:FLOWSTATISTICS***************
CreatedTime:THU OCT 25 09:57:43 2012
LatestModifiedTime:THU OCT 25 09:58:03 2012
Times-of-schedule:5
Time-of-last-schedule:THU OCT 25 10:05:11 2012
Alarm-type:none
Threshold-of-inputPkt:200000000 direction:be
Threshold-of-inputFlow:200000000 direction:be
Threshold-of-outputPkt:200000000 direction:be
Threshold-of-outputFlow:200000000 direction:be
Interface: vlan 2
Statistics-interval:60(s)
Number-of-history-kept:255
Periods:1
Status:UNREACHABLE
----------------------------------------------------------------
```

Status: UNREACHABLE indicates that the entity is unreachable when there is no input/output traffic on interface vlan2.

#View the history records.

```
Device1#show rtr history 1
----------------------------------------------------------------
```

```
ID:1          Name:flow-statistics1   CurHistorySize:5     MaxHistorysize:255
History recorded as following:
THU OCT 25 10:05:11 2012
      Input pkt:0          (packets/s),Input flow:0        (bits/s),
      Output pkt:0         (packets/s),Output flow:0       (bits/s)
THU OCT 25 10:04:11 2012
      Input pkt:209        (packets/s),Input flow:214000   (bits/s),
      Output pkt:0         (packets/s),Output flow:0       (bits/s)
THU OCT 25 10:03:11 2012
      Input pkt:8460       (packets/s),Input flow:8663000  (bits/s),
      Output pkt:0         (packets/s),Output flow:0       (bits/s)
THU OCT 25 10:02:11 2012
      Input pkt:8460       (packets/s),Input flow:8663000  (bits/s),
      Output pkt:0         (packets/s),Output flow:0       (bits/s)
THU OCT 25 10:01:12 2012
      Input pkt:6456       (packets/s),Input flow:6610000  (bits/s),
      Output pkt:0         (packets/s),Output flow:0       (bits/s)
------------------------------------------------------------------
```

The history records provide details about the rate (number-based and bit-based) of the input and output interface vlan2 for each schedule.

Note

- The reachability of the FLOW-statistics entity is defined as follows: When the entity is in scheduling, and there is traffic flow in the IN or OUT direction of the interface, the entity status is REACHEABLE, otherwise, it is UNREACHABLE.

85.3.7 Configuring an ICMP-Echo Ipv6 Entity to Detect Network Communication

Network Requirements

- The ICMP-echo ipv6 entity is used on Device1 to detect the network communication from Device1 to Device3.

Network Topology

Figure 5 Network Topology for Configuring an ICMP-echo Ipv6 Entity

Configuration Steps

Step 1: Configure the IPV6 address and route of each interface to enable communication between Device1 and Device3. (Omitted)

Step 2: Configure an ICMP-echo ipv6 entity and add attribute parameters.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 icmpv6echo
Device1(config-rtr-icmpv6echo)#set 2136::2 5 70 2 12 extend 2135::1 0 TRUE
Device1(config-rtr-icmpv6echo)#alarm-type log
Device1(config-rtr-icmpv6echo)#number-of-history-kept 255
Device1(config-rtr-icmpv6echo)#threshold-pktLoss 10 direction be
Device1(config-rtr-icmpv6echo)#threshold-rtt 1000  direction be
Device1(config-rtr-icmpv6echo)#exit
```

#View the parameters of an ICMP-echo ipv6 entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:Icmpv6Echo1             Created:TRUE
***************type:ICMPV6ECHO***************
CreatedTime:Tue Sep 17 10:05:52 2019
LatestModifiedTime:Tue Sep 17 10:21:06 2019
Times-of-schedule:0
TargetIpv6:2136::2
Transmit-packets:5
Totally-send-packets:0
Packet-size:70
Timeout:2(s)
Alarm-type:log
Threshold-of-rtt:1000(ms) direction:be
Threshold-of-packet-loss:10 direction:be
Number-of-history-kept:255
Periods:1
Extend parameters:
sourceIpv6:2135::1     tos:0   Verify-data:TRUE
In-scheduling:FALSE
Schedule frequency:12(s)
Status:DEFAULT

----------------------------------------------------------------
```

The results show that the entity parameters are consistent with the configuration.

In-scheduling: FALSE indicates that the entity is not scheduled.

Status: DEFAULT indicates that the entity status is DEFAULT.

Note

- When an entity is not scheduled, its status is DEFAULT; when an entity is scheduled, if the entity is reachable, its status is REACHABLE, if it is unreachable, its status is UNREACHABLE.

Step 3: Schedule a defined ICMP-echo ipv6 entity, and define attribute parameters of the schedule.

#Configure Device1

```
Device1(config)#rtr schedule 1 entity 1 start now ageout 20 life forever
```

Step 4: Check the result.

1) When the network communication from Device1 to Device3 is normal.

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:Icmpv6Echo1            Created:TRUE
****************type:ICMPV6ECHO****************
CreatedTime:Tue Sep 17 10:05:52 2019
LatestModifiedTime:Tue Sep 17 10:21:06 2019
Times-of-schedule:2
Time-of-last-schedule:Tue Sep 17 10:24:08 2019
TargetIpv6:2136::2
Transmit-packets:5
Totally-send-packets:10
Packet-size:70
Timeout:2(s)
Alarm-type:log
Threshold-of-rtt:1000(ms) direction:be
Threshold-of-packet-loss:10 direction:be
Number-of-history-kept:255
Periods:1
Extend parameters:
sourceIpv6:2135::1     tos:0   Verify-data:TRUE
In-scheduling:TRUE
Schedule frequency:12(s)
Status:REACHABLE
----------------------------------------------------------------
```

In-scheduling: TRUE indicates that the entity is in scheduling.

Status: REACHABLE means that the entity status is reachable, that is, the network communication from Device1 to Device3 is normal.

1) When the network communication from Device1 to Device3 fails.

Since the entity parameters are configured with the alarm mode as log, an alarm message will be printed when the threshold value is reached or exceeded, as follows:

```
%SLA-4:Rtr 1 (ICMPV6ECHO) rtt [9000ms] was exceeded(>=) threshold [1000ms].
```

#View the status of an entity.

```
Device1#show rtr entity 1
----------------------------------------------------------------
ID:1          name:Icmpv6Echo1            Created:TRUE
****************type:ICMPV6ECHO****************
CreatedTime:Tue Sep 17 10:05:52 2019
LatestModifiedTime:Tue Sep 17 10:21:06 2019
Times-of-schedule:21
Time-of-last-schedule:Tue Sep 17 10:28:08 2019
TargetIpv6:2136::2
Transmit-packets:5
Totally-send-packets:105
Packet-size:70
Timeout:2(s)
Alarm-type:log
Threshold-of-rtt:1000(ms) direction:be
Threshold-of-packet-loss:10 direction:be
Number-of-history-kept:255
Periods:1
Extend parameters:
sourceIpv6:2135::1     tos:0   Verify-data:TRUE
```

```
In-scheduling:TRUE
Schedule frequency:12(s)
Status:UNREACHABLE
------------------------------------------------------------------
```

In-scheduling: TRUE indicates that the entity is in scheduling.

Status: UNREACHABLE means that the entity status is unreachable, that is, the network communication from Device1 to Device3 fails.

#View the history records.

```
Device1#show rtr history 1
------------------------------------------------------------------
ID:1    Name:Icmpv6Echo1      CurHistorySize:4      MaxHistorysize:255
History recorded as following:
Tue Sep 17 10:24:42 2019
      PktLoss:5       ,Rtt:invalid
Tue Sep 17 10:24:29 2019
      PktLoss:1       ,Rtt:400      (ms)
Tue Sep 17 10:24:17 2019
      PktLoss:0       ,Rtt:1        (ms)
Tue Sep 17 10:24:05 2019
      PktLoss:0       ,Rtt:0        (ms)
------------------------------------------------------------------
```

The history records provide details about the packet loss and latency of each schedule; an invalid Rtt indicates that there is a failure in the network causing the network to be unreachable.

85.3.8 Configure TRACK to Coordinate with SLA

Network Requirements

- TRACK is in coordination with SLA. The validity of static routes on Device1 is determined on the basis of entity status.

Network Topology

Figure 6 Network Topology for Configuring TRACK to Coordinate with SLA

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: On Device1, configure the ICMP-echo entity to detect the network communication from Devicde1 to Device2, and add the entity to the entity group.

#Configure Device1.

```
Device1#config terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 icmpecho
Device1(config-rtr-icmpecho)#set 110.1.0.2 5 70 2 12 extend 110.1.0.1 0 true false
Device1(config-rtr-icmpecho)#number-of-history-kept 255
Device1(config-rtr-icmpecho)#exit
Device1(config)#rtr group 1
Device1(config-rtr-group)#member 1
Device1(config-rtr-group)#exit
```

Step 4: Define TRACK, and associate it with SLA.

#Configure Device1.

```
Device1(config)#track 1
Device1(config-track)#rtr 1
```

Step 5: Add a static route and associate it with TRACK.

#Configure Device1.

```
Device1(config)#ip route 192.0.0.0 255.255.255.0 110.1.0.2 track 1
```

Step 6: Schedule the entity and checking the validity of the static route.

#Configure Device1.

```
Device1(config)#rtr schedule 1 group 1 start now ageout 100 life forever
```

Step 7: Check the result.

1) When the network communication from Device1 to Device2 is normal.

#View the status of an entity group.

```
Device1#show rtr group 1
----------------------------------------------
ID:1          name:rtrGroup1        Members schedule interval:0
Option: AND    Status:REACHABLE
*****************************
type:SINGLE    Entity Id :1
```

The entity group status is REACHEABLE.

#View the route of network segment 192.0.0.0/24 in the routing table of 'Device1.

```
Device1#show ip route 192.0.0.0
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set

S   192.0.0.0/24 [1/10] via 110.1.0.2, 00:00:09, vlan2
```

The result shows that there is a route to the network segment 192.0.0.0/24, indicating that the static route is determined to be valid when the entity group status is RECHABLE.

1) When the network communication from Device1 to Device2 fails.

#View the status of an entity group.

```
Device1#show rtr group 1
----------------------------------------------
ID:1          name:rtrGroup1        Members schedule interval:0
Option: AND    Status:UNREACHABLE
*****************************
type:SINGLE    Entity Id :1
```

The entity group status is UNREACHEABLE.

#View the route of network segment 192.0.0.0/24 in the routing table of 'Device1.

```
Device1#show ip route 192.0.0.2
Codes: C - connected, S - static, R - RIP,  O - OSPF, OE-OSPF External, M - Management
       D - Redirect, E - IRMP, EX - IRMP external, o - SNSP, B - BGP, i-ISIS

Gateway of last resort is not set
```

The result shows that there is no route to the network segment 192.0.0.0/24, indicating that the static route is determined to be invalid when the entity status is UNREACHABLE.

85.3.9 Configure TRACK to Coordinate with ICMP-Echo Ipv6

Network Requirements

- TRACK is in coordination with icmp-echo ipv6. The validity of static routes on Device1 is determined on the basis of entity status.

Network Topology

Figure 7 Network Topology for Configuring TRACK to Coordinate with Icmp-echo Ipv6

Configuration Steps

Step 1: Configure IP addresses for the ports. (Omitted)

Step 2: On Device1, configure the ICMP-echo ipv6 entity to detect the network communication from Devicde1 to Device2, and add the entity to the entity group.

#Configure Device1.

```
Device1#config terminal
Device1(config)#rtr enable
Device1(config)#rtr 1 icmpv6echo
Device1(config-rtr-icmpv6echo)# set 2135::2 5 70 2 12 extend 2135::1 0 FALSE
Device1(config-rtr-icmpv6echo)#number-of-history-kept 255
Device1(config-rtr-icmpv6echo)#exit
Device1(config)#rtr group 1
Device1(config-rtr-group)#member 1
Device1(config-rtr-group)#exit
```

Step 3: Define TRACK, and associate it with SLA.

#Configure Device1.

```
Device1(config)#track 1
Device1(config-track)#rtr 1
Device1(config-track)#exit
```

Step 4: Add a static route and associate it with TRACK.

#Configure Device1.

```
Device1(config)#ipv6 route 2136::/64 2135::2 track 1
```

Step 5: Schedule an entity group.

#Configure Device1.

```
Device1(config)#rtr schedule 1 group 1 start now ageout 20 life forever
```

Step 6: Check the result.

1) When the network communication from Device1 to Device2 is normal.

#View the status of an entity group.

```
Device1#show rtr group 1
----------------------------------------------
ID:1          name:rtrGroup1        Members schedule interval:0
Option: AND    Status:REACHABLE
*****************************
type:SINGLE    Entity Id :1
```

The entity group status is REACHEABLE.

#View the route of network segment 2136::/64 in the routing table of Device1.

```
Device1#show ipv6 route 2136::/64
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
     U - Per-user Static route
     O - OSPF, OE-OSPF External, M - Management



S   2136::/64 [1/0]
   via 2135::2 [0], 00:50:17, vlan100
       2135::2 [0], vlan100
```

The result shows that there is a route to the network segment 2136::/64, indicating that the coordinated static route is determined to be valid when the entity group status is RECHABLE.

1) When the network communication from Device1 to Device2 fails.

#View the status of an entity group.

```
Device1#show rtr group 1
----------------------------------------------
ID:1          name:rtrGroup1        Members schedule interval:0
Option: AND     Status:UNREACHABLE
*****************************
type:SINGLE     Entity Id :1
```

The entity group status is UNREACHEABLE.

#View the route of network segment 2136::/64 in the routing table of Device1.

```
Device1#show ipv6 route 2136::/64
Codes: C - Connected, L - Local, S - static, R - RIP,  B - BGP, i-ISIS
     U - Per-user Static route
     O - OSPF, OE-OSPF External, M - Management
```

The result shows that there is no route to the network segment 2136::/64, indicating that the coordinated static route is determined to be invalid when the entity status is UNREACHABLE.

86 NTP

86.1 Overview

NTP (Network Time Protocol) is the standard Internet protocol used to synchronize the time in Internet. NTP is to synchronize the device time to the standard time. Currently, the adopted time standard is UTC (Universal Time Coordinated).

The design of NTP fully considers the complexity of the time synchronization on Internet. NTP provides the strict, practical, and valid mechanism, applicable to the Internet environments with various scales and speeds. NTP not only corrects the present time, but also continuously tracks the time change and can adjust automatically. Even if the network fails, it can maintain the time stability. NTP generates less network overhead and has measures to ensure network security. The adoption of these measures allows NTP to obtain reliable and accurate time synchronization over the Internet.

In practice, an appropriate NTP working mode should be selected according to the network deployment to meet the network clock synchronization requirements under different circumstances. NTP supports the following three working modes:

- Client/Server Mode

In client/server mode, the client sends a clock synchronization packet to the server with the Mode field set at 3 (client mode), and the server automatically enters the server mode after receiving the packet and sends a response packet with the Mode field set at 4 (server mode). The client synchronizes the system clock after receiving the response packet. In this mode, the client can synchronize the clock from the server, while the server cannot synchronize the clock from the client.

- Peer-to-Peer (P2P) Mode

In P2P mode, NTP packets with the Mode field set at 3 (client mode) and 4 (server mode) are first interacted between the active and passive peers. After that, the active peer sends a clock synchronization packet with the Mode field set at 1 (active peer mode) to the passive peer, and the passive peer automatically enters the passive peer mode after receiving the packet and sends a clock synchronization packet with the Mode field set at 2 (passive peer mode). After packet interaction, the P2P mode is established. In this mode, the active and passive peers can synchronize their clocks with each other. If both clocks are already synchronized, the clock with the smaller number of layers prevails.

- Broadcast Mode

In broadcast mode, the broadcast server periodically sends a clock synchronization packet with the Mode field set at 5 (broadcast server mode) to the broadcast address 255.255.255.255, and the broadcast client listens to the broadcast packet from the broadcast server. After the broadcast client receives the first broadcast packet, NTP packets with the Mode field set at 3 (client mode) and 4 (server mode) are interacted between the broadcast client and the broadcast server to obtain the network latency between the broadcast client and the broadcast server. After that, the broadcast client continues to listen for broadcast packets and synchronizes the system clock based on the received broadcast packets.

86.2 NTP Function Configuration

Table 86 NTP Function Configuration List

Configuration Task	
Configure NTP basic functions.	Configure the NTP client/server mode.
	Configure NTP P2P mode.
	Configure NTP broadcast mode.
Configure NTP optional parameters.	Configuring the NTP reference clock.
	Configure the source interface for NTP packets.

Configuration Task	
	Configure the sending and receiving control of NTP packets.
	Configure the number of NTP dynamic sessions.
Configure the NTP authentication function.	Configure the NTP client/server mode authentication.
	Configure the NTP P2P mode authentication
	Configure the NTP broadcast mode authentication.
Configure the NTP access control.	Configure the NTP access control.

86.2.1 Configure Basic Functions of NTP

Configuration Condition

Before configuring **NTP** basic functions, do the following tasks:

- Configure the network layer address of the interface so that the network layer is reachable between the NTP clock service requesting end and the clock service delivering end.
- NTP is enabled on the NTP clock service delivering end.

Configure NTP Client/Server Mode

Under the NTP client/server mode, no special configuration is required on the server, but it is necessary to ensure that the server clock is synchronized and the number of clock layers is less than the number of clock layers on the client.

The following configuration is required on the NTP client.

Table 1 Configuring the NTP Client

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Specify the NTP server.	**ntp server** [**vrf** *vrf-name*] { *ip-address* | **ipv6** *ipv6-address* | *domain-name* } [**version** *version-number* | **key** *key-number* | **source** *interface-name*]*	Mandatory By default, no NTP server is specified.

Note

- The *ip-address* parameter is a unicast address and cannot be a broadcast address, a multicast address, or the IP address of this device.
- The *ipv6-address* parameter is a global unicast address or the Link-Local address, or a multicast address.
- After specifying the source interface for sending client packets by **source** interface-name, the primary IP address or the first global unicast IPV6 address of the interface will be set as the source IP address for sending client packets. If the configured server address is an IPv6 Link-local address, the source interface must be specified.
- Multiple servers can be specified by configuring the **ntp server** or **ntp server ipv6** command multiple times, up to a maximum of 64 servers (the sum of ipv4+ipv6+domains) can be specified.

Configure NTP P2P Mode

When using the NTP P2P mode, there is no need to specifically configure the passive peer, however, you need to ensure that the passive peer can send and receive NTP packets, which can be achieved by configuring the **ntp enable (ipv6)** command on the passive peer or any of the NTP command in "1.2.1 Configuring NTP Basic Functions" to enable NTP.

The following configuration is required on the NTP active peer.

Table 2 Configuring the NTP Active Peer

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Specify the NTP passive peer.	**ntp peer** [**vrf** *vrf-name*] { *ip-address* | **ipv6** *ipv6-address* | *domain-name* } [**version** *version-number* | **key** *key-number* | **source** *interface-name*] *	Mandatory By default, no NTP passive peer is specified.

Note

- The *ip-address* parameter is a unicast address and cannot be a broadcast address, a multicast address, or the IP address of this device.
- The *ipv6-address* parameter is a global unicast address or the Link-Local address, or a multicast address.
- After specifying the source interface for sending active peer packets by **source** *interface-name*, the primary IP address or the first global unicast IPV6 address of the interface will be set as the source IP address for sending active peer packets. If the configured peer address is an IPv6 Link-local address, the source interface must be specified.
- Multiple passive peers can be specified by configuring the **ntp peer** or **ntp peer ipv6** command multiple times, up to a maximum of 64 passive peers (the sum of ipv4+ipv6+domain) can be specified.

Configure NTP Broadcast Mode

When using the NTP broadcast mode, both the broadcast server and the broadcast client need to be configured, and the clock of the broadcast server needs to be synchronized and the number of clock layers is less than the number of clock layers of the broadcast client. Since an interface for sending NTP broadcast packets needs to be specified on the broadcast server and an interface for receiving NTP broadcast packets needs to be specified on the broadcast client, the configuration of the broadcast mode can only be performed in the specific interface mode.

The following configuration is required on the NTP broadcast client.

Table 3 Configuring the NTP Broadcast Client

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Enable the NTP broadcast client on the interface.	**ntp broadcast-client**	Mandatory By default, NTP broadcast client is disabled on the interface.

The following configuration is required on the NTP broadcast server.

Table 4 Configuring NTP Broadcast Server

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the interface configuration mode	**interface** *interface-name*	-
Enable the NTP broadcast server on the interface.	**ntp broadcast-server** [**key** *key-number* | **version** *version-number*]*	Mandatory By default, NTP broadcast server is disabled on the interface.

86.2.2 Configure NTP Optional Parameters

Configuration Condition

None

Configuring NTP Reference Clock

NTP can synchronize system time in two ways:

- Synchronization with local clock: i.e., the local clock is used as the NTP reference clock.
- Synchronization with other clock sources in the network: i.e., using any of the three aforementioned NTP working modes.

Table 5-6 Configuring the Local Clock as the NTP Reference Clock

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the local clock as the NTP reference clock.	**ntp master** [*stratum-number*]	Mandatory By default, the local clock is not configured as the NTP reference clock.

Note

- After configuring the local clock as the NTP reference clock, the NTP cannot synchronize the clock from other clock sources in the network.
- After configuring the local clock as the NTP reference clock, the local device can be used as a clock source to synchronize other devices in the network. Please use this configuration with caution to avoid causing clock errors on other devices in the network.

Configure Source Interface for NTP Packets

If the source interface for a NTP packet is configured, the primary IP address of the specified source interface will be selected as the source IP address of the packet when the device actively sends a NTP packet.

Table 7-8 Configuring Source Interface for the NTP Packet

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the source interface for NTP packets.	**ntp source** *interface-name*	Mandatory By default, the source interface of a NTP packet is not configured.

Note

- If the source interface is specified using the command ntp server or ntp peer, the source interface specified by the command ntp server or ntp peer is used first.
- If ntp broadcast is configured in the interface mode, the source interface for a NTP broadcast packet is the interface on which the above command is configured.
- If the source interface of the specified NTP packet is in the down state, the source address of the default routing interface primary address or the first global unicast address encapsulating ntp is restored to send packets.
- If the source interface of the specified NTP packet has no configured address and is in up state, and there is no corresponding ipv4 or ipv6 address, the source address of the default routing interface primary address or the first global unicast address encapsulating ntp is restored to send the packet.

Configure the Sending and Receiving Control of NTP Packets

By default, the device does not receive and send all NTP packets. You can enable receiving and sending NTP packets by configuring the sending and receiving control of NTP packets.

Table 9-10 Configuring the Sending and Receiving Control of NTP Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable to receive and send NTP packets.	**ntp enable [ipv6]**	Mandatory By default, receiving and sending NTP packets is prohibited.

Note

- After configuring the **no ntp enable** command, all IPV4 NTP packets will be prohibited from being received and sent, and if the **ntp enable** command is configured, receiving and sending IPV4 NTP pakcets will be enabled.
- After configuring the **no ntp enable ipv6** command, all IPV6 NTP packets will be prohibited from being received and sent. If the **ntp enable ipv6** command is configured, the receiving and sending of IPV6 NTP packets will be enabled.

Configure the Number of NTP Dynamic Sessions

Set the maximum number of NTP dynamic connections allowed to be established locally by configuring the number of NTP dynamic sessions.

Table 11-12 Configuring the Number of NTP Dynamic Sessions

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Set the maximum number of NTP dynamic connections allowed to be established locally.	**ntp max-dynamic-sessions** *number*	Mandatory By default, the number of NTP dynamic sessions allowed to be established is 100.

86.2.3 Configure the NTP Authentication Function

In some networks with high security requirements, authentication needs to be enabled when running the NTP protocol. By authenticating the interaction packets between the NTP clock service requesting end and the delivering end, it ensures that the clock service requesting end is synchronized to a legitimate time, improving network security.

Configuration Condition

Before configuring the **NTP** authentication function, do the following tasks:

- Configure the network layer address of the interface so that the network layer is reachable between the NTP clock service requesting end and the clock service delivering end.
- NTP is enabled on the NTP clock service delivering end.

Configure the NTP Client/Server Mode Authentication

When configuring the NTP client/server mode authentication, you need to enable authentication on both the client and the server, configure the authentication key, set the authentication key as a trusted key, and specify the key associated with the server on the client.

The following configuration is required on the NTP client.

Table 13-14 Configuring NTP Client Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the NTP authentication function.	**ntp authenticate**	Mandatory By default, the NTP authentication function is not enabled.
Configure the authentication key.	**ntp authentication-key** *key-number* **md5 {0** *plain-key* **| 7** *cipher-key***}**	Mandatory By default, no authentication key is configured.
Configure the specified key as a trusted key.	**ntp trusted-key** *key-number*	Mandatory By default, no trusted key is specified.

Step	Command	Description
Specify the key associated with the server.	**ntp server** [**vrf** *vrf-name*] { *ip-address* | *domain-name* | **ipv6** *ipv6-address* } [**version** *version* | **source** *interface-name*] **key** *key-number*	Mandatory

The following configuration is required on the NTP server.

Table 15-16 Configuring NTP Server Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the NTP authentication function.	**ntp authenticate**	Mandatory By default, the NTP authentication function is not enabled.
Configure the authentication key.	**ntp authentication-key** *key-number* **md5 {0** *plain-key* **| 7** *cipher-key***}**	Mandatory By default, no authentication key is configured.
Configure the specified key as a trusted key.	**ntp trusted-key** *key-number*	Mandatory By default, no trusted key is specified.

Note

- The server and client need to be configured with the same authentication key.

Configure the NTP P2P Mode Authentication

When configuring the NTP peer mode authentication, you need to enable authentication on both active and passive peers, configure the authentication key, set the authentication key as a trusted key, and specify the key associated with the passive peer on the active peer.

The following configuration is required on the NTP active peer.

Table 17-18 Configuring NTP Active Peer Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the NTP authentication function.	**ntp authenticate**	Mandatory By default, the NTP authentication function is not enabled.
Configure the authentication key.	**ntp authentication-key** *key-number* **md5 {0** *plain-key* **| 7** *cipher-key***}**	Mandatory By default, no authentication key is configured.
Configure the specified key as a trusted key.	**ntp trusted-key** *key-number*	Mandatory By default, no trusted key is specified.
Specify the key associated with the passive peer.	**ntp peer** [**vrf** *vrf-name*] *ip-address* | *domain-name* | **ipv6** *ipv6-address* [**version** *version* | **source** *interface-name*] **key** *key-number*	Mandatory

The following configuration is required on the NTP passive peer.

Table 19-20 Configuring NTP Passive Peer Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the NTP authentication function.	**ntp authenticate**	Mandatory By default, the NTP authentication function is not enabled.
Configure the authentication key.	**ntp authentication-key** *key-number* **md5 {0** *plain-key* **| 7** *cipher-key***}**	Mandatory By default, no authentication key is configured.

Step	Command	Description
Configure the specified key as a trusted key.	**ntp trusted-key** *key-number*	Mandatory By default, no trusted key is specified.

Note

- Active and passive peers need to be configured with the same authentication key.

Configure the NTP Broadcast Mode Authentication

When configuring the NTP broadcast mode authentication, you need to enable authentication on both the broadcast client and the broadcast server, configure the authentication key, set the authentication key as the trusted key, and specify the key associated with this broadcast server on the broadcast server.

The following configuration is required on the NTP broadcast client.

Table 21-22 Configuring NTP Broadcast Client Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the NTP authentication function.	**ntp authenticate**	Mandatory By default, the NTP authentication function is not enabled.
Configure the authentication key.	**ntp authentication-key** *key-number* **md5 {0** *plain-key* **| 7** *cipher-key***}**	Mandatory By default, no authentication key is configured.
Configure the specified key as a trusted key.	**ntp trusted-key** *key-number*	Mandatory By default, no trusted key is specified.

The following configuration is required on the NTP broadcast server.

Table 23-24 Configuring NTP Broadcast Server Authentication

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the NTP authentication function.	**ntp authenticate**	Mandatory By default, the NTP authentication function is not enabled.
Configure the authentication key.	**ntp authentication-key** *key-number* **md5 {0** *plain-key* **| 7** *cipher-key***}**	Mandatory By default, no authentication key is configured.
Configure the specified key as a trusted key.	**ntp trusted-key** *key-number*	Mandatory By default, no trusted key is specified.
Enter the interface configuration mode	**interface** *interface-name*	-
Specify the key associated with the broadcast server.	**ntp broadcast-server** [**version** *version-number*] **key** *key-number*	Mandatory

Note

- The broadcast server and the broadcast client need to be configured with the same authentication key.

86.2.4 Configure the NTP Access Control

Configuration Condition

Before configuring the **NTP** access control, do the following tasks:

- Configure the ACL associated with the access control.

Configure the NTP Access Control

NTP can restrict access to the local NTP service by associating it with an ACL.

Table 25-26 Configuring NTP Access Control

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the NTP access control.	**ntp access-control list** *access-list-name*	Mandatory By default, the NTP access control is not configured.

86.2.5 NTP Monitoring and Maintaining

Table 27-28 NTP Monitoring and Maintaining

Command	Description
show ntp associations [ipv6]	Display NTP session information.
show ntp status	Display NTP status information.
snmp-server enable traps ntp [stratum-change | sync-lost | sync-success]*	Enable the Trap function of NTP.

86.3 Typical Configuration Example of NTP

86.3.1 Configure the NTP IPV4 Server and Client

Network Requirements

- Device1 is the NTP server and Device2 is the NTP client.
- Device1 and Device2 are interconnected through their respective interface VLAN2, and are route reachable.
- The NTP server is the clock source and the client gets the clock from the server.

Network Topology

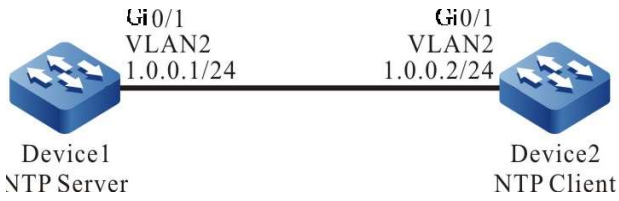


Figure 1-2 Network Topology for Configuring NTP Server and Client

Configuration Steps

Step 1: Configure IP addresses for the interfaces (omitted).

Step 2: Configure the NTP server Device1.

#Enable NTP IPV4 for Device1, configure the time as China Standard Time, local clock as the reference clock, and the number of clock layers at 3.

```
Device1#configure terminal
Device1(config)#ntp enable
Device1(config)#clock timezone BINJING 8
Device1(config)#ntp master 3
Device1(config)#exit
```

Step 3: Configure the NTP client Device2.

#Enable NTP IPV4 for Device2 and configure the time as China Standard Time.

```
Device2#configure terminal
Device2(config)#ntp enable
Device2(config)#clock timezone BINJING 8
```

#Specify the NTP server Device1, and the IP address is 1.0.0.1.

```
Device2(config)#ntp server 1.0.0.1
Device2(config)#exit
```

Step 4: Check the result.

#On the client Device2, execute **show ntp status** command to check the clock synchronization status and other information, indicating that the client and the NTP server Device1 has been synchronized, the number of clock layers is greater than Device1 by 1, which is 4.

```
Device2#show ntp status

Current NTP status information
 NTP ipv4 is enabled
 NTP ipv6 is disabled
Clock is synchronized, stratum 4, reference is 1.0.0.1
reference time is D442EB0E.432F29BD (01:49:02.262 Tue Nov 06 2012)
```

#Execute the **show clock** command on the client Device2 to check the device clock.

```
Device2#show clock
BEIJING(UTC+08:00) TUE NOV 06 09:49:30 2012
```

86.3.2 Configure the NTP IPV4 Server and Multi-Level Client

Network Requirements

- Device1 is the NTP server, and Device2 and Device3 are the NTP clients.
- Device2 is interconnected with Device1 and Device3 through interface vlan2 and vlan3, respectively, and the routes are reachable.
- Device1 provides the clock for Device2 and Device2 provides the clock for Device3.

Network Topology

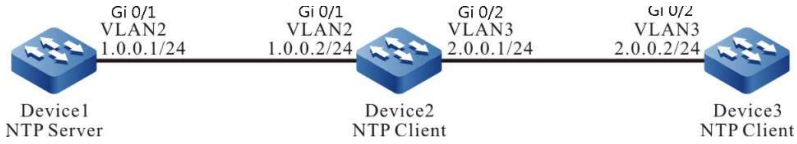


Figure 3-4 Network Topology for Configuring NTP Server and Multi-Level Client

Configuration Steps

Step 1: Configure IP addresses for the interfaces (omitted).

Step 2: Configure the NTP server Device1.

#Enable NTP IPV4 for Device1, configure the time as China Standard Time, local clock as the reference clock, and the number of clock layers at 3.

```
Device1#configure terminal
Device1(config)#ntp enable
Device1(config)#clock timezone BINJING 8
Device1(config)#ntp master 3
Device1(config)#exit
```

Step 3: Configure the NTP client Device2.

#Enable NTP IPV4 for Device2 and configure the time as China Standard Time.

```
Device2#configure terminal
Device2(config)#ntp enable
Device2(config)#clock timezone BINJING 8
```

#Specify the NTP server Device1 with the IP address 1.0.0.1.

```
Device2(config)#ntp server 1.0.0.1
```

Step 4: Configure the NTP client Device3.

#Configure to enable NTP IPV4 for Device3 and configure the time as China Standard Time.

```
Device3#configure terminal
Device3(config)#ntp enable
Device3(config)#clock timezone BINJING 8
```

#Specify the NTP server Device2 with the IP address 2.0.0.1.

```
Device3(config)#ntp server 2.0.0.1
```

Step 5: Check the results and the clock synchronization information on Device2 and Device3 respectively.

#On the client Device2, execute **show ntp status** command to check the clock synchronization status and other information, indicating that Device2 and the NTP server Device1 has been synchronized, the number of clock layers is greater than Device1 by 1, which is 4.

```
Device2#show ntp status
Current NTP status information
NTP ipv4 is enabled
NTP ipv6 is disabled
Clock is synchronized, stratum 4, reference is 1.0.0.1
reference time is D44CC35E.BAA6A190 (13:02:22.729 Tue Nov 13 2012)
```

#Execute the **show clock** command on the client Device2 to check the device clock.

```
Device2#show clock
BEIJING(UTC+08:00) TUE NOV 13 21:02:24 2012
```

#On the client Device3, execute **show ntp status** command to check the clock synchronization status and other information, indicating that Device3 and Device2 has been synchronized, the number of clock layers is greater than Device2 by 1, which is 5.

```
Device3#show ntp status
Current NTP status information
                NTP ipv4 is enabled
                NTP ipv6 is disabled
Clock is synchronized, stratum 5, reference is 2.0.0.1
reference time is D44CC365.5CC8C4C8 (13:02:29.362 Tue Nov 13 2012)
```

#Execute the **show clock** command on the client Device3 to check the device clock.

```
Device3#show clock
BEIJING(UTC+08:00) TUE NOV 13 21:02:36 2012
```

86.3.3 Configure NTP Server and Client with MD5 Authentication

Network Requirements

- Device1 acts as the NTP server, Device2 acts as the NTP client, and both sides are authenticated with the MD5 algorithm.
- Device1 and Device2 are interconnected through their respective interface VLAN2, and are route reachable.
- The NTP server is the clock source and the client gets the clock from the server.

Network Topology

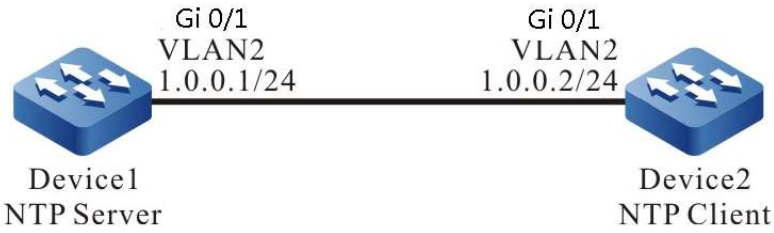


Figure 86-86 Network Topology for Configuring NTP Server and Client with MD5 Authentication

Configuration Steps

Step 1: Configure IP addresses for the interfaces (omitted).

Step 2: Configure the NTP server.

#Enable NTP IPV4 for Device1, configure the time as China Standard Time, local clock as the reference clock, and the number of clock layers at 3.

```
Device1#configure terminal
Device1(config)#ntp enable
Device1(config)#clock timezone BINJING 8
Device1(config)#ntp master 3
Device1(config)#exit
```

Enable authentication.

```
Device1(config)#ntp authenticate
```

#Configure the authentication key serial number as 1, the algorithm as MD5, and the key as admin.

```
Device1(config)#ntp authentication-key 1 md5 0 admin
```

#Configure the key with serial number 1 to be trusted.

```
Device1(config)#ntp trusted-key 1
```

Step 3: Configure the NTP client.

#Enable NTP IPV4 for Device2 and configure the time as China Standard Time.

```
Device2#configure terminal
Device2(config)#ntp enable
Device2(config)#clock timezone BINJING 8
```

#Specify the NTP server for the client, and the IP address is 1.0.0.1.

```
Device2(config)#ntp server 1.0.0.1
```

Enable authentication.

```
Device2(config)#ntp authenticate
```

#Configure the authentication key serial number as 1, the algorithm as MD5, and the key as admin.

```
Device2(config)#ntp authentication-key 1 md5 0 admin
```

#Configure the key with serial number 1 to be trusted.

```
Device2(config)#ntp trusted-key 1
```

Step 4: Check the result.

#On the client Device2, execute **show ntp status** command to check the clock synchronization status and other information, indicating that the client and the NTP server Device1 has been synchronized, the number of clock layers is greater than Device1 by 1, which is 4.

```
Device2#show ntp status
Current NTP status information
 NTP ipv4 is enabled
  NTP ipv6 is disabled
Clock is synchronized, stratum 4, reference is 1.0.0.1
reference time is D442ECE1.8BB7B219 (01:56:49.545 Tue Nov 06 2012)
```

#Execute the **show clock** command on Device2 to check the device clock.

```
Device2#show clock
BEIJING(UTC+08:00) TUE NOV 06 09:56:52 2012
```

Caution

- The NTP client and the server must have the same authentication serial number and the same key.

86.3.4 Configure the NTP IPV4 P2P Mode

Network Requirements

- Device1, Device2 and Device3 are interconnected through their respective interfaces and are reachable by route.
- Device1 sets the local clock as the reference clock and the layer number is 3.
- Device2 acts as the NTP client, and set Device1 as the NTP server.
- Device3 sets Device2 as the peer, Device3 as the active peer, and Device2 as the passive peer.

Network Topology

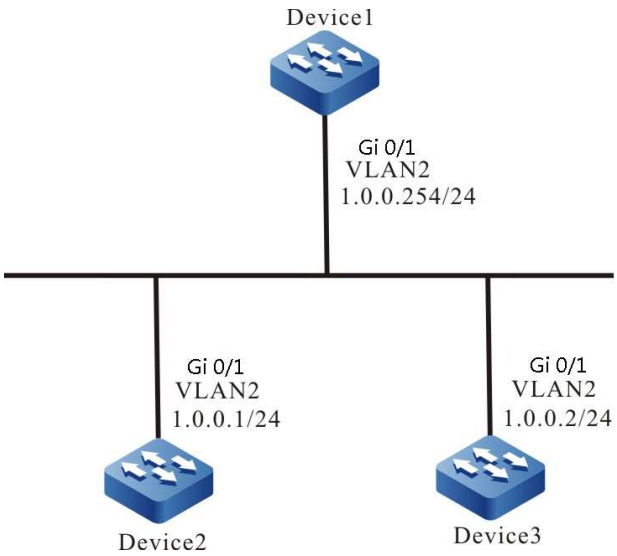


Figure 5-6 Network Topology for Configuring the NTP P2P Mode

Configuration Steps

Step 1: Configure IP addresses for the ports. (Omitted)

Step 2: Enable NTP IPV4 on Device1, and configure the time as China Standard Time and the number of local clock layers as 3.

```
Device1#configure terminal
Device1(config)#ntp enable
Device1(config)#clock timezone BINJING 8
Device1(config)#ntp master 3
```

Step 3: Device2 specifies Device1 as the NTP server.

#Enable NTP IPV4 on Device2 and configure the time as China Standard Time.

```
Device2#configure terminal
Device2(config)#ntp enable
Device2(config)#clock timezone BEIJING 8
```

#Specify the NTP server IP address as 1.0.0.254.

```
Device2(config)#ntp server 1.0.0.254
```

Step 4: Device3 sets Device2 as the peer.

#Enable NTP IPV4 on Device3 and configure the time as China Standard Time.

```
Device3#configure terminal
Device3(config)#ntp enable
Device3(config)#clock timezone BEIJING 8
```

#Specify the NTP peer IP address as 1.0.0.1.

```
Device3(config)#ntp peer 1.0.0.1
```

Step 5: Check the result.

#Execute the **show ntp status** command on client Device2 to check the clock synchronization status and other information.

```
Device2#show ntp status
Current NTP status information
 NTP ipv4 is enabled
 NTP ipv6 is disabled
Clock is synchronized, stratum 4, reference is 1.0.0.254
reference time is D8E9785D.221F1F5 (03:09:17.8 Tue Apr 28 2015)
```

Device2 clock layer number is larger than Device1 by 1, which is 4, and the reference clock server address is 1.0.0.254, indicating that the client Device2 and the server Device1 have been synchronized.

#Execute the **show clock** command on the client Device2 to check the device clock.

```
Device2#show clock
BEIJING(UTC+08:00) TUE APR 28 11:10:36 2015
```

#Execute the **show ntp status** command on the active peer Device3 to check the clock synchronization status and other information.

```
Device3#show ntp status
Current NTP status information
```

NTP ipv4 is enabled

NTP ipv6 is disabled

Clock is synchronized, stratum 5, reference is 1.0.0.1

reference time is D8E9795C.29835CC9 (03:13:32.162 Tue Apr 28 2015)

Device3 clock layer number is larger than Device2 by 1, which is 5, and the reference clock server address is 1.0.0.1, indicating that active peer Device3 has been synchronized with passive peer Device2.

#Execute the **show clock** command on the client Device3 to check the device clock.

Device3#show clock

BEIJING(UTC+08:00) TUE APR 28 11:16:19 2015

86.3.5 Configure NTP Broadcast Mode

Network Requirements

- Device1, Device2 and Device3 are interconnected through their respective interfaces and are reachable by route.
- Device1 sets the local clock as the reference clock and the layer number is 3.
- Device1 acts as the NTP broadcast server and sends NTP broadcast packets from the vlan2 interface.
- Device2 and Device3 are NTP broadcast clients, listening for NTP broadcast packets on their respective interfaces vlan2.

Network Topology

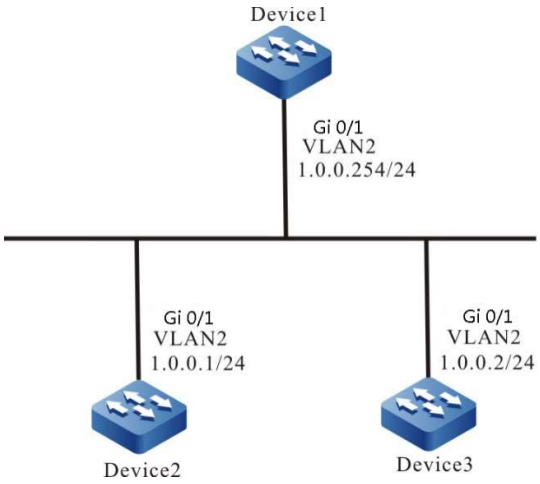


Figure 7-8 Network Topology for Configuring the NTP Broadcast Mode

Configuration Steps

Step 1: Configure IP addresses for the ports. (Omitted)

Step 2: Device1 sets the local clock as the reference clock and the layer number as 3. Configure Device1 as the NTP broadcast server to send NTP broadcast packets on interface vlan2.

#Enable NTP IPV4 on Device1, and configure the time as China Standard Time and the number of local clock layers as 3.

```
Device1#configure terminal
Device1(config)#ntp enable
Device1(config)#clock timezone BINJING 8
Device1(config)#ntp master 3
```

#Configure Device1 as the NTP broadcast server to send NTP broadcast packets on interface vlan2.

```
Device1(config)#interface vlan2
Device1(config-if- vlan2)#ntp broadcast-server
```

Step 3: Configure Device2 as the NTP broadcast client to listen for NTP broadcast packets on interface vlan2.

```
Device2#configure terminal
Device2(config)#ntp enable
Device2(config)#clock timezone BINJING 8
Device2(config)#interface vlan2
Device2(config-if- vlan2)#ntp broadcast-client
```

Step 4: Configure Device3 as the NTP broadcast client to listen for NTP broadcast packets on interface vlan2.

```
Device3#configure terminal
Device3(config)#ntp enable
Device3(config)#clock timezone BINJING 8
Device3(config)#interface vlan2
Device3(config-if- vlan2)#ntp broadcast-client
```

Step 5: Check the result.

#Execute the **show ntp status** command on client Device2 to check the clock synchronization status and other information.

Device2#show ntp status

Current NTP status information

NTP ipv4 is enabled

NTP ipv6 is disabled

Clock is synchronized, stratum 4, reference is 1.0.0.254

reference time is D8E97C99.5110D9FE (03:27:21.316 Tue Apr 28 2015)

Device2 clock layer number is larger than Device1 by 1, which is 4, and the reference clock server address is 1.0.0.254, indicating that the client Device2 and the server Device1 have been synchronized.

#Execute the **show clock** command on the client Device2 to check the device clock.

Device2#show clock

BEIJING(UTC+08:00) TUE APR 28 11:27:22 2015

#Execute the **show ntp status** command on client Device3 to check the clock synchronization status and other information.

Device3#show ntp status

Current NTP status information

NTP ipv4 is enabled

NTP ipv6 is disabled

Clock is synchronized, stratum 4, reference is 1.0.0.254

reference time is D8E97CAC.78F42CA6 (03:27:40.472 Tue Apr 28 2015)

Device3 clock layer number is larger than Device1 by 1, which is 4, and the reference clock server address is 1.0.0.254, indicating that the client Device3 and the server Device1 have been synchronized.

#Execute the **show clock** command on the client Device3 to check the device clock.

Device3#show clock

BEIJING(UTC+08:00) TUE APR 28 11:27:41 2015

86.3.6 Configure the NTP IPV6 Server and Client

Network Requirements

- Device1 is the NTP server and Device2 is the NTP client.
- Device1 and Device2 are interconnected through their respective interface VLAN2, and are route reachable.
- The NTP server is the clock source and the client gets the clock from the server.

Network Topology

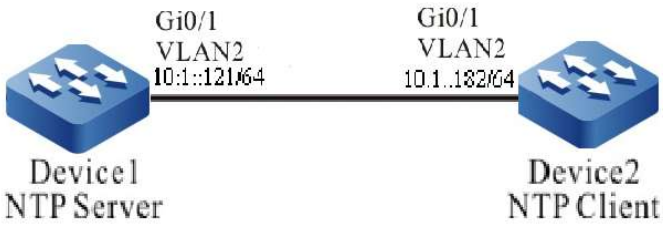


Figure 86 Network Topology for Configuring NTP IPV6 Server and Client

Configuration Steps

Step 1: Configure the IPv6 address of each interface (omitted).

Step 2: Configure the NTP server Device1.

#Enable NTP IPV6 on Device1, and configure the time as China Standard Time, local clock as the reference clock, and the number of local clock layers as 3.

Device1#configure terminal

Device1(config)#ntp enable ipv6

Device1(config)#clock timezone BINJING 8

Device1(config)#ntp master 3

Device1(config)#exit

Step 3: Configure the NTP client Device2.

#Enable NTP IPV6 on Device2 and configure the time as China Standard Time.

Device2#configure terminal

```
Device2(config)#ntp enable ipv6
Device2(config)#clock timezone BINJING 8
```

#Specify the NTP server Device1 with the IPV6 address 10:1::121.

```
Device2(config)#ntp server ipv6 10:1::121
Device2(config)#exit
```

Step 4: Check the result.

#On the client Device2, execute **show ntp status** command to check the clock synchronization status and other information, indicating that the client and the NTP server Device1 has been synchronized, the number of clock layers is greater than Device1 by 1, which is 4.

```
Device2#show ntp status
Current NTP status information
 NTP ipv4 is disabled
  NTP ipv6 is enabled
Clock is synchronized, stratum 4, reference is 10:1::121
reference time is D442EB0E.432F29BD (01:49:02.262 Tue Nov 06 2012)
```

#Execute the **show clock** command on the client Device2 to check the device clock.

```
Device2#show clock
BEIJING(UTC+08:00) TUE NOV 06 09:49:30 2012
```

86.3.7 Configure the NTP IPV6 P2P Mode

Network Requirements

- Device1, Device2 and Device3 are interconnected through their respective interfaces and are reachable by route.
- Device1 sets the local clock as the reference clock and the layer number is 3.
- Device2 acts as the NTP client, and set Device1 as the NTP server.
- Device3 sets Device2 as the peer, Device3 as the active peer, and Device2 as the passive peer.

Network Topology

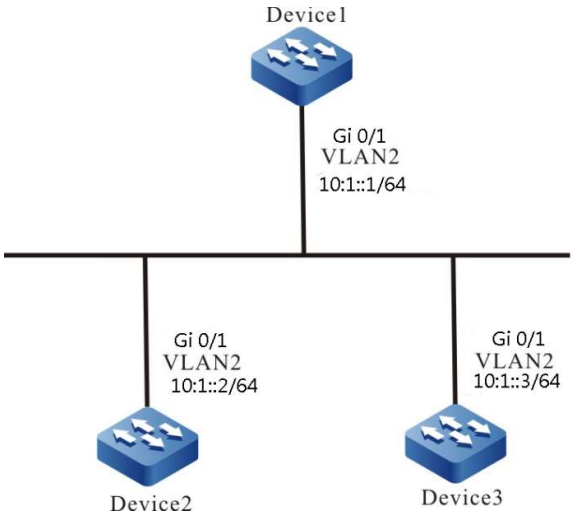


Figure 4-7 Network Topology for Configuring NTP IPV6 Peer Mode

Configuration Steps

Step 1: Configure the IPv6 address for each interface. (Omitted)

Step 2: Enable NTP IPV6 on Device1, and configure the time as China Standard Time and the number of local clock layers as 3.

```
Device1#configure terminal
Device1(config)#ntp enable ipv6
Device1(config)#clock timezone BINJING 8
Device1(config)#ntp master 3
```

Step 3: Device2 specifies Device1 as the NTP server.

#Enable NTP IPV6 on Device2 and configure the time as China Standard Time.

```
Device2#configure terminal
Device2(config)#ntp enable ipv6
Device2(config)#clock timezone BEIJING 8
```

#Specify the NTP server IPV6 address as 10:1::1.

```
Device2(config)#ntp server ipv6 10:1::1
```

Step 4: Device3 sets Device2 as the peer.

#Enable NTP IPV6 on Device3 and configure the time as China Standard Time.

```
Device3#configure terminal
Device3(config)#ntp enable ipv6
Device3(config)#clock timezone BEIJING 8
```

#Specify the NTP peer IPV6 address as 10:1::2.

Device3(config)#ntp peer ipv6 10:1::2

Step 5: Check the result.

#Execute the **show ntp status** command on client Device2 to check the clock synchronization status and other information.

Device2#show ntp status

Current NTP status information

NTP ipv4 is disabled

NTP ipv6 is enabled

Clock is synchronized, stratum 4, reference is 10:1::1

reference time is D8E9785D.221F1F5 (03:09:17.8 Tue Apr 28 2015)

Device2 clock layer number is larger than Device1 by 1, which is 4, and the reference clock server address is 10:1::1, indicating that the client Device2 and the server Device1 have been synchronized.

#Execute the **show clock** command on the client Device2 to check the device clock.

Device2#show clock

BEIJING(UTC+08:00) TUE APR 28 11:10:36 2015

#Execute the **show ntp status** command on the active peer Device3 to check the clock synchronization status and other information.

Device3#show ntp status

Current NTP status information

NTP ipv4 is disabled

NTP ipv6 is enabled

Clock is synchronized, stratum 5, reference is 10:1::2

reference time is D8E9795C.29835CC9 (03:13:32.162 Tue Apr 28 2015)

Device3 clock layer number is larger than Device2 by 1, which is 5, and the reference clock server address is 10:1::2, indicating that active peer Device3 has been synchronized with passive peer Device2.

#Execute the **show clock** command on the client Device3 to check the device clock.

Device3#show clock

BEIJING(UTC+08:00) TUE APR 28 11:16:19 2015

87 Mirroring

87.1 Overview

87.1.1 Overview

Port mirror, also called SPAN (Switched Port Analyzer), is one management mode used to monitor the data flow of the device port. SPAN includes local SPAN, remote SPAN, and VLAN SPAN.

87.1.2 Basic Concepts

SPAN Session

SPAN session means to mirror the data flow of one or multiple monitor ports on the device and send to the destination port. The mirrored data flow can be the input data flow and also can be the output data flow or mirror the input and output data flow at the same time. We can configure SPAN for the disabled port and the SPAN session does not take effect, but as long as the related port is enabled, SPAN takes effect.

Local SPAN

Local SPAN supports the port mirror on one device. All mirror ports and destination ports are on the same device.

Remote SPAN

Remote SPAN, also called RSPAN (Remote Switched Port Analyzer), supports that the mirror port can destination port are not on one device, realizing the remote monitoring across the L2 network. In the specified RSPAN VLAN, each RSPAN Session makes the mirror packets be forwarded in the L2 network. RSPAN includes RSPAN Source Session, RSPAN VLAN, and RSPAN Destination Session. We need to configure RSPAN source session and RSPAN destination session on different devices. When configuring the RSPAN source session, we need to specify one or multiple mirror ports and a RSPAN VLAN. The data mirrored by the monitor port is sent to RSPAN VLAN. To configure RSPAN destination session on another device, we need to specify the destination port and RSPAN VLAN. RSPAN destination session sends RSPAN VLAN data to the destination port.

VLAN SPAN

VLAN SPAN supports VLAN mirroring on a single device. Mirror a copy of one or more monitored VLAN streams to the destination port. The mirrored data flow can be the input data flow and also can be the output data flow or mirror the input and output data flow at the same time.

Traffic Type

Traffic type includes Receive (Rx) (the received traffic of the mirror port, Transmit (Tx) (the forwarded traffic of the mirror port, and Both (the received and forwarded traffic of the mirror port).

SPAN Source Port

SPAN source port is also called monitored port. Its data is monitored for network analysis. The monitored data flow can be at the input direction, output direction or both. It can function in different VLANs. The source port can be general port or aggregation group. One source port can only belong to one SPAN session.

SPAN Destination Port

SPAN destination port can only be one separate actual physical port or aggregation group. One destination port can only be used in one SPAN session. The destination port can be general port or aggregation group.

The device supports taking the destination port as the general forwarding port, but for universality and to make the monitored data not be interfered by other data flow, it is suggested to delete the destination port from all VLANs.

Note

- The destination port should not be connected to other devices, as this may result in a network loop.
- The destination port cannot carry any other services.
- The destination port should be greater than or equal to the bandwidth of the monitored port, otherwise packet loss may occur.
- The destination port cannot enable LACP (Link Aggregation Control Protocol) or the 802.1X function to avoid mirroring data from being affected.
- Up to 4 destination ports can be supported for a single session. Depending on the chip, the number of destination ports supported by different boards may vary.

RSPAN VLAN

RSPAN VLAN should be one idle VLAN, specially used by RSPAN. We can select one idle VLAN during configuration, but should ensure that the other devices on the path from the mirror port to the destination port are all configured with the VLAN and add the corresponding ports of the other devices on the path to the VLAN.

87.2 SPAN Function Configuration

Table 87 SPAN Function Configuration List

Configuration Task	
Configure Local SPAN	Configure a Local SPAN session
Configure RSPAN	Configure RSPAN VLAN
	Configure a RSPAN source session
	Configure a RSPAN destination session
Configure VLAN SPAN	Configure a VLAN SPAN session

87.2.1 Configure Local SPAN

Local SPAN is used to analyze the data flow of the local device port.

Configuration Condition

None

Configure a Local SPAN Session

The Local SPAN session can copy packets received or forwarded by one or more source ports, and forward them from the destination port without affecting the forward of normal service of the source port.

Table 87 Configuring Local SPAN Sessions

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure the source of a Local SPAN session.	**monitor session** *session-number* **source** { **interface** *interface-list* | **interface link-aggregation** *link-aggregation-id* } [**both** | **tx** | **rx**]	Mandatory By default, the source of a Local SPAN session is not configured.

Step	Command	Description
Configure the destination of a Local SPAN session.	**monitor session** *session-number* **destination** { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Mandatory By default, the destination of a Local SPAN session is not configured.

Note

- When configuring the source of a session and specifying the port on which mirroring is enabled as the aggregation group, the specified aggregation group should have been created. If the aggregation group has not been created, the configuration fails. Similarly, when configuring a session destination and specifying the mirror packet forwarding port as the aggregation group, the specified aggregation group should also have been created. If the aggregation group has not been created, the configuration fails.
- The same port cannot be both the source and destination port for the same session.
- The same port cannot be used in more than one session at the same time.

87.2.2 Configure RSPAN

The RSPAN session is used to analyze the data flow from the source port of a remote device that is reachable by the Layer-2 network. An RSPAN session consists of an RSPAN source session and an RSPAN destination session.

Configuration Condition

None

Configure RSPAN VLAN

An RSPAN session enable mirrored packets to traverse the Layer-2 network by tagging the mirrored packets with RSPAN VLAN tags.

Table 87 Configuring RSPAN VLAN

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure VLAN as RSPAN VLAN.	**remote-span**	Mandatory By default, no RSPAN VLAN is configured.

Note

- The RSPAN VLAN should not carry other service traffic, only RSPAN traffic.
- RSPAN VLAN disables the MAC address learning function.
- Do not configure any ports into the RSPAN VLAN except those used to carry RSPAN traffic.

Configure a RSPAN Source Session

After configuring the RSPAN source session, the mirror packet is tagged with RSPAN VLAN and then forwarded from the destination port of the RSPAN source session.

Table 87 Configuring RSPAN Source Sessions

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the source of an RSPAN source session.	**monitor session** *session-number* **source** { **interface** *interface-list* | **interface link-aggregation** *link-aggregation-id* } [**both** | **tx** | **rx**]	Mandatory By default, the source of an RSPAN source session is not configured.
Configure the destination of an RSPAN source session.	**monitor session** *session-number* **destination remote vlan** *vlan-id* **interface** *interface-name*	Mandatory By default, the destination of an RSPAN source session is not configured.

Note

- When configuring the source of a session and specifying the port on which mirroring is enabled as the aggregation group, the specified aggregation group should have been created. If the aggregation group has not been created, the configuration fails.
- Specify that the VLAN must be set as an RSPAN VLAN before an RSAPN source session.
- The source and destination of the same session cannot appear at the same port.
- The same port cannot be used in more than one session at the same time.
- The destination port of an RSPAN source session can only be a normal port, not an aggregation group.
- The RSPAN source session supports only one destination port.

Configure a RSPAN Destination Session

When the RSPAN destination session receives a packet, it identifies the mirror packet based on the RSPAN VLAN tag and forwards the mirror packet to the analysis device.

Table 1 Configuring RSPAN Destination Sessions

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the source of an RSPAN destination session.	**monitor session** *session-number* **source remote vlan** *vlan-id*	Mandatory By default, the source of an RSPAN destination session is not configured.
Configure the destination of an RSPAN destination session.	**monitor session** *session-number* **destination** { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Mandatory By default, the destination of an RSPAN destination session is not configured.

Note

- Specify that the VLAN must be set as an RSPAN VLAN before an RSAPN destination session.
- The same port cannot be used in more than one session at the same time.

- The type of the destination port of an RSPAN destination session should be Hybrid.

87.2.3 Configure VLAN SPAN

The VLAN SPAN session is used to analyze the data flow of the specified VLAN.

Configuration Condition

None

Configure a VLAN SPAN Session

VLAN SPAN is similar to Local SPAN. The VLAN SPAN session can copy packets received or forwarded by one or more VLAN, and forward them from the destination port without affecting the forward of normal service of the VLAN.

Table 87-7 Configuring VLAN SPAN Sessions

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure the source VLAN of a VLAN SPAN session.	**monitor session** *session-number* **source vlan** [**both** | **tx** | **rx**]	Mandatory By default, the source VLAN of a VLAN SPAN session is not configured.
Configure the reflector port of a VLAN SPAN session.	**monitor session** *session-number* **reflector-port interface** *interface-name*	Mandatory By default, the reflector port of a VLAN SPAN session is not configured.
Configure the destination of a VLAN SPAN session.	**monitor session** *session-number* **destination interface** *interface-name*	Mandatory By default, the destination of a VLAN SPAN session is not configured.

Note

- The destination port of a VLAN SPAN session cannot be a member port of the source VLAN

of the VLAN SPAN session.

- The destination port of a VLAN SPAN session can only be a normal port, not an aggregation group.
- The source VLAN member ports of a VLAN SPAN session cannot appear in multiple sessions at the same time.
- When configuring the source VLAN for a VLAN SPAN session, if the member ports of the source VLAN already belong to other sessions, the VLAN image cannot be successfully configured.
- The system supports only one VLAN SPAN session.
- If a packet exceeding the default mtu value of the port is sent in VLAN mirror, the reflector port needs to be configured with the mtu value.

87.2.4 SPAN Monitoring and Maintaining

Table 87 SPAN Monitoring and Maintaining

Command	Description
show monitor rspan-vlan	Display RSPAN VLAN.
show monitor session { *session-number* | **all** | **local** | **remote**}	Display the SPAN session configuration information.

87.3 Typical Configuration Example of Port Mirroring

87.3.1 Configure Local SPAN

Network Requirements

- PC1, PC2, and PC3 are connected to Device, and PC1 and PC2 communicate in VLAN 2;
- Configure Local SPAN on Device with the source port as gigabitethernet0/1 and the destination port as gigabitethernet0/3 to enable PC3 to monitor the packets sent and received by Device port gigabitethernet0/1.

Network Topology

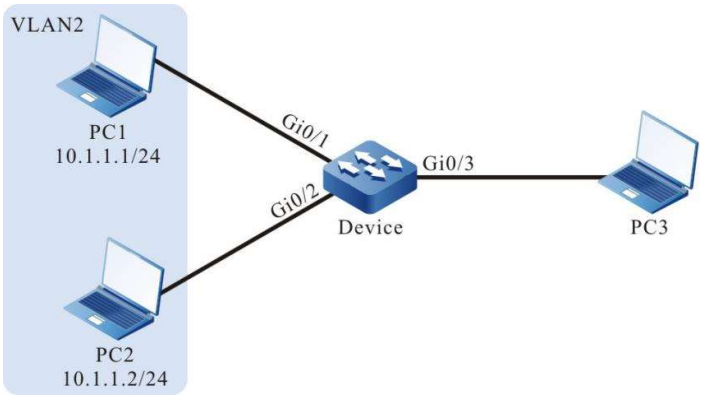


Figure 87 Network Topology for Configuring Local SPAN

Configuration Steps

Step 1: Configure VLANs and the link type of the ports.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 on Device as Access, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1-0/2
Device(config-if-range)#switchport mode access
Device(config-if-range)#switchport access vlan 2
Device(config-if-range)#exit
```

Step 2: Configure Local SPAN.

#Configure Local SPAN on Device, with the port for mirroring source session as gigabitethernet0/1 and the port for destination session as gigabitethernet0/3.

```
Device(config)#monitor session 1 source interface gigabitethernet 0/1 both
Device(config)#monitor session 1 destination interface gigabitethernet 0/3
```

#Check the Local SPAN session information of on Device.

```
Device#show monitor session all
------------------------------------------------------------
Session 1
Type            : SPAN Local Session
Destination Interface : gi0/3
Source Interface(both): gi0/1
```

Step 3: Check the result.

#When PC1 and PC2 communicate with each other, the packets sent and received on port gigabitethernet0/1 can be captured on PC3.

87.3.2 Configure RSPAN

Network Requirements

- PC1 and PC2 are connected to Device1 and communicate in VLAN2, and PC3 is connected to Device2.
- Configure RSPAN on Device1 and Device2 to enable PC3 to monitor the packets sent and received on Device1 port gigabitethernet0/1 through RSPAN VLAN3.

Network Topology

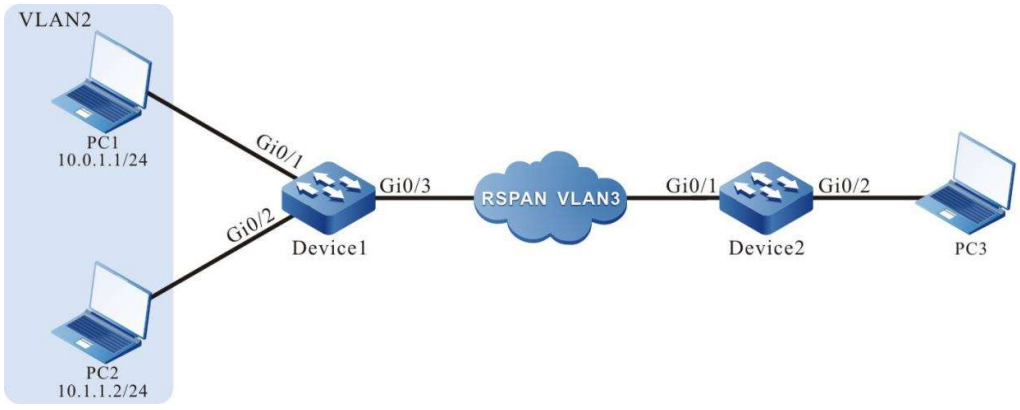


Figure 87 Network Topology for Configuring RSPAN

Configuration Steps

Step 1: Configure VLANs and the link type of the ports.

#Create VLAN2 on Device1.

```
Device1#configure terminal
Device1(config)#vlan 2
Device1(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 on Device1 as Access, allowing the services of VLAN2 to pass.

```
Device1(config)#interface gigabitethernet 0/1-0/2
Device1(config-if-range)#switchport mode access
Device1(config-if-range)#switchport access vlan 2
Device1(config-if-range)#exit
```

#On Device1, configure the link type of port gigabitethernet0/3 as Trunk.

```
Device1(config)#interface gigabitethernet 0/3
Device1(config-if-gigabitethernet0/3)#switchport mode trunk
Device1(config-if-gigabitethernet0/3)#exit
```

#Configure the link type of port gigabitethernet0/1 on Device2 as Trunk.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#switchport mode trunk
Device2(config-if-gigabitethernet0/1)#exit
```

#Configure the link type of port gigabitethernet0/2 as Hybrid on Device2.

```
Device2(config)#interface gigabitethernet 0/2
Device2(config-if-gigabitethernet0/2)#switchport mode hybrid
Device2(config-if-gigabitethernet0/2)#exit
```

Step 2: Configure RSPAN on Device1 and Device2.

#Configure VLAN3 as RSPAN VLAN on Device1 and configure port gigabitethernet0/3 to allow services of VLAN3 to pass.

```
Device1(config)#vlan 3
Device1(config-vlan3)#remote-span
Device1(config-vlan3)#exit
Device1(config)#interface gigabitethernet 0/3
Device1(config-if-gigabitethernet0/3)#switchport trunk allowed vlan add 3
Device1(config-if-gigabitethernet0/3)#exit
```

#Configure RSPAN on Device1, with the port for mirroring source session as gigabitethernet0/1 and the port for destination session as gigabitethernet0/3.

```
Device1(config)#monitor session 1 source interface gigabitethernet 0/1 both
Device1(config)#monitor session 1 destination remote vlan 3 interface gigabitethernet 0/3
```

View RSAPN session information on Device1.

```
Device1#show monitor session all
------------------------------------------------------------
Session 1
Type           : RSPAN Source Session
RSPAN VLAN     : 3
Destination Interface : gi0/3
Source Interface(both): gi0/1
```

#Configure VLAN3 as RSPAN VLAN on Device2 and configure port gigabitethernet0/1 to allow services of VLAN3 to pass.

```
Device2(config)#vlan 3
Device2(config-vlan3)#remote-span
Device2(config-vlan3)#exit
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)# switchport trunk allowed vlan add 3
Device2(config-if-gigabitethernet0/1)#exit
```

#Configure RSPAN on Device2, with the port for mirroring source session as RSAPN VLAN3 and the port for destination session as gigabitethernet0/2.

```
Device2(config)#monitor session 1 source remote vlan 3
Device2(config)#monitor session 1 destination interface gigabitethernet 0/2
```

#View RSAPN session information on Device2.

```
Device2#show monitor session all
------------------------------------------------------------
Session 1
Type           : RSPAN Destination Session
RSPAN VLAN     : 3
Destination Interface : gi0/2
```

Step 3: Check the result.

#When PC1 and PC2 communicate with each other, the packets sent and received on Device1 port gigabitethernet0/1 can be captured on PC3.

87.3.3 Configure VLAN SPAN

Network Requirements

- PC1, PC2, and PC3 are connected to Device, and PC1 and PC2 communicate in VLAN 2;
- Configure VLAN SPAN on Device with the source vlan as vlan2, the reflector port as gigabitethernet0/4 and the destination port as gigabitethernet0/3 to enable PC3 to monitor the packets sent and received by the vlan2 interface of the Device.

Network Topology

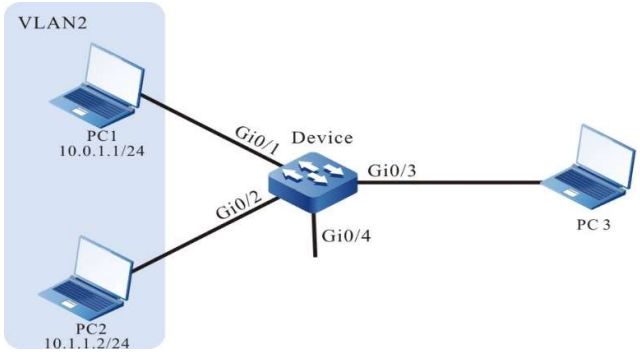


Figure 87 Network Topology for Configuring VLAN SPAN

Configuration Steps

Step 1: Configure VLANs and the link type of the ports.

Create VLAN2 on Device.

```
Device#configure terminal
Device(config)#vlan 2
Device(config-vlan2)#exit
```

#Configure the link type of ports gigabitethernet0/1 and gigabitethernet0/2 on Device as Trunk, allowing the services of VLAN2 to pass.

```
Device(config)#interface gigabitethernet 0/1-0/2
Device(config-if-range)#switchport mode trunk
Device(config-if-range)# switchport trunk allowed vlan add 2
Device(config-if-range)#exit
```

Step 2: Configure VLAN SPAN.

#Configure VLAN SPAN on Device, with the port for mirroring source session as VLAN2 and the port for destination session as gigabitethernet0/3.

```
Device(config)#monitor session 1 source vlan 2 both
Device(config)#monitor session 1 reflector-port interface gigabitethernet0/4
Device(config)# monitor session 1 destination interface gigabitethernet0/3
Device#show monitor session all
------------------------------------------------------------
Session 1
Type            : SPAN VLAN Session
Destination Interface  : gi0/3
Reflector Interface  : gi0/4
Source VLAN(both): 2
```

Step 3: Check the result.

#When PC1 and PC2 communicate with each other, the packets sent and received on VLAN2 can be captured on PC3.

88 sFlow

88.1 Overview

sFlow, a technology for network traffic sampling and monitoring, follows the RFC3176 standard. sFlow performs different samplings according to different configurations. The sampling process is: First analyze the packet head from the sampled packet, encapsulate as the sFlow packet according to the standard definition, and send to the third-party receiver, which is convenient for the user to analyze and monitor the traffic entering the device via the third-party receiver.

sFlow includes the following two sampling modes:

- Sampler sampling mode: It is one sampling mode provided by the switching chip, sampling the traffic entering the port at random;
- Poller sampling mode: It is one software sampling mode, used to collect the packet and traffic statistics information of the port regularly.

sFlow defines the following two roles:

- Agent role: It is the sFlow agent on the device, used to manage the two sampling modes of sFlow and execute the sampling task;
- Receiver role: It is the mapping of the third-party receiver supporting the sFlow protocol on the local device, used to save the information of the third-party receiver (such as IP address and UDP port number) and regularly send the sFlow packets buffered on the device to the third-party receiver.

88.2 sFlow Function Configuration

Table 88 sFlow Function Configuration List

Configuration Task	
Configure basic functions of sFlow.	Create the agent role.
	Create receiver Role

Configuration Task	
Configure sFlow Sampling Mode	Configure sampler Sampling Mode
	Configure poller Sampling Mode

88.2.1 Configure Basic Functions of sFlow

Configuration Condition

- No.

Create the Agent Role

The agent role is used to configure and manage sampling. Currently, the network address type supported by the agent role can only be IPv4.

Table 88 Creating Agent Role

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create the agent role.	**sflow agent ip** *ip-address*	Mandatory By default, no agent role is created.

Create Receiver Role

The receiver role is used to save the information of the third-party receiver and send the sFlow packets buffered on the device to the third-party receiver via the UDP mode. The triggering conditions of sending packets include the following two:

- When the specified buffer area is full and cannot be filled with new sFlow sampling information, first encapsulate the buffered part to the sFlow packet, send to the third-party receiver, and then fill the new part to the buffer area. This can reduce the number of the sFlow packets sent by the device to the third-party receiver obviously.
- Encapsulate the buffered sFlow sampling information as the sFlow packet periodically and send to the third-party receiver. This can avoid that the buffered part cannot be encapsulated as the sFlow packet and sent to the third-party receiver because of not receiving new sFlow sampling information within a long time.

Table 88 Creating Receiver Role

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create receiver Role	**sflow receiver** *receiver-index* **owner** *owner-name* **ip** *ip-address* [**packet-size** *packet-size-value* **timeout** *timeout-value* **udp-port** *udp-port-number*]	Mandatory By default, no receiver role is created.

88.2.2 Configure sFlow Sampling Mode

Configuration Condition

Before configuring the sFlow sampling mode, first complete the following task:

- Create the agent role
- Create the receiver role

Configure Sampler Sampling Mode

In the sampler sampling mode, that is port flow sampling, the switching chip samples the traffic received by the port at random. After getting the sample packet, first copy the head information of the packet, resolve the copied content, get the desired sample information from it, and at last, encapsulate the sample information and send to the corresponding third-party receiver of the receiver role.

Table 88 Configuring Interface Sampler Sampling Method

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure sampler Sampling Mode	**sflow sampler receiver** *receiver-index* [**header-size** *header-size-value* **sample-rate** *sample-rate-value*	Mandatory

Step	Command	Description
	direction *direction-value* **type** *type-value*]	By default, do not configure the sampler sampling mode.

Configure Poller Sampling Mode

The poller sampling mode, that is port regular polling sampling, is to regularly encapsulate the packet and traffic statistics information on the port within the period and send to the corresponding third-party receiver of the receiver role.

Table 1 Configuring Poller Sampling Method

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure poller Sampling Mode	**sflow poller** *poller-index* **receiver** *receiver-index* [**interval** *interval-value* **type** *type-value*]	Mandatory By default, no poller sampling method is configured.

88.2.3 sFlow Monitoring and Maintaining

Table 2 sFlow Monitoring and Maintaining

Command	Description
clear sflow receiver *receiver-index* **statistics**	Clear the sFlow sampling statistics associated with the specified receiver role.
show sflow	Display the configuration and operation information of sFlow.
show sflow agent	Display the configuration and operation information of the agent role.

Command	Description
show sflow poller [**interface** *interface-name*]	Display the configuration and operation information of the poller sampling method on the interface.
show sflow receiver [*receiver-index* [**statistics**]]	Displays sFlow sampling statistics, configuration and operational information associated with the receiver role.
show sflow sampler [**interface** *interface-name*]	Display the configuration and operation information of the sampler sampling method on the interface.

88.3 Typical Configuration Example of sFlow

88.3.1 Configure Basic Functions of sFlow

Network Requirements

- Device is an sFlow agent device that is route reachable to the NMS server.
- The NMS server monitors Device's interface data traffic via sFlow.

Network Topology

Figure 88 Network Topology for Configuring Basic Functions of sFlow

Configuration Steps

Step 1: Configure the VLAN and add the interface to the corresponding VLAN. (Omitted)

Step 2: Configures IP addresses for the ports. (Omitted)

Step 3: Configure the sFlow function.

#Enable an sFlow agent.

```
Device#configure terminal
Device(config)#sflow agent ip 1.1.1.1
```

#Configure the destination IP address and destination UDP interface number of the sFlow statistics output packet, the sending interval of packets is 5 seconds, and the cache is 1400 bytes.

```
Device(config)#sflow receiver 1 owner 1 ip 129.255.151.10 timeout 5 udp-port 6343 packet-size 1400
```

#Sampler sampling of the flow in the inbound direction of interface gigabitethernet0/1 with a sampling frequency of 10.

```
Device(config)#interface gigabitethernet 0/1
Device(config-if-gigabitethernet0/1)#sflow sampler receiver 1 sample-rate 10 direction rx
```

#Poller sampling of flows in the inbound direction of interface gigabitethernet0/1 with a polling period of 20 seconds.

```
Device(config-if-gigabitethernet0/1)#sflow poller 1 receiver 1 interval 20
Device(config-if-gigabitethernet0/1)#exit
```

Step 4: Check the result.

#View information about the sFlow on Device.

```
Device#show sflow

sFlow Agent Configuration: (Interval = 120, Current Tick = 0x002a6476)

            Address                        Receivers   Samplers    Pollers
 Version   Id  Type      Net Address     Socket  Number      Number      Number      Boot Time / Exec Time
--------- ---- ------- ----------------- -------- ----------- ----------- ----------- -----------/-----------
 1.3       1   IPv4    1.1.1.1          0x1c     1/10        1/864       1/864       0x00000ab2/0x002a644c


sFlow Receivers Configuration: (Reset Delta = 18000, Current Tick = 0x002a6476)

sFlow Receivers num:1(limit 10)

                                                    Datagram Maximum
 Index          Owner            Net Address     Port   Version  Datagram Timeout Reset Time /Expire Time
------- ------------------------- ----------------- ------- -------- -------- ------- -----------/-----------
    1   1                     129.255.151.10     6343       5     1400       5   0x002a644c/0x002a6578



sFlow Samplers Configuration:

sFlow Samplers num:1(limit 864)


 Sampling Types: H - raw packet header  E - ethernet packet
                 F - IPv4 packet        S - IPv6 packet


             Receiver Sampling Sampling  Maximum Sampling
  Interface   Index    Rate     Direction Header  Types
------------- -------- -------- --------- ------- --------
 gi0/1            1       10   rx          128   H



sFlow Pollers Configuration: (Current Tick = 0x002a6476)

sFlow Pollers num:1(limit 864)
```

```
Sampling Types: G - generic counter
                E - ethernet counter


                                Receiver Sampling
  Interface   Instance Index    Types    Interval
------------- -------- -------- -------- --------
 gi0/1            1       1   G            20
```

#The flow information of the inbound direction of interface gigabitethernet0/1 on Device can be viewed on the NMS.

89 LLDP

89.1 Overview

89.1.1 Overview of LLDP Protocol

LLDP (Link Layer Discovery Protocol) is the link layer protocol defined in the IEEE 802.1ab standard. It organizes the information of the local device to TLV (Type/Length/Value), encapsulates in LLDPDU (Link Layer Discovery Protocol Data Unit) and sends to the direct-connected neighbor device. Meanwhile, it saves the LLDPDU received from the neighbor device in the standard MIB (Management Information Base) mode. With LLDP, the device can save and manage its own and direct-connected neighbor device information for the network management system to query and judge the link communication status.

89.1.2 TLV Type Information

TLV that LLDP can encapsulate includes the basic TLV, organization-defined TLV and MED (Media Endpoint Discovery) TLV. Basic TLV is a group of TLV regarded as the basis of the network device management. Organization defined TLV and MED TLV is the TLV defined by the standard organization and other institutions, used to strengthen the management for the network devices. We can configure whether to release in LLDPDU according to the actual demand.

Basic TLV

In basic TLV, there are several types of TLV, which are mandatory for realizing the LLDP function, that is, should be released in LLDPDU, as shown in the following table.

Table 89 Basic TLV Description

TLV Type	Description	Whether it must be released
End of LLDPDU TLV	Mark the end of LLDPDU	Yes
Chassis ID TLV	MAC address of the sending device.	Yes

TLV Type	Description	Whether it must be released
Port ID TLV	Used to identify the port on the sender of LLDPDU. When the device does not send the MED TLV, the content is the port name, and when the MED TLV is scheduled to be sent, the content is the MAC address of the port.	Yes
Time To Live TLV	The time-to-live of local device information on neighbor devices.	Yes
Port Description TLV	Description string of the port.	no
System Name TLV	Name of the device.	no
System Description TLV	DESCRIPTION OF SYSTEM	no
System Capabilities TLV	The main functions of the system, and those of which that are enabled.	no
Management Address TLV	Management address, and the corresponding interface number and OID (Object Identifier). The management address can be a manually configured IP address; if not configured, the primary IP address of the management port of the device is selected; if the management port is not configured, the primary IP address of the VLAN through which the interface is allowed is selected; if no primary IP address is configured for any VLAN, the management address	Yes

TLV Type	Description	Whether it must be released
	value is null. The TLV will be sent by default.	

Organization-defined TLV

The organization-defined TLV includes the 802.1 organization-defined TLV and 802.3 organization-defined TLV, as shown in the following table.

Table 89 802.1 Organization Definition TLV Description

TLV Type	Description	Whether it must be released
Port VLAN ID TLV	Port VLAN ID	no
Port And Protocol VLAN ID TLV	Port and Protocol VLAN ID	no
VLAN Name TLV	Port VLAN Name	no
Protocol Identity TLV	The protocol type supported by the port, the local device does not support sending Protocol Identity TLVs, but can receive TLVs of such type.	no

Table 1 802.3 Organizational Definition TLV Description

TLV Type	Description	Whether it must be released
MAC/PHY Configuration/Status TLV	The rate and duplex status of the port; whether the port rate auto-negotiation is supported; whether the auto-negotiation function is enabled; and the current rate and duplex status.	no

TLV Type	Description	Whether it must be released
Power Via MDI TLV	Power supply capacity of the port.	no
Link Aggregation TLV	Whether the port supports link aggregation and whether it can enable link aggregation.	no
Maximum Frame Size TLV	The maximum frame length supported, taking the configured MTU (Max Transmission Unit) of the port.	no

MED TLV

MED TLV specific information is shown in the table below.

Table 2 MED TLV Description

TLV Type	Description	Whether it must be released
LLDP-MED Capabilities TLV	The MED device type of the device and the type of LLDP MED TLV that can be encapsulated in the LLDPDU.	no
Network Policy TLV	Information about the port's VLAN ID, supported applications (such as voice and video), the priority of the application, and the policy used, etc.	no
Extended Power-via-MDI TLV	Power supply capacity of the device.	no
Hardware Revision TLV	Hardware version of the device.	no

TLV Type	Description	Whether it must be released
Firmware Revision TLV	Firmware version of the device.	no
Software Revision TLV	Software version of the device.	no
Serial Number TLV	Serial number of the device.	no
Manufacturer Name TLV	Manufacturer of the device.	no
Model Name TLV	Module name of the device.	no
Asset ID TLV	Assertion identifiers for the device for directory management and assertion tracking.	no
Location Identification TLV	Location identification information of connected devices for use by other devices in location-based applications.	no

89.1.3 LLDP Working Mechanism

LLDP Working Mode

Four LLDP working modes are supported by port:

- RxTx: It either sends or receives LLDPDU.
- Tx: It only sends LLDPDU.
- Rx: It only receives LLDPDU.
- Disable: It neither sends nor receives LLDPDU.

LLDP Sending Mechanism

The LLDP sending mechanism:

- When the port works in the RxTx or Tx mode, regularly send LLDPDU to the neighbor

device according to the sending period of the LLDP packet;

- After the port enables the polling function, regularly poll whether the LLDP concerned configuration in the local device changes. If the configuration changes, send LLDPDU at once. To prevent the frequent change of the local information from causing lots of the sent LLDPDU, it is necessary to delay and wait for some time and then continue to send the next LLDPDU when sending one LLDPDU every time.
- When some configuration related with the local device LLDP changes (for example, select the released TLV type), or if finding the configuration change after enabling the polling function, enable the fast sending mechanism, that is, immediately send the LLDPDU of the specified quantity continuously, and then restore the normal LLDP packet sending period.
- When the global LLDP function is disabled or the port enabled with LLDP executes shutdown, adds to the aggregation group, and disables the LLDP, as well as restarts the device, send one LLDPDU with CLOSE TLV to inform the neighbor device.

LLDP Receiving Mechanism

When the port works in the RxTx or Rx mode, check the validity of the received LLDPDU and the carried TLV. After passing the validity check, save the neighbor information to the local device and set the age time of the neighbor information at the local device according to the TTL (Time To Live) carried in LLDPU. If the TTL value in the received LLDPDU is 0, age the neighbor information at once. The storing capability of the LLDP protocol for the neighbor is limited. If the neighbor reach the threshold, more neighbor advertising packets are dropped and cannot be saved.

89.2 LLDP Function Configuration

Table 3 LLDP Function Configuration List

Configuration Task	
Configure LLDP basic functions.	Enable the LLDP function globally.
	Enable port LLDP functions.
	Enable the LLDP port-based learning neighbor function.
Configure the LLDP working mode.	Configure the LLDP working mode.
Configure TLV allowed to be released.by LLDP.	Configure the basic TLV allowed to be released.
	Configure the organization-defined TLV that is allowed to be released.

Configuration Task	
	Configure the MED TLV that are allowed to be released.
Configure the LLDP parameters.	Configure the time-to-live of neighbors.
	Configure the delay time for sending packets.
	Configure the sending period of packets.
	Configure the number of fast packets to be sent.
	Configuration delay of reinitialization.
	Configure the inspection cycle of LLDP configuration.

89.2.1 Configure LLDP Basic Functions

Enable the LLDP function both globally and on ports to allow the LLDP to work properly. The local device gets the neighbor device information by interacting LLDPDUs with other devices.

Configuration Condition

None

Enable the LLDP Function Globally

Table 4 Enabling Global LLDP Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the LLDP function globally.	**lldp run**	Mandatory By default, the LLDP function is not enabled globally.

Enable Port LLDP Functions

Table 5 Enabling LLDP Function on Ports

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Enable port LLDP functions.	**lldp enable**	Mandatory By default, the LLDP function is not enabled on the port.

Enable the LLDP Port-based Learning Neighbor Function

After configuring the LLDP port-based learning neighbor function, you are able to learn and display neighbors based on a single port of the device. By default, the device learns and displays neighbors based on ports and aggregation group ports.

Table 6 Enabling LLDP Port-Based Learning Neighbor Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the LLDP port-based learning neighbor function.	**lldp mode-ap**	Optional By default, this function is disabled.

89.2.2 Configure the LLDP Working Mode

Configuration Condition

None

Configure the LLDP Working Mode

Users can set different working modes depending on the role of the device in the network. It is recommended to configure the LLDP working mode as Rx if it is a seed device (central device for network topology collection), otherwise it is recommended to configure the LLDP working mode as Tx.

Table 89 Configuring the LLDP Working Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the LLDP working mode to Rx.	**lldp receive**	Optional By default, the LLDP working mode is RxTx. The LLDP working mode is jointly determined by the commands **lldp receive** and **lldp transmit**.
Configure the LLDP working mode to Tx.	**lldp transmit**	

89.2.3 Configure TLV Allowed to Be Released.by LLDP

By releasing TLV, you allow neighbor devices to obtain details of local devices.

Configuration Condition

None

Configure the Basic TLV Allowed to be Released by LLDP

Users can release different basic TLVs according to the needs of the actual application.

Table 89-10 Configuring the Basic TLVs Allowed to be Published by LLDP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the Basic TLV Allowed to be Released by LLDP	**lldp tlv-select** { **basic-tlv** { **all** | **port-description** | **system-capability** | **system-description** | **system-name** } }	Optional By default, all basic TLVs are allowed to be released.

Configure the Organization-Defined TLVs Allowed to be Released

Users can release different organization-defined TLV according to the needs of the actual application.

Table 89-11 Configuring the Organization-Defined TLVs Allowed to be Published by LLDP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the L2/L3 Ethernet interface configuration mode.	**interface i***nterface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	
Configure the Organization-Defined TLVs Allowed to be Released	**lldp tlv-select** {**dot1-tlv** { **all** | **port-vlan-id** | **protocol-vlan-id** | **vlan-name** } | **dot3-tlv** { **all** | **link-aggregation** | **mac-physic** | **max-frame-size** | **power** } }	Optional By default, all organization-defined TLVs are allowed to be released.

Configure the MED TLVs Allowed to be Released by LDDP

Users can release different MED TLVs according to the needs of the actual application.

Table 89-12 Configuring the MED TLVs Allowed to be Published by LLDP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Configure the MED TLVs Allowed to be Released by LDDP	**lldp med-tlv-select** { **all** | **capability** | **location-id elin-address** *phonenum* | **network-policy** | **power-via-mdi** | **inventory** }	Optional By default, not all MED TLVs are allowed to be released.

89.2.4 Configure the LLDP Parameters

Configuration Condition

None

Configure the Time-to-live of Neighbors

Specify the time-to-live (TTL) of local device information on the neighbor device by configuring the TTL of neighbors, so that the neighbor device can delete the local device information after the local device's TTL expires.

Table 89-13 Configuring Neighbor TTL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the TTL of local devices on the neighbor devices.	**lldp holdtime** *holdtime-value*	Optional By default, the TTL of local devices on the neighbor devices is 120 seconds.

Configure the Delay Time for Sending Packets

By configuring the packet sending delay time, you can prevent the frequent changes of local information from causing a large number of LLDPDUs to be sent.

Table 89-14 Configuring the Delay Time for Sending Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the delay time for sending LLDP packets.	**lldp transmit-delay** *transmit-delay-value*	Optional By default, LLDP packets are sent with a delay time of 2 seconds.

Configure the Sending Period of Packets

By configuring sending period of a packet, the local device will send a LLDP packet to the neighbor device periodically, so that the information of the local device on the neighbor device will not expire.

Table 89-5 Configuring the Sending Period of Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the sending period of LLDP packets.	**lldp transmit-interval** *transmit-interval-value*	Optional By default, the interval of sending a LLDP packet is 30 seconds.

Configure the Number of Fast Packets to Be Sent

When some configurations related to LLDP of the local device (e.g., the type of TLV selected for releasing) change, or when the polling mechanism checks that the LLDP care configuration information in the local device changes after enabling the polling function, in order to let other devices discover the changes of the local device as soon as possible, the fast sending mechanism will be enabled, i.e., the specified number (default is 3) of LLDPDUs will be sent continuously immediately before reverting to the normal sending period.

Table 89-16 Configuring the Number of Fast Packets Sent

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Configure the number of fast packets to be sent.	**lldp fast-count** *fast-count-value*	Optional By default, the number of fast packets sent is 3.

Configuration Delay of Reinitialization

When the port working mode changes, the port protocol state machine will be re-initialized. To prevent frequent changes of the port working mode from constantly re-initializing the port protocol state machine, you can configure the re-initialization delay time of the port.

Table 89-17 Configuring the Reinitialization Delay

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configuration delay of reinitialization.	**lldp reinit** *reinit-value*	Optional By default, the reinitialization delay time is 2 seconds.

Configure the Inspection Cycle of LLDP Configuration

To enable timely notification of LLDP configuration changes to the neighbor device, you can configure to set the LLDP configuration inspection period.

Table 89-18 Configuring the LLDP Configuration Inspection Period

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration
Enter Aggregation Group Configuration Mode	**interface link-aggregation** *link-aggregation-id*	

Step	Command	Description
		takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enable the polling function and configure the polling period.	**lldp check-change-interval** *check-change-interval-value*	Optional By default, the polling function is disabled.

89.2.5 LLDP Monitoring and Maintaining

Table 89-19 LLDP Monitoring and Maintaining

Command	Description
clear lldp neighbors [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Clear neighbor information.
show lldp neighbors [**detail** | **interface** *interface-name* [**detail**] | **interface link-aggregation** *link-aggregation-id* [**detail**]]	Display neighbor information.
show lldp neighbors oui [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Display neighbor OUI address information and write Voice-VLAN OUI table entry status.
clear lldp statistics	Clear LLDP packet statistics.
show lldp statistics { **interface** *interface-name* | **interface link-aggregation** *link-aggregation-id* }	Display LLDP packet sending and receiving statistics for the specified port.
show lldp	Display information about LLDP global configuration.
show lldp interface *interface-name*	Display the LLDP working mode of the specified port and check the

Command	Description
	polling period for LLDP configuration changes.
show lldp interface link-aggregation *link-aggregation-id*	Display the LLDP working mode of the specified aggregation group and check the polling period for LLDP configuration changes.
show lldp tlv-select [**interface** *interface-name* | **interface link-aggregation** *link-aggregation-id*]	Used to display configuration information of basic TLVs and organization-defined TLVs.
show lldp voice neighbors [**detail** | **interface** *interface-name* [**detail**] | **interface link-aggregation** *link-aggregation-id* [**detail**]]	Display voice neighbor information.

89.3 Typical Configuration Example of LLDP

89.3.1 Configure the Basic Functions of LLDP

Network Requirements

- Configure the LLDP function on Device1, Device2 and Device3 respectively to achieve link-layer neighbor discovery.

Network Topology

Figure 89 Network Topology for Configuring Basic Functions of LLDP

Configuration Steps

Step 1: Enable the LLDP function on Device.

#Enable the LLDP function on Device1.

```
Device1#configure terminal
Device1(config)#lldp run
```

#Enable the LLDP function on Device2.

```
Device2#configure terminal
Device2(config)#lldp run
```

#Enable the LLDP function on Device3.

```
Device3#configure terminal
Device3(config)#lldp run
```

Step 2: Configure the LLDP function on ports.

#Enable the LLDP function on port gigabitethernet0/1 of Device1.

```
Device1(config)#interface gigabitethernet 0/1
Device1(config-if-gigabitethernet0/1)#lldp enable
Device1(config-if-gigabitethernet0/1)#exit
```

#On ports gigabitethernet0/1 and gigabitethernet0/2 of Device2, enable the LLDP function.

```
Device2(config)#interface gigabitethernet 0/1
Device2(config-if-gigabitethernet0/1)#lldp enable
Device2(config-if-gigabitethernet0/1)#exit
Device2(config)#interface gigabitethernet 0/2
Device2(config-if-gigabitethernet0/2)#lldp enable
Device2(config-if-gigabitethernet0/2)#exit
```

#Enable the LLDP function on port gigabitethernet0/1 of Device3.

```
Device3(config)#interface gigabitethernet 0/1
Device3(config-if-gigabitethernet0/1)#lldp enable
Device3(config-if-gigabitethernet0/1)#exit
```

Step 3: Check the result.

#View neighbor information on Device1.

```
Device1#show lldp neighbors
Capability codes:
      (R) Router, (B) Bridge, (T) Telephone, (C) DOCSIS Cable Device
      (W) WLAN Access Point, (P) Repeater, (S) Station, (O) Other
Index      Local Intf          Hold-time  Capability    Peer Intf          Device ID
1          gi0/1               120        P,R,          gi0/1              Device2
```

Device1 discovers neighbor Device2.

#View the information of Device1 neighbor.

```
Device1#show lldp neighbors detail
Basic information
Chassis ID                : 0001.7a54.5d0b
Interface ID              : gi0/1
Interface Description     : gigabitethernet0/1
System Name               : Device2
System Description        : HIT (R) Operating System Software
Copyright (C) 2021 Belden Singapore Pte Ltd.All Rights Reserved.
Time Remaining            : 111 seconds
System Capabilities       : P,R,
Enabled Capabilities      : P,R,
Management Addresses      : IP,10.0.0.1

802.1 organizationally information
```

```
Port VLAN ID                : 1
Port And Protocol VLAN ID   : 0
VLAN Name Of VLAN 1         : DEFAULT

802.3 organizationally information
Auto Negotiation            : Supported, Enabled
PMD Auto Negotiation Advertised : 10BASE-T,10BASE-TFD,100BASE-TX,100BASE-TXFD,FDX-PAUSE,1000BASE-TFD,
Media Attachment Unit Type  : 1000BaseTFD,
Port Class                  : PSE
PSE Power                   : Supported, Enabled
PSE Pairs Control Ability   : No
Power Pairs                 : 1
Power Class                 : 1
Link Aggregation            : Supported, Disabled
Link Aggregation ID         : 0
Max Translate Unit          : 1824

MED organizationally information
Capabilities                : Not Supported
Class Type                  : Not Supported
Application Type            : Not Supported
Policy                      : Not Supported
VLAN Tagged                 : Not Supported
VLAN ID                     : Not Supported
L2 Priority                 : Not Supported
DSCP Value                  : Not Supported
Location ID                 : Not Supported
Power Type                  : Not Supported
Power Source                : Not Supported
Power Priority              : Not Supported
Power Value                 : Not Supported
HardwareRev                 : Not Supported
FirmwareRev                 : Not Supported
SoftwareRev                 : Not Supported
SerialNum                   : Not Supported
Manufacturer Name           : Not Supported
Model Name                  : Not Supported
Asset Tracking Identifier   : Not Supported
----------------------------------------------


Total entries displayed: 1
```

Note

- Refer to Device1 to view the neighbor information of Device2 and Device3.

90 NDSP

90.1 Overview

90.1.1 Overview of NDSP Protocol

NDSP (Network Devices Searching Protocol) is a device searching protocol based on multicast packets. It can be used to search the direct-connected device. It organizes the information of the local device to TLV (Type/Length/Value), encapsulates in NDSPPDU (Network Devices Searching Protocol Data Unit) and sends to the direct-connected neighbor device. Meanwhile, it caches the information of the direct-connected device to local device after resolution of the NDSPPDU received from the neighbor device. With NDSP, the device can save and manage its own and direct-connected neighbor device information for the network management system to query and judge the link communication status.

NDSP has only one table, i.e. direct-connected neighbor table. For general networks, there is only one direct-connected neighbor on one interface. Thus, the number of entries will not exceed that of interfaces.

90.2 NDSP Function Configuration

Table 8-1 NDSP Function Configuration List

Configuration Task	
Configure basic functions of NDSP	Enable Global NDSP Function
	Enable NDSP Function of Port
Configure the LLDP parameters.	Configure the time-to-live of neighbors.
	Configure the sending period of packets.

90.2.1 Configure Basic Functions of NDSP

Enable the NDSP function both globally and on ports to allow the NDSP to work properly. The local device discovers neighbor and gets the neighbor device information by interacting NDSPPDUs with other devices.

Configuration Condition

None

Enable Global NDSP Function

Table 8-2 Enabling Global NDSP Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable Global NDSP Function	**ndsp run**	Mandatory By default, the NDSP function is not globally enabled.

Enable NDSP Function of Port

Table 8-3 Enabling NDSP Function of Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2/3 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**Interface link-aggregation** *link-aggregation-id*	
Enable NDSP Function of Port	**ndsp enable**	Mandatory By default, the NDSP function is disabled on the port.

90.2.2 Configure NDSP Parameters

Configuration Condition

None

Configure the Time-to-live of Neighbors

Specify the time-to-live (TTL) of local device information on the neighbor device by configuring the TTL of neighbors, so that the neighbor device can delete the local device information after the local device's TTL expires.

Table 8-4 Configuring Neighbor TTL

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the TTL of local devices on the neighbor devices.	**ndsp holdtime** *holdtime-value*	Optional By default, the TTL of local devices on the neighbor devices is 30 seconds.

Configure the Sending Period of Packets

By configuring sending period of a packet, the local device will send a NDSP packet to the neighbor device periodically, so that the information of the local device on the neighbor device will not expire.

Table 8-5 Configuring the Sending Period of Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the sending period of NDSP packets	**ndsp timer** *value*	Optional By default, the NDSP packet sending interval is 10 seconds.

90.2.3 NDSP Monitoring and Maintaining

Table 8-6 NDSP Monitoring and Maintaining

Command	Description
show ndsp neighbors [**detail**]	Display neighbor information.

90.3 Typical Configuration Example of NDSP

90.3.1 Configure Basic Functions of NDSP

Network Requirements

- Configure the NDSP function on Device1 and Device2 respectively to achieve link-layer neighbor discovery.

Network Topology

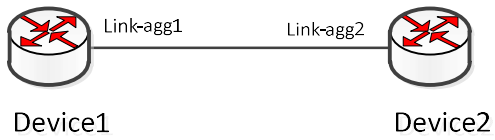


Figure 8-1 Network Topology for Configuring Basic Functions of NDSP

Configuration Steps

Step 1: Enable the NDSP function on the Device.

#Enable the NDSP function on Device1.

```
Device1#configure terminal
Device1(config)#ndsp run
```

#Enable the NDSP function on Device2.

```
Device2#configure terminal
Device2(config)# ndsp run
```

Step 2: Configure the NDSP function on the port.

#Enable the NDSP function on port link-aggregation 1 of Device1.

```
Device1(config)# interface link-aggregation 1
Device1(config-if-link-aggregation1)# ndsp enable
Device1(config-if-link-aggregation1)#exit
```

#On port link-aggregation 2 of Device2, enable the NDSP function.

```
Device2(config)# interface link-aggregation 2
Device2(config-if-link-aggregation2)# ndsp enable
Device2(config-if-link-aggregation2)#exit
```

Step 3: Check the result.

#View neighbor information on Device1.

```
Device1#show ndsp neighbors
Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
                  S - Switch, H - Host, I - IGMP, r - Repeater

Device ID        Local Interface     Holdtime  Capability  Neighbor Interface    Platform
00017a6a01f2     link-agg1           30        S           link-agg2             HIT-switch
```

Device1 discovers neighbor Device2.

#View the information of Device1 neighbor.

```
Device1#show ndsp neighbors detail
-------------------------
Device ID: 00017a6a01f2
Platform: HIT,  Capabilities: Switch
Port: link-agg1,  Port ID (outgoing port): link-agg2
Holdtime : 26 sec

Version :
HIT (R) Operating System Software, Version 9.5.0.2(26)(integrity) RELEASE SOFTWARE Copyright (C) 2021 Belden Singapore Pte Ltd.All Rights Reserved. Belden Singapore Pte Ltd.
Compiled Feb 27 2020, 17:00:44

Native VLAN : 1
```

Note

- Refer to Device1 to view the neighbor information of Device2.

91 SNMP

91.1 Overview

SNMP (Simple Network Management Protocol) is one standard protocol of managing Internet. It ensures that the management information can be transmitted between Network Managing Station and managed device SNMP agent. It is convenient for the system administrator to manage the network system.

SNMP is one application layer protocol in the client/server mode. It mainly includes three parts:

- NMS（Network Management Station）；
- SNMP agent

- MIB（Management Information Base）。

The structure set of all managed objects maintained by the device is called MIB. The managed objects are organized according to the hierarchical tree structure. MIB defines the network management information got by one device. To be consistent with the standard network management protocol, each device should use the format defined in MIB to display the information. One subset of IOS ASN.1 defines the syntax for MIB. Each MIB uses the tree structure defined in ASN.1 to organize all available information. Each piece of information is one node with punctuation and each node contains one object ID and one short text description.

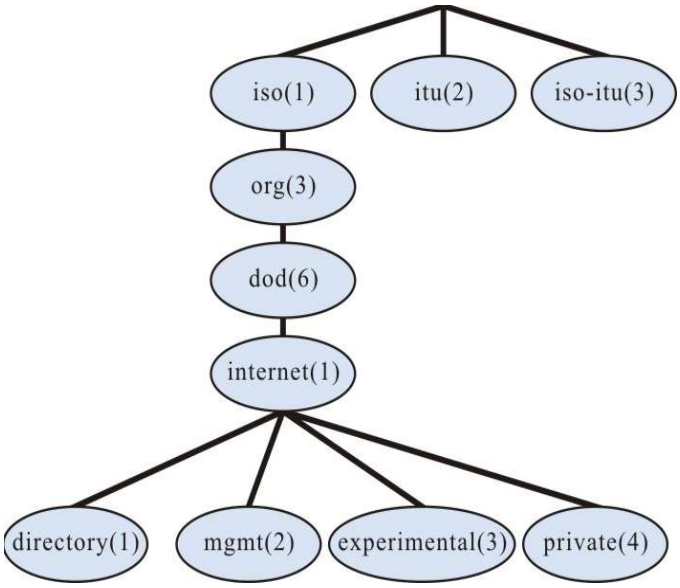


Figure 1 Schematic Diagram of the ASN.1 Tree for Network Management

SNMP protocol versions include SNMPv1, SNMPv2, and SNMPv3.

- SNMPv1: The first version of the SNMP protocol. The disadvantages: security problem, bandwidth waste, no communication capability between managers, the protocol only provides the limited operations;
- SNMPv2: It makes some improvement on the basis of SNMPv1, making the functions stronger and the security better;
- SNMPv3: original identity, information integrality and some aspects of re-transmission protect, content confidentiality, authorization and process control, the remote configuration and management capability needed by the above three capabilities;

Therefore, the development of SNMPv3 is centralized on two targets, that is, provide the workable security platform at the enhanced architecture and maintain the consistency of the network management system.

The SNMP protocol mainly includes the following operations:

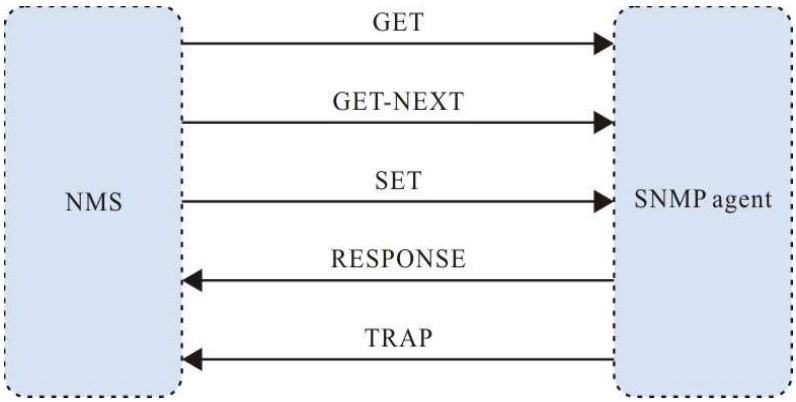


Figure 2 SNMP Management Operation Diagram

- Get-request: SNMP network work station gets one or multiple parameters from the SNMP agent.
- Get-next-request: SNMP network work station gets the next parameter of one or multiple parameters from the SNMP agent.
- Get-bulk: SNMP network work station gets the batch parameters from the SNMP agent.
- Set-request: SNMP network work station sets one or multiple parameters of the SNMP agent.
- Get-response: SNMP agent returns one or multiple parameters and it is the responding operation of the SNMP agent for the above three operations.
- Trap: The packet sent by the SNMP agent actively, informing that something happens to the SNMP network work station.

SNMPv1 and SNMPv2 use the authentication name to check whether to have the right to use the MIB object, so only when the authentication name of the network work station is consistent with one authentication name defined in the device, we can manage the device.

The authentication name has the following two attributes:

- Read-only: The read authority of the authorized network work station for all MIB objects of the device;
- Read-write: The read and write authority of the authorized network work station for all MIB objects of the device.

SNMPv3 determines which security mechanism to be adopted to process the data by the security model and the security level. There are three security models: SNMPv1, SNMPv2c, and SNMPv3.

Table 91 Supported Security Models and Security Levels

Security Model	Security Level	Certificates	encryption	Description
SNMPv1	NoAuthNoPriv	Authentication name	None	Confirm data legitimacy by authentication name.
SNMPv2c	NoAuthNoPriv	Authentication name	None	Confirm data legitimacy by authentication name.
SNMPv3	NoAuthNoPriv	User Name	None	Confirm data legitimacy by username.
SNMPv3	AuthNoPriv	MD5/SHA/SM3	None	Data authentication using HMAC-MD5/HMAC-SHA/SM3

Security Model	Security Level	Certificates	encryption	Description
SNMPv3	AuthPriv	MD5/SHA/SM3	AES/DES/SM4	Data authentication using HMAC-MD5/HMAC-SHA/SM3 and data encryption using CFB-AES-128/CBC-DES/ CBC-SM4

91.2 SNMP Function Configuration

Table 91 SNMP Function Configuration List

Configuration Task	
Configure basic functions of SNMP.	Enable the SNMP service.
	Configure the MIB view.
	Configure the contact information of the administrator.
	Configure the physical location information of the device.
Configure SNMPv1/v2.	Configure SNMP community names.
	Configure the SNMP Trap function.
Configure SNMPv3.	Configure an SNMP user group.
	Configure an SNMP user.
	Configure an SNMP advertisement.
	Configure SNMP agent forwarding.

91.2.1 Configure Basic Functions of SNMP

Configuration Condition

None

Enable SNMP Service

If the device is enabled with SNMP service, then the device can be configured and managed by the SNMP network management software.

Table 91 Enabling the SNMP Service

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Enable the SNMP service.	**snmp-server start [rfc]**	Mandatory The SNMP service is disabled by default.

Configure MIB View

By using the view-based access control model, it is determined whether the managed objects associated with an operation are allowed by the view, and only those managed objects that are allowed by the view are allowed to be accessed.

Table 91 Configuring MIB View

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure the MIB view.	**snmp-server view** *view-name oid-string* { **include** | **exclude** }	Mandatory By default, the SNMP view name is Default.
Configure the type of system uptime obtained in the MIB.	**snmp-server mib2 sysuptime { snmp-agent-uptime | system-uptime }**	Mandatory By default, its type is system-uptime.

Configure Contact Information of Administrator

Administrator contact information is an information node in the SNMP protocol, which can be obtained by the network management software via SNMP.

Table 1 Configuring Contact Information of Administrator

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure the contact information of the administrator.	**snmp-server contact** *contact-line*	Mandatory

Configure Physical Location Information of Device.

The physical location information of the device is an information node in the SNMP protocol, which can be obtained by the network management software via SNMP.

Table 2 Configuring the Physical Location of the Device

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure the physical location information of the device.	**snmp-server location** *location*	Mandatory

91.2.2 Configure SNMPv1/v2.

Configuration Condition

Before configuring SNMPv1/v2, do the following:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer.

Configure SNMP Community Names

SNMPv1/SNMPv2c uses community-name-based security scheme. An SNMP community name can be regarded as a password between the NMS and SNMP agents, which means the SNMP agent only accepts

management operations with the same community name, and SNMPs with different community names will be discarded directly and not be responded.

Table 91 Configuring Community Name

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure SNMP agent community names.	**snmp-server community** *community-name* [**view** *view-name*] { **ro | rw** } [*access-list-number | access-list-name*]	Mandatory By default, the community name is public.

91.2.3 Configure SNMPv3.

Configuration Condition

Before configuring the SNMPv3, do the following:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Interface IP addresses have been configured so that neighbor nodes are reachable at the network layer.

Create an SNMP User Group

When performing control, you can associate certain users with a group. Users in the same group all have the same access rights.

- A group can be configured to associate with a view. There are three types of such views: read-only views, writable views, and advertisement views.
- You can configure the security level of the group and configure whether authentication and encryption are required.

Table 3 Creating SNMP User Groups

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Create an SNMP User Group	**snmp-server group** *group-name* **v3** { **authnopriv** | **authpriv** | **noauth** } [**notify** *notify-view* | **read** *read-view* | **write** *write-view*]	Mandatory **authnopriv** means authentication without encryption. **authpriv** means both authenticated and encrypted. **noauth** means encryption without authentication.

Create an SNMP User

Through the user-based security model for security management, NMSs can only communicate through the SNMP agent using a legitimate user, which of course needs to be configured.

For SNMPv3, you can also specify the security level, authentication algorithm (MD5, SHA or SM3), authentication password, encryption algorithm (DES, AES or SM4), and encryption password.

Table 91 Configuring User

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Create an SNMP User	**snmp-server user** *user-name group-name* [**remote** *ip-address port-num*] **v3** [**auth** { **md5** | **sha**| **SM3** } *password* [**encrypt** {**des** | **aes | SM4** } *password*]] [**access** *access-list-number* | access-list-name | ***Ipv6*** *access-list-number*]	Mandatory

Note

- Configure User Security Model (USM)-based SNMPv3 users, saving the authentication and encryption information for each user. Note that the encryption protocol can be configured only after the authentication protocol has been configured.
- For remote users (the so-called remote is relative to the local SNMPv3 entity, if the local SNMPv3 entity has to deal with other SNMPv3 entities, then the other SNMPv3 entities are called remote SNMPv3 entities, which are mentioned in noify and proxy), you also need to specify the IP address and UDP port number of the remote user. When configuring a remote user, please note that you must first configure the engageID of the remote SNMP entity corresponding to that user. In addition, each user must correspond to a group so that a security model and security name can be mapped to a group name through view-based access control.
- When configuring automatic agent forwarding, if you don't know the ip address of the device being proxied, just enter 0.0.0.0 as ip-address. In addition, automatic agent forwarding must be used in combination with the keepalive mechanism.

Configure an SNMP Advertisement

The types of SNMPv3 advertisement configurations are as follows:

- SNMPv3 advertisement configuration: configure the SNMPv3 advertisement, specify the type of the advertisement message as inform.
- SNMPv3 advertisement filtering configuration: advertisement filtering indicates the filtering used to determine whether an advertisement message should be sent to a destination address.
- SNMPv3 advertisement address mapping table configuration: associate an advertisement address with a filter table.

Table 4 Configuring Advertisement

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure an SNMP advertisement.	**snmp-server notify notify** *notify-name taglist* **inform**	Mandatory
Configure SNMP advertisement filtering.	**snmp-server notify filter** *filter-name oid-subtree* { **exclude** | **include** }	Mandatory exclude: means to filter out all advertisements of the objects under the MIB subtree. include: indicates that all objects under the MIB subtree are notified.

Step	Command	Description
Configure SNMP address parameters.	**snmp-server AddressParam** { *address-name* | **paramIn** } **v3** *user-name* { **noauth** | **authpriv** | **authnopriv** }	Mandatory
Configure SNMP advertisement filtering mapping table.	**snmp-server notify profile** *filter-name address-param*	Mandatory *filter-name*: Specify the name of the advertisement filter to be mapped. *address-param*: Specify the name of the address parameter to be mapped.

Configure SNMP Agent Forwarding

If the NMS cannot directly access a managed SNMP agent, then an intermediate device is required to support agent forwarding. Currently, only SNMPv3 supports agent forwarding.

Table 5 Configuring Proxy Forwarding

Step	Command	Description
Enter the global configuration mode.	**config terminal**	-
Configure SNMP remote engine identity.	**snmp-server engineID remote** *ip-address port-num* [**vrf** *vrf-name*] *engine-id* [*group-name*]	Mandatory Configure the engine identity of an SNMP entity that needs to be forwarded by the agent.
Configure SNMP address parameters.	**snmp-server AddressParam** [*address-name* | **paramIn**] **v3** *user-name* { **noauth** | **authpriv** | **authnopriv** }	Mandatory
Configure the SNMP advertisement address.	**snmp-server TargetAddress** *target-name ip-address port-num address-param taglist time-out retry-num*	Mandatory

Step	Command	Description
Configure SNMP agent forwarding.	**snmp-server proxy** *proxy-name* { **inform** | **trap** | **read** | **write** } { *engineId* | **auto** } *engineId address-param target-addr* [*context-name*]	Mandatory

91.2.4 Configure SNMP Trap

Trap is a message sent proactively by the SNMP agent to the NMS to report some specific events. Trap packets are divided into: generic trap and custom trap. Generic trap includes the following: Authentication, Linkdown, Linkup, Coldstart, Warmstart, crc-error, out-packet-error, out-usage-rate, in-packet-error, in-usage-rate, while custom traps are output according to the needs of each module.

Table 6 Configuring Trap

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable traps for link interface donw or up.	**snmp-server enable traps snmp** [**linkup** | **linkdown**]	Mandatory SNMP Trap is not enabled by default.
Enter the interface configuration mode	**interface** *interface-type interface-num*	Optional
Configure trap for interface status change.	**snmp trap link-status**	Optional
Configure trap target host.	**snmp-server host {** *ip-address | host-name* **} traps {community** *community-name* **version { 1 | 2 } | user** *username* **authnopriv | authpriv | noauth version 3 }[port** *port-num* **| vrf** *vrf-name* **]**	Mandatory The ip-address needs to be specified as the IP address of the NMS.
Configure the source address of a trap packet.	**snmp-server trap-source** *ip-address*	Optional

Note

- Since trap information is usually large in quantity, it may occupy device resources and affect device performance. So it is recommended to enable the trap function of specified modules as needed, and avoid enabling all modules' trap.

91.2.5 SNMP Monitoring and Maintaining

Table 7 SNMP Monitoring and Maintaining

Command	Description
show snmp-server	Check information on SNMP protocol packet statistics.
show snmp-server AddressParams	Check information on SNMP-agent address parameters.
show snmp-server community	Check the information of an SNMP-agent community.
show snmp-server contact	Check the contact information of the device's administrator.
show snmp-server context	Check the SNMPv3 contextual environment.
show snmp-server engineGroup	Display information of an SNMP-agent engine group.
show snmp-server engineID	Display information of an SNMP-agent engine ID.
show snmp-server group	Check the information of an SNMP-agent user group.
show snmp-server Host	Display information of an SNMP-agent trap host.
show snmp-server location	Check the information about the location of the device.

Command	Description
show snmp-server notify filter	Display information of SNMP-agent advertisement filtering.
show snmp-server notify notify	Display information of an SNMP-agent advertisement.
show snmp-server notify profile	Display information associated with an SNMP-agent advertisement.
show snmp-server port	Check the port number configured for the SNMP protocol.
show snmp-server proxy	Check the information of SNMP-agent forwarding.
show snmp-server reg-list	Check the module information of SNMP-registered MIBs.
show snmp-server TargetAddress	Check the information of SNMP-agent address table entry.
show snmp-server user	Check the SNMP user information.
show snmp-server view	Check the SNMP view information.

91.3 Typical Configuration Example of SNMP

91.3.1 Configure an SNMP v1/v2c Proxy Server

Network Requirements

- Device acts as an SNMP Agent device that is route reachable to the NMS server.
- The NMS monitors and manages Device through SNMP v1 or SNMP v2c, and Device will actively report to the NMS in case of failure or error.

Network Topology

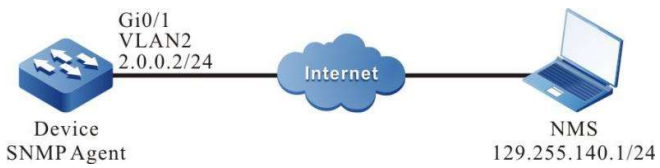


Figure 3 Network Topology for Configuring SNMP v1/v2c Proxy Servers

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Enable an SNMP agent on Device and configure the community name of the SNMP.

#Configure Device.

Enable the SNMP agent and configure the name of the node view as default, the read-only community name as public, and the read-write community name as public.

```
Device#configure terminal
Device(config)#snmp-server start
Device(config)#snmp-server view default 1.3.6.1 include
Device(config)#snmp-server community public view default ro
Device(config)#snmp-server community public view default rw
```

Step 4: Configure Device to actively send Trap packets to the Network Management System (NMS) and use the community name public.

#Configure Device.

```
Device(config)#snmp-server enable traps
Device(config)#snmp-server host 129.255.140.1 traps community public version 2
```

Note

- The SNMP version specified in the **snmp-server host** command must be the same as the SNMP version running on the NMS.

Step 5: Configure the NMS.

#Set the "read-only community name" and the "read-write community name" on the SNMP v1/v2c NMS. In addition, you have to set the "timeout" and "number of retries". Users can query and configure the device through the network management system.

Note

- When using the read-only community name, users can only perform query operations on the

device through the network management system.

- When using the read/write community name, users can query and configure the device through the network management system.

Step 6: Check the result.

#The NMS can query and set the values of certain parameters of Device through the MIB node. The NMS can receive various trap information from Device, such as interface up and down of Device, routing changes caused by network turbulence, etc. Device will generate the corresponding trap information and send it to NMS.

91.3.2 Configure an SNMP v3 Proxy Server

Network Requirements

- Device acts as an SNMP Agent device that is route reachable to the NMS server.
- The NMS manages Device via SNMP v3.

Network Topology

Figure 4 Network Topology for Configuring SNMP v3 Proxy Servers

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the interfaces (omitted).

Step 3: Enable an SNMP agent on Device and configure SNMP v3 basic information.

#Configure Device.

Enable an SNMP agent; configure the name of the node view as default, with access to all objects under node 1.3.6.1.

```
Device#configure terminal
Device(config)#snmp-server start
Device(config)#snmp-server view default1.3.6.1 include
```

Configure user group as public, security level as authpriv, read/write view, and notify view as default; configure user name as public, which belongs to the user group public, authentication algorithm as MD5, authentication password as admin, encryption algorithm as DES, and encryption password as admin.

```
Device(config)#snmp-server group public v3 authpriv read default write default notify default
Device(config)#snmp-server user public public v3 auth md5 admin encrypt des admin
```

Configure the contextual environment as public.

```
Device(config)#snmp-server context public
```

Step 4: Configure the NMS.

#On the NMS using SNMP v3, you need to set the user name and select the security level. According to different security levels, you need to set authentication algorithm, authentication password, encryption algorithm, and encryption password, among others, respectively. In addition, you have to set the "timeout" and "number of retries". Users can query and configure the device through the network management system.

Step 5: Check the result.

#The NMS can query and set the value of certain parameters of Device through the MIB node.

91.3.3 Configure SNMP v3 Trap Advertisements

Network Requirements

- Device acts as an SNMP Agent device that is route reachable to the NMS server.
- The NMS monitors Device via SNMP v3. Device will actively report to the NMS in case of failure or error.

Network Topology

Figure 5 Network Topology for Configuring SNMPv3 Trap Advertisement

Configuration Steps

Step 1: Configure IP addresses for the interfaces (omitted).

Step 2: Enable an SNMP agent on Device and configure SNMP v3 basic information.

#Configure Device.

Enable an SNMP agent; configure the name of the node view as default, with access to all objects under node 1.3.6.1.

```
Device#configure terminal
Device(config)#snmp-server start
Device(config)#snmp-server view default 1.3.6.1 include
```

Configure user group as public, security level as authpriv, read/write view, and notify view as default; configure user name as public, which belongs to the user group public, authentication algorithm as MD5, authentication password as admin, encryption algorithm as DES, and encryption password as admin.

```
Device(config)#snmp-server group public v3 authpriv read default write default notify default
Device(config)#snmp-server user public public v3 auth md5 Admin encrypt des Admin
```

Configure to have Device send all trap messages.

```
Device(config)#snmp-server enable traps
```

Step 3: Configure to have Device send SNMP v3 trap packets to the NMS.

#Configure Device.

Configure the SNMP v3 trap user name on the NSM as public and the security level as authpriv.

```
Device(config)#snmp-server host 129.255.140.1 version 3 user public authpriv
```

Step 4: Configure the NMS.

#The NMS needs to be configured with the same username and password as the SNMP agent, run the network management software and listen for UDP port number 162.

Step 5: Check the result.

#The NMS can receive various trap information from Device, such as interface up and down of Device, routing changes caused by network turbulence, etc. Device will generate the corresponding trap information and send it to NMS.

91.3.4 Configure SNMP v3 Inform Advertisements

Network Requirements

- Device acts as an SNMP Agent device that is route reachable to the NMS server.
- The NMS monitors Device via SNMP v3. Device will actively report to the NMS in case of failure or error.

Network Topology

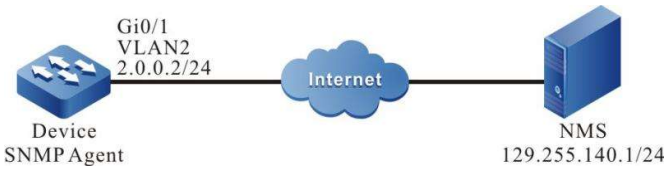


Figure 6 Network Topology for Configuring SNMPv3 Advertisement

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the interfaces (omitted).

Step 3: Enable an SNMP agent on Device and configure SNMP v3 basic information.

#Configure Device.

Enable an SNMP agent; configure the name of the node view as default, with access to all objects under node 1.3.6.1.

```
Device#configure terminal
Device(config)#snmp-server start
Device(config)#snmp-server view default 1.3.6.1 include
```

Configure the user group as group1, the security level as authpriv, and set as default for both read and write view and notify view.

```
Device(config)#snmp-server group group1 v3 authpriv read default write default notify default
```

Configure user name as user2, which belongs to the user group group1, authentication algorithm as MD5, authentication password as admin, encryption algorithm as DES, and encryption password as admin.

```
Device(config)#snmp-server user user2 group1 public v3 auth md5 admin encrypt des admin
```

Configure the contextual environment as public.

```
Device(config)#snmp-server context public
```

Step 4: Configure Device to send advertisement messages to the NMS.

#Configure Device.

Configure the IP address and enginID of remote users, i.e., NMS.

```
Device(config)#snmp-server engineID remote 129.255.140.1 162 bb87654321
```

Configure remote user name as user1, which belongs to the user group group1, authentication algorithm as MD5, authentication password as admin, encryption algorithm as DES, and encryption password as admin.

```
Device(config)#snmp-server user user1 group1 remote 129.255.140.1 162 v3 auth md5 admin encrypt des admin
```

Configure the local address parameter named as param-user1; configure the target address name as target-user1, use the address parameter param-user1, and the target address list name target-user1.

```
Device(config)#snmp-server AddressParam param-user1 v3 user1  authpriv
Device(config)#snmp-server TargetAddress target-user1  129.255.140.1 162 param-user1 tag-user1 10 3
```

Configure the advertisement entity of notify as notify-user1; configure the filter entity of notify as filter-user1, containing the advertisement of all objects under node 1.3.6.1; configure the advertisement configuration table so that the filter entity fileter-user1 is associated with the address parameter param-user1.

```
Device(config)#snmp-server notify notify notify-user1 tag-user1  inform
Device(config)#snmp-server notify filter filter-user1 1.3.6.1 include
Device(config)#snmp-server notify profile filter-user1 param-user1
```

Step 5: Configure the NMS.

#On the NMS using SNMP v3, you need to set the user name and select the security level. According to different security levels, you need to set authentication algorithm, authentication password, encryption algorithm, and encryption password, etc., and listen on UDP port number 162.

Step 6: Check the result.

#The NMS can receive various trap information from Device, such as interface up and down of Device, routing changes caused by network turbulence, etc. Device will generate the corresponding trap information and send it to NMS.

91.3.5 Configure SNMP v3 Agent Forwarding

Network Requirements

- Device2 is route reachable to the NMS server.
- Device2 acts as the agenting device, i.e. Agent, and Device1 acts as the device being proxied.
- SNMP v3 is running on both Device1 and Device2.
- The NMS is running SNMP v3. The NMS manages Device1 and Device2 through SNMP v3.

Network Topology

Figure 91 Network Topology for Configuring SNMP v3 Proxy Forwarding

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the interfaces (omitted).

Step 3: Enable an SNMP agent on the agent device Device2 and configure SNMP v3 basic information.

#Configure Device2.

Enable an SNMP agent, configure the name of the node view as default, with access to all objects under node 1.3.6.1.

```
Device2#configure terminal
Device2(config)#snmp-server start
Device1(config)#snmp-server view default 1.3.6.1 include
```

Configure user group as group-local, security level as authpriv, read/write view, and notify view as default; configure user name as user1, which belongs to the user group group-local, authentication algorithm as MD5, authentication password as proxy, encryption algorithm as DES, and encryption password as proxy.

```
Device1(config)#snmp-server group group-local v3 authpriv read default write default notify default
Device1(config)#snmp-server user user1 group-local v3 auth  md5 proxy encrypt des proxy
```

Step 4: Enable an SNMP agent on the device being proxied, i.e. Device1, and configure the SNMP view.

#Configure Device1.

```
Device1#configure terminal
Device1(config)#snmp-server start
Device1(config)#snmp-server view default 1.3.6.1 include
```

Step 5: Configure the information of the proxied device on the agent device Device2.

#Configure Device2.

Configure the IP address of the device being proxied and the enginID.

```
Device2(config)#snmp-server engineID remote 150.1.2.2 161 800016130300017a000137
```

Configure the user group of the proxied device as group-user, the security level as authpriv, and use default for read/write view and notify view.

```
Device2(config)#snmp-server group group-user v3 authpriv read default write default notify default
```

Configure user name as re-user, which belongs to the user group group-user, authentication algorithm as MD5, authentication password as admin, encryption algorithm as DES, and encryption password as admin.

```
Device2(config)#snmp-server user re-user group-user remote 150.1.2.2 161 v3 auth md5 admin encrypt des admin
```

Configure the local address parameter named as plocal; the name of the remote address parameter as puser; configure the target address name as tuser, and use the address parameter puser.

```
Device2(config)#snmp-server AddressParam plocal v3 user1 authpriv
Device2(config)#snmp-server AddressParam puser v3 re-user authpriv
Device2(config)#snmp-server TargetAddress tuser 150.1.2.2 161 puser taguser 10 2
```

Configure the agent forwarding name as proxy-re-user, the operation permission as write, the enginID of the proxied device as 800016130300017a000137, the address parameter used as plocal, and the target address used as tuser; and configure the name of the contextual environment as proxyuser.

```
Device2(config)#snmp-server proxy proxy-re-user write 800016130300017a000137 plocal tuser proxyuser
Device2(config)#snmp-server context proxyuser
```

#Check the enginID information of Device2.

```
Device2#show snmp-server engineID
Local  engine ID: 8000161303000000052fd
```

IPAddress: 150.1.2.2 remote port: 161 remote engine ID: 800016130300017a000137

Note

- The enginID of the remote device must be the same as that of the proxied device. The enginID of the device can be viewed with the command **show snmp-server engineID**.
- The proxied device is listening on UDP protocol and port 161.

Step 6: Perform SNMPV3 related configuration on Device1, the device being proxied.

#Configure Device1.

Configure user group as g1, security level as authpriv, read/write view, and notify view as default; configure user name as re-user, authentication algorithm as MD5, authentication password as admin, encryption algorithm as DES, and encryption password as admin.

```
Device1(config)#snmp-server group g1 v3 authpriv read default write default notify default
Device1(config)#snmp-server user re-user g1 v3 auth md5 admin encrypt des admin
Device1(config)#snmp-server context proxyuser
```

Step 7: Configure the NMS.

#SNMP v3 uses authentication and encryption security mechanism, you need to set the user name and select the security level on the NMS. According to different security levels, you need to set authentication algorithm, authentication password, encryption algorithm, and encryption password, among others, respectively. In addition, you have to set the "timeout" and "number of retries". Users can use the NMS to complete the query and configuration operation of the device. When the proxied device is to be queried or configured, it is also necessary to set the enginID of the agent forwarding to be the enginID of the proxied device on the NMS.

Step 8: Check the result.

#The NMS can query and set the value of certain parameters of Device2 and Device1 through the MIB node.

92 RMON

92.1 Overview

One important function of the network management is to monitor the element performances of the network. In the traditional SNMP network management mode, the initiative of the management is mainly mastered by the network management station. Usually, the network management work station regularly polls the data of the device and then measures and analyzes in the network management system, so as to get the desired information of the administrator. In this mode, the network management work station needs to send and receive lots of packets to the network devices. When there are many devices in the network, it causes the additional load for the network. Meanwhile, the network blocking and other factors take various accidents to the running of the network management system. As for this, we put forward the RMON (Remote Network Monitoring) concept.

RMON still requires SNMP protocol support, which is actually a set of MIBs assigned under MIB-2 with the object identifier 1.3.6.1.2.1.16. Compared with other general MIB, RMON adds the calculation at Agent during realizing, that is, put the processing, such as performance statistics in the device. This realizes the distributed processing in the whole network, reducing the disadvantages brought by the polling of the network management work station.

RMON needs to realize lots of calculation functions, so the previous RMON proxy (also called Probe) is acted by a special device, distributed in the network to monitor the corresponding target. With the improvement of the processing capability of the network device, RMON is gradually integrated to the network devices, so as to realize the RMON requirement high-efficiently. However, this also puts forward higher performance requirement for the network devices. After all, the calculations of RMON occupy lots of system resources, reducing the system performance. This is also the additional cost brought by the management, so RMON is mainly realized in the hardware with the network processing capability, such as switching chip.

There are 10 groups of RMON MIB:

- statistics: to measure all Ethernet interfaces of the device, such as broadcast and conflict;
- history: to record the samples of the periodical statistics information that is taken out from the statistics group;
- alarm: to permit the administration Console user to configure the sampling interval and

alarm when the values of any counters or integers (recorded by the RMON proxy) exceed the threshold value;

- host: to include the input/output traffics of various types of hosts adhering to the subnet;
- hostTopN: to contain the stored statistics information of hosts, some parameters in the host tables of these hosts are the highest;
- matrix: to indicate the error and utilization information in the form of matrix, so that the operator can use any address pair to search

for information;

- filter: to permit the monitor to monitor the packets matched with the filter;
- capture: The packet capture group creates a set of buffers to store the packets captured from the channel.
- event: to present the table of all events generated by the RMON proxy;
- tokenRing: to maintain the statistic and configuration information of a subnet which is a token ring

92.2 RMON Function Configuration

Table 92 RMON Function Configuration List

Configuration Task	
Enable the RMON function.	Enable the RMON function.
Configure RMON alarm groups.	Configure RMON alarm instances.
Configuring RMON extended alarm groups.	Configuring RMON extended alarm instance
Configure RMON event groups.	Configure RMON to trigger events.
Configure RMON history groups.	Configure RMON history instances.
Configure RMON statistics groups.	Configure the RMON statistics management function.

92.2.1 Enable the RMON function.

Configuration Condition

None

Enable the RMON Function

RMON is enabled to provide the relevant resources for the monitoring function of RMON, and the resources will take effect only after the monitoring group function of RMON is configured.

Table 92 Enabling the RMON Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the RMON function.	**rmon**	Mandatory

92.2.2 Configure RMON Alarm Groups

RMON alarm group function refers to the configuration of multiple alarms, each alarm monitors an alarm instance, and an alarm event is triggered when the alarm instance data value changes beyond the rising threshold or falling threshold during the sampling interval, and the alarm is processed according to the processing method defined by the alarm event group. When the data value continuously exceeds the threshold value, only the first exceedance is alerted.

Configuration Condition

Before configuring RMON alarm groups, do the following:

- Enable the SNMP agent function.
- Enable the trap function of RMON in SNMP.

Configure RMON Alarm Instances

Table 92 Configuring RMON Alarm Instances

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enable the RMON function.	**rmon**	Optional
Configure RMON alarm groups.	**rmon alarm** *alarm-num OID interval* { **absolute | delta** } **risingthreshold** *rising-threshold* [*rising-event*] **fallingthreshold** *falling-threshold* [*falling-event*] [**owner** *owner*]	Mandatory By default, the alarm trigger event group is 1. By default, the alarm group is owned by config.

92.2.3 Configuring RMON Extended Alarm Groups

RMON extended alarm groups can perform calculations on alarm variables, and then compare the results with the set thresholds to achieve more alarm functions.

Configuration Condition

Before configuring RMON alarm groups, do the following:

- Enable the SNMP agent function.
- Enable the trap function of RMON in SNMP.
- Configure a statistics group.

Configure RMON Alarm Instances

Table 92 Configuring RMON Alarm Instances

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the RMON function.	**rmon**	Optional
Configure a statistics group.	**rmon statistics ethernet** *statistics-num OID* [**owner** *owner*]	Mandatory By default, the statistics group is owned by config.

Step	Command	Description
Configure RMON alarm groups.	**rmon prialarm** *alarm-num WORD interval* { **absolute** | **delta** } **risingthreshold** *rising-threshold rising-event* **fallingthreshold** *falling-threshold falling-event* **entrytype forever** [**owner***owner*]	Mandatory By default, the alarm group is owned by config.

92.2.4 Configure RMON Event Groups

Configure the RMON event group function means configuring multiple events, defining the event number of each event and how it is handled. Events are handled in the following ways: events are recorded in the log, events send TRAP messages to the network management, events are recorded in the log and TRAP messages are sent to the network management without being handled.

Configuration Condition

Before configuring an RMON event group, do the following:

- Enable the SNMP agent function.
- Enable the trap function of RMON in SNMP.

Configuring RMON to Trigger Events

RMON triggering events is mainly used for event handling when an RMON alarm occurs.

Table 92 Configuring RMON to Trigger Events

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the RMON function.	**rmon**	Optional
Configure RMON event groups.	**rmon event** *event-num* [**description** *event-description* / **log** *max-num* / **owner** *owner* / **trap** *communit*]	Mandatory By default, the event group is owned by config.

92.2.5 Configure RMON History Groups

Configure the RMON history group function means configuring multiple history groups, and the RMON history group stores the subnet data obtained by sampling at a fixed interval. The group consists of a history control table, which defines the subnet interface number being sampled, the size of the sampling interval, and the amount of data sampled each time, and a data table, which stores the various data obtained during the sampling period.

Configuration Condition

Before configuring the RMON history group, do the following:

- Enable the SNMP agent function.

Configure RMON History Instances

The RMON history group mainly configures information such as the monitoring object of the history control table, the size of the sampling interval, and the quantity of sampled data.

Table 92 Configuring RMON History Groups

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the RMON function.	**rmon**	Optional
Configure RMON history groups.	**rmon history control** *history-num OID buckets-num* [**interval** *interval*] [**owner** *owner*]	Mandatory By default the sampling interval is 1800 seconds. By default, the history group is owned by config.

92.2.6 Configure RMON Statistics Groups

To configure the RMON statistics group function is to configure the statistics of Ethernet interfaces which are the monitoring objects. The statistics group provides a table, each row of which represents the statistics of a subnet, from which the network administrator can obtain various statistics of a segment (the traffic of a segment, the distribution of various types of packets, the number of various types of error packets, the number of collisions, etc.).

Configuration Condition

Before configuring an RMON statistics group, do the following:

- Enable the RMON function.
- Enable the SNMP agent function.

Configure the Statistics Management Function

Table 92 Configuring the RMON Statistics Management Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the RMON function.	**rmon**	Mandatory
Configure RMON statistics groups.	**rmon statistics ethernet** *statistics-num OID* [**owner** *owner*]	Mandatory By default, the statistics group is owned by config.

92.2.7 RMON Monitoring and Maintaining

Table 92 RMON Monitoring and Maintaining

Command	Description
show rmon alarm	Display the configured RMON alarms in the device.
show rmon alarm supportVariable	Display the monitoring objects supported by RMON in the device.
show rmon event	Display the configured RMON alarm events in the device.
show rmon history { **control | ethernet** *control-num* }	Display the configured RMON history groups in the device.
show rmon prialarm	Display the configured RMON extended alarms in the device.
show rmon statistics ethernet	Display the configured RMON statistics groups in the device.

92.3 Typical Configuration Example of RMON

92.3.1 Configure Basic Functions of RMON

Network Requirements

- Device is an RMON agent device that is route reachable to the NMS server.
- Monitoring and management of event groups, alarm groups, history groups, and statistics groups of RMON through NMS.

Network Topology

Figure 92 Network Topology for Configuring Basic Functions of RMON

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses for the ports. (Omitted)

Step 3: Configure an SNMP agent.

#Enable the SNMP agent to configure the name of the node view as default, and the read-only community name as public.

```
Device#configure terminal
Device(config)#snmp-server start
Device(config)#snmp-server view default 1.3.6.1 include
Device(config)#snmp-server community public view default ro
```

#Enable the SNMP Trap function to configure the destination address of the Trap packet and the community name to be used.

```
Device(config)#snmp-server enable traps
Device(config)#snmp-server host 129.255.151.1 traps community public
```

Step 4: Configure the RMON event groups, alarm groups, history groups, and statistics groups of Device.

#Enable an RMON agent.

```
Device(config)#rmon
```

#Configure the event group named Event with the serial number 1 to log packets in the inbound direction of port gigabitethernet0/1.

```
Device(config)#rmon event 1 description gigabitethernet0/1_in_octes log 100 trap public
```

#Configure the alarm event group named Alarm, with the monitoring object as ifInOctets.1. Configure relative value sampling, with the sampling interval to be 10 seconds. Configure the rising and fallling thresholds to 100, and configure the event triggered by the threshold to be event 1.

```
Device(config)#rmon alarm 1 ifInOctets.1 10 delta risingthreshold 100 1 fallingthreshold 100 1 owner 1
```

#Configure the statistics group of RMON.

```
Device(config)#rmon statistics ethernet 1 ifIndex.1
```

#Configure the history group of RMON.

```
Device(config)#rmon history control 1 ifIndex.1 10
```

Note

- The instance index number ifInOctets.1 corresponds to port gigabitethernet0/1 on the device. You can display all Layer-2 port snmp index values by show interface switchport snmp ifindex, show interface snmp ifindex to display all Layer-3 port snmp index value, show interface switchport XXXX snmp ifindex to show the specified Layer-2 port snmp index value, show interface XXXX snmp ifindex to show the specified Layer-3 port snmp index value.
- The object instance index number for remote monitoring needs to be read from the interface table ifEntry in MIB-2.

Step 5: Configure the NMS.

#Set the "read-only community name", "timeout" and "number of retries" on the SNMP v1/v2c NMS.

Step 6: Check the result.

#Check the RMON event group table entry configuration for Device.

```
Device#sh rmon event
Event 1 is active, owned by config
Description : gigabitethernet_0/1_in_octes
Event firing causes: log and trap, last fired at 11:38:07

Current log entries:
      logIndex          logTime           Description
---------------------------------------------------------------
            1          11:38:07       gigabitethernet_0/1_in_octes
```

#Check the RMON alarm table entry configuration for Device.

```
Device#show rmon alarm
Alarm 1 is active, owned by 1
Monitoring variable: ifInOctets.1,      Sample interval: 10 second(s)
```

```
Taking samples type: delta,     last value was 4225
Rising threshold :   100,       assigned to event: 1
Falling threshold :  100,       assigned to event: 1
```

#Check the RMON event group table entry configuration for Device.

```
Device#sh rmon statistics ethernet
--------------------------------
Ethernet statistics table information:
        Index: 1
        Data Source: ifIndex.1
        Owner: config
        Status: Valid
--------------------------------
 ifIndex.1 statistics information:
--------------------------------
 DropEvents:0
 Octets: 26962295
 Pkts:252941
 BroadcastPkts:156943
 MulticastPkts:62331
 CRCAlignErrors:51
 UndersizePkts:0
 OversizePkts:0
 Fragments:0
 Jabbers:0
 Collisions:0
 Pkts64Octets:167737
 Pkts65to127Octets:47962
 Pkts128to255Octets:22497
 Pkts256to511Octets:9967
 Pkts512to1023Octets:4032
 Pkts1024to1518Octets:745
```

#Check the RMON history group table entry configuration for Device.

```
Device#show rmon history control
-----------------------------------
RMON history control entry index: 1
        Data source: IfIndex.1
        Buckets request: 10
        Buckets granted: 2
        Interval: 1800
        Owner: config
        Entry status: Valid
-----------------------------------
```

#The NMS can query the History, Event and Statistics information in Device through the MIB node.

The NMS is able to receive trap information for alarm events from Device. For example, when the rate of change of traffic in the inbound direction of the monitored interface is greater than the rising threshold or less than the falling threshold, Device will generate the corresponding trap message and send it to the NMS.

93 CWMP

93.1 Overview

CWMP (CPE WAN Management Protocol, i.e. user-side device WAN management protocol) is a protocol developed by BroadBandForum.org (formerly DSL Forum) for managing and configuring CPE (Customer Premise Equipment user-side equipment), also known as TR -069, which defines a common protocol framework, message specification, management method and data model for managing client-side equipment in carrier Internet broadband access networks.

CWMP can be described as a data framework model that describes the communication between end devices like broadband routers and ACS (Auto-Configuration Server) for remote and centralized configuration management of user-side devices (e.g., broadband routers, switches, Internet gateway devices, set-top boxes, etc.) from the network side.

The CWMP protocol is an application layer protocol that sits on top of IP, which makes the protocol widely applicable with no restrictions on access methods. CPE based on access methods such as ADSL (Asymmetrical Digital Subscriber Loop), Ethernet, and PON (Passive Optical Network) can use this protocol. The TR069-based system architecture is shown in Figure 1-1. The end-to-end architecture of the CWMP protocol has three features:

1. It has a resilient connection model where both CPE and ACS can trigger the establishment of connections, avoiding the need to maintain connections between CPE and ACS.

2. Automatic discovery between CPE and ACS is possible.

3. ACS can dynamically configure and monitor CPE.

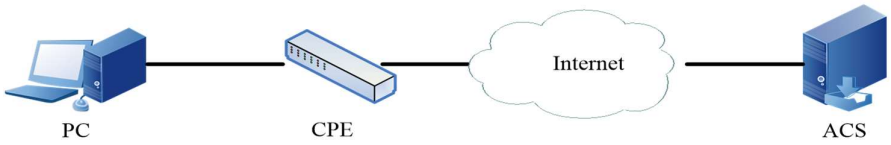


Figure 93 Architecture Diagram of CPE and ACS

For user-side devices, CWMP accomplishes the following four main tasks:

1. Automatic configuration and dynamic service configuration for CPE. For ACS, each CPE can flag itself in the protocol (e.g., model, version, etc.), and depending on the rules that can be set, ACS can issue a configuration for a specific CPE or for a group of CPEs. The CPE can automatically request configuration information in the ACS after power on, and the ACS can also initiate configuration at any desired moment. This feature enables "zero-configuration installation" of CPE or dynamic change of service parameters controlled from the network side.

2. Management of version files and configuration files of CPE. CWMP provides the management and download of version files and configuration files in CPE. ACS can identify the version number of the user device, decide whether to update the software version of the user device remotely, and be able to know whether the update was successful when it is completed. CPE is under the control of ACS to perform backup by uploading configuration files and restore by downloading configuration files.

3. Remote upgrade of CPE device configuration. It is a function initiated by ACS to remotely upgrade the configuration of CPE. Currently, ACS remotely upgrades the device's configuration by segmenting the CPE's configuration down.

4. Implement security management of device ports: Through CWMP's custom RPC method (remote procedure call), the security management of device ports can be performed, including the functions of disabling, enabling, auto-binding, un-auto-binding, 802.1x based ports, disabling 802.1x, etc. of device ports.

Warning

- The device with 16M Flash will not be powered off or rebooted during the version upgrade via CWMP, and it is necessary to ensure the correct version of the upgrade, otherwise the system may not start.

Note

- When the device is operating in the VST mode, the device does not support the CWMP function.

93.2 CWMP Function Configuration

Table 93 CWMP Function Configuration List

Configuration Task	
Configure basic functions of CWMP.	Enter the CWMP configuration mode.
	Enable a CWMP agent.
	Configure ACS server-related information.
	Configure the WAN device interface.
	Configure CWMP to send INFORM packets periodically.
	Configure the period for CWMP to send INFORM packets.
	Configure the CWMP file download function.
	Configure the CWMP file breakpoint transfer function.
	Configure CWMP provision code.
Configure CWMP authentication and encryption functions.	Configure CWMP authentication information.
	Configure ACS certificates for CWMP.
	Configure ACS certificate fingerprints for CWMP.
Configure CWMP extended functions.	Configure CWMP to specify the source IP address.
	Configure CWMP link backup.

93.2.1 Configure Basic Functions of CWMP

Configuration Condition

You need to enter the global configuration mode before configuring the basic functions of a CWMP agent.

Enter the CWMP Configuration Mode

Enter the CWMP agent configuration mode before performing any CWMP-agent-related configuration.

Table 93 Entering the CWMP Configuration Mode

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory

Enable a CWMP Agent

If the CWMP agent is enabled on the device, then the device can interact with ACS through the CWMP agent to achieve remote configuration and management of the device.

Table 93 Enabling CWMP Proxy Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.

Configure ACS Server-related Information

By configuring ACS-related information, including the connection address of the ACS server, the device can communicate with the ACS server.

Table 93 Configuring ACS Server-related Information

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure ACS related information.	**management server url** *url-string*	Mandatory By default, the device is not configured with the relevant parameters of ACS. For non-encrypted methods, the *url-string* uses the http protocol; for encrypted methods, the *url-string* uses the https protocol.
Configure the user name for the device to initiate a connection to the ACS.	**management server** *user-name*	Optional By default, the device is not configured with the relevant parameters of ACS. If the user name is not configured on the ACS, it can be configured without.
Configure the password corresponding to the user name for the device to initiate a connection to the ACS.	**management server** *password*	Optional By default, the device is not configured with the relevant parameters of ACS. If the user name and corresponding password are not configured on the ACS, the configuration can be done without.

Configure the WAN Device Interface

Specify the interface as the default WAN device interface in the interface mode. If no default WAN device is specified, the CWMP agent cannot send the Inform packet to connect to the ACS server.

Table 93 Configuring WAN Device Interfaces

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Access to the Layer-3 interface to be used.	**interface** *interface-name*	Mandatory Must be configured under the Layer-3 interface.
Configure the default WAN device.	**cwmp wan default**	Mandatory By default, no wan device interface is specified for the CWMP agent.

Note

- Failure to specify a default WAN device will result in CWMP not being able to send Inform packets to connect to the ACS. This is because when organizing Inform packets, you need to clearly know the parameter name of the WAN device connected to the external network in the current system and the IP address of this device interface.
- When a Layer-3 interface is specified as the default WAN device, if no WAN IP address is configured in the CWMP mode and an IP address is configured for this interface, the connection request URL is generated using this interface IP address.

Configure CWMP to Send INFORM Packets Periodically

By configuring CWMP to send Inform packets periodically, the device can send Inform packets to the ACS periodically, and the ACS will process them accordingly according to the pre-configuration after receiving the Inform packets from the device.

Table 93 Configuring CWMP to Send INFORM Packets Periodically

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure CWMP to send INFORM packets periodically.	**enable inform**	Mandatory By default, the function of CWMP sending INFORM packets periodically is enabled.

Configure the Period for CWMP to Send INFORM Packets

After configuring to enable CWMP periodically send Inform packets, you can configure the period for the CWMP agent to send Inform packets. The default sending period is 43200 seconds (12 hours).

Table 93 Configuring the Period for CWMP to Send Inform Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure CWMP to send INFORM packets periodically.	**enable inform**	Mandatory By default, the function of CWMP sending INFORM packets periodically is enabled.
Configure the period for CWMP to send INFORM packets.	**inform interval** *inform-interval*	Mandatory By default, the time interval for the device to

Step	Command	Description
		automatically and periodically send inform packets is 43200 seconds.

Note

- If you have configured to enable the CWMP agent to send Inform packets without configuring the sending period for the Inform packets, CWMP sends Inform packets to ACS at the default period of 43200 seconds (12 hours).
- After modifying the periodic sending interval of Inform packets, the modified value will take effect only after the expiration of the last interval. If you need the modification to take effect immediately, you can do so by restarting the CWMP agent, where enable and no enable are described in the relevant sections of the CWMP command manual.

Configure the CWMP File Download Function

When you need the CWMP agent to support file download for version file and configuration file, you need to configure the file download function of the CWMP agent in advance.

Table 93 Configuring CWMP File Download

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure the CWMP file download function.	**enable download**	Mandatory By default, CWMP does not enable the file download function.

Configure the CWMP File Breakpoint Transfer Function

When you configure the file download function of CWMP, you can configure this function when you need CWMP to support the breakpoint transfer function of files.

Table 93 Configuring CWMP File Breakpoint Transfer

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure the CWMP file download function.	**enable download**	Mandatory By default, CWMP does not enable the file download function.
Configure the CWMP file breakpoint transfer function.	**enable download resume**	Mandatory By default, CWMP does not enable the file breakpoint transfer function.

Note

- Before you can configure the breakpoint transfer function of CWMP files, you must configure the file download function of CWMP. If there is no configuration file download function at the beginning, the file breakpoint transfer will not work even if the file renewal function is configured later.

Configure CWMP Provision Code

The provision code used to configure the CWMP, is used to mark the basic service information provided by the CWMP.

Table 93 Configuring the Provision Code of CWMP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure CWMP provision code.	**provision code** *provision-code*	Mandatory By default, CWMP is not configured with a provision code.

93.2.2 Configure CWMP Authentication and Encryption Functions

Configuration Condition

Before configuring the authentication and encryption functions of CWMP, do the following:

- The basic configuration of a CWMP agent has been completed, including the enabling configuration of the CWMP agent and the information configuration of the ACS proxied by the CWMP agent.
- When configuring the encryption function, prepare the certificate and import it manually when needed.

Configure the Authentication Function of CWMP

When the ACS needs to initiate a connection to the device, the CWMP agent needs to be configured to authenticate the connection request from the ACS for security reasons.

Table 93 Configuring the Authentication Function of CWMP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure the user name for the CPE to authenticate connection requests from the ACS.	**connection request username** *user-name*	Mandatory By default, no user name is configured.
Configure the password for the CPE to authenticate connection requests from the ACS.	**connection request password** *password*	Mandatory By default, no password is configured.

Configure ACS Certificates for CWMP

For security reasons, when the device connects to ACS by HTTPS, it is necessary to specify the location of the server-side certificate so that the validity of the ACS-side certificate can be verified with this certificate.

Table 1 Configuring the ACS Certificate of CWMP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure the CA certificate path required to connect to the ACS server via HTTPS.	**certificate ca** *ca-path*	Mandatory The default path is: /flash/tr069/ca.pem.

Configure ACS Certificate Fingerprints for CWMP

From security consideration, when the device connects to ACS by HTTPS, it can configure the required certificate fingerprint and verify its validity directly with the fingerprint of the server-side certificate.

Table 93 Configuring the ACS Certificate Fingerprint for CWMP

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure the certificate fingerprint required to connect to the ACS server via HTTPS.	**certificate ca fingerprint** *fingerprint-string*	Mandatory *fingerprint-string* specifies the fingerprint information to verify the CA certificate, the content is a 40-bit hexadecimal number.

Note

- You can choose one of the two ways to configure the ACS certificate and the ACS certificate fingerprint, and if both are configured, the ACS certificate will be used first.

93.2.3 Configure CWMP Extended Functions

Configuration Condition

Before configuring the extended functionality of CWMP, do the following:

- The basic configuration of CWMP has been completed, including the enabling configuration of the CWMP agent and the information configuration of the ACS proxied by the CWMP agent.
- Layer-3 interface IP addresses have been configured so that neighbor nodes are reachable at the network layer.
- When you need to use the link backup function, the Layer-3 interface configured as backup should be functional, including the IP address configured and the interface status as UP.

Configure CWMP to Specify the Source IP Address

With a source IP address configured, the ACS communicates directly with this specified IP address.

Table 2 Configuring CWMP to Specify the Source IP Address

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the CWMP agent configuration mode.	**cwmp agent**	Mandatory
Enable a CWMP agent.	**enable**	Mandatory By default, the CWMP agent is diabled.
Configure the source IP address specified by the CWMP agent.	**ip source** *ip-address*	Mandatory By default, the source address of the packet is not specified when the device is building a link with ACS, and the source address of the packet is the output interface of the packet.

Configure CWMP Link Backup

After the link backup function is configured in the interface mode, it enables the device with multiple WAN ports to be configured, with one default WAN port and the others are backup WAN ports. Generate a connection request URL with the default WAN port IP to send to ACS during normal times. When the default WAN port is down, it will choose one from the backup WAN port as the current WAN port, and then use its IP to generate the connection request URL.

Table 93 Configuring CWMP Link Backup

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the Layer-3 interface where backup needs to be set.	**interface** *interface-name*	Mandatory

Step	Command	Description
Configure the backup interface proxied by the CWMP agent.	**cwmp wan backup**	Mandatory By default, no wan device backup interface is specified for the CWMP agent.

Note

- Only one CWMP wan default interface and one CWMP wan backup interface can be configured per device.

93.2.4 CWMP Monitoring and Maintaining

Table 3 CWMP Monitoring and Maintaining

Command	Description
show cwmp agent	Display relevant information about the CWMP agent.
show cwmp session	Display information about CWMP agent sessions.
show cwmp methods	Display the RPC (Remote Procedure Call) methods supported by the CWMP agent.
show cwmp parameter all	Display the names of all parameters of the CWMP agent.
show cwmp parameter *para-string*	Display detailed information of a specified parameter of the CWMP agent.
show cwmp parameter notify { active | **all** | **forceactive** | **passive }**	Display the parameter names of an advertisement of the CWMP agent.
show cwmp parameter values [*para-string* | **error**]	Display detailed information of a specified parameter of the CWMP agent.

93.3 Typical Configuration Example of CWMP

93.3.1 Configure the Authentication Function of CWMP

Network Requirements

- Device accesses ACS through Network, enables CWMP function on Device, and configures authentication function on both Device and ACS.
- After the authentication succeeds, Device will perform version upgrade, configuration recovery, configuration backup, and configuration upgrade tasks issued by ACS.

Network Topology

Figure 93 Network Topology for Configuring the CWMP Authentication Function

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure the IP address and route of the interface. (Omitted)

Step 3: Configure CWMP.

#Enable the CWMP agent and file download function on Device and configure the URL of ACS.

```
Device#configure terminal
Device(config)#cwmp agent
Device(config-cwmp)#enable
Device(config-cwmp)#management server url http://129.255.136.200:8080/openacs/acs
Device(config-cwmp)#enable download
Device(config-cwmp)#exit
```

#Configure the VLAN2 interface as the default WAN device.

```
Device(config)#interface vlan 2
Device(config-if-vlan2)#cwmp wan default
Device(config-if-vlan2)#exit
```

Step 4: Configure the ACS server.

#Create a fragment template on the ACS and configure both the username and password used for authentication to be admin. (Omitted)

#Create a configuration upgrade task on the ACS, select the created fragment template, and send the configuration upgrade task to Device. (Omitted)

Note

- The ACS ensures that the it can be authenticated by Device by configuring the upgrade task to send the username and password used for authentication down to Device.

#Create version upgrade task/configuration recovery task/configuration backup task on ACS.

Step 5: Check the result.

#The user name and password issued by ACS to Device can be seen on Device via the **show running-config** command.

```
cwmp agent
 management server url http://129.255.136.200:8080/openacs/acs
 connection request username admin
 connection request password admin
 enable download
 enable
 exit
```

#Device can successfully execute the version upgrade task/configuration recovery task/configuration backup task issued by ACS.

93.3.2 Configure CWMP to Specify the Source IP Address

Network Requirements

- Device accesses ACS through Network, enables CWMP function on Device.
- Specify the source IP address of CWMP as 1.0.0.1 to allow Device to access the ACS through the firewall and perform the version upgrade, configuration recovery, and configuration backup tasks issued by the ACS.

Network Topology

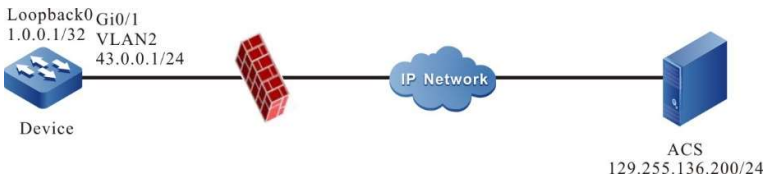


Figure 93 Network Topology for Configuring Specified Source IP Address

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses and routes for the ports. (Omitted)

Step 3: Configure CWMP.

#Enable the CWMP agent and file download function on Device, configure the URL of ACS, and configure the source IP address of CWMP as 1.0.0.1.

```
Device#configure terminal
Device(config)#cwmp agent
Device(config-cwmp)#enable
Device(config-cwmp)#management server url http://129.255.136.200:8080/openacs/acs
Device(config-cwmp)#enable download
Device(config-cwmp)#ip source 1.0.0.1
Device(config-cwmp)#exit
```

#Configure the Loopback0 interface as the default WAN device.

```
Device(config)#interface loopback 0
Device(config-if-loopback0)#cwmp wan default
Device(config-if-loopback0)#exit
```

Step 4: Configure the firewall.

#The firewall denies the passage of packets with the source IP address 43.0.0.1 and allows the passage of packets with the source IP address 1.0.0.1.

Step 5: Configure the ACS server.

#Create version upgrade task/configuration recovery task/configuration backup task on ACS.

Step 6: Check the result.

#The configured source IP address can be seen on Device by **show running-config**.

```
cwmp agent
 management server url http://129.255.136.200:8080/openacs/acs
 enable download
 enable
 ip source 1.0.0.1
 exit
```

#Device can successfully execute the version upgrade task/configuration recovery task/configuration backup task issued by ACS.

93.3.3 Configure CWMP Link Backup

Network Requirements

- Device can access the ACS through two lines, giving preference to the VLAN2 interface to communicate with the ACS.
- When the VLAN2 interface fails, Device communicates with the ACS through the VLAN3 interface, and when the VLAN2 interface is restored, Device communicates with the ACS through the VLAN2 interface.

Network Topology

Figure 93 Network Topology for Configuring CWMP Link Backup

Configuration Steps

Step 1: Configure VLANs, and add ports to the required VLANs. (Omitted)

Step 2: Configure IP addresses and routes for the ports. (Omitted)

Step 3: Configure CWMP.

#Enable the CWMP agent and file download function on Device and configure the URL of ACS.

```
Device#configure terminal
Device(config)#cwmp agent
Device(config-cwmp)#enable
Device(config-cwmp)#management server url http://129.255.136.200:8080/openacs/acs
Device(config-cwmp)#enable download
Device(config-cwmp)#exit
```

#Configure the VLAN2 interface as the default WAN device.

```
Device(config)#interface vlan2
Device(config-if-vlan2)#cwmp wan default
Device(config-if-vlan2)#exit
```

#Configure the VLAN3 interface as the backup WAN device.

```
Device(config)#interface vlan3
Device(config-if-vlan3)#cwmp wan backup
Device(config-if-vlan3)#exit
```

Step 4: Check the result.

#Check the CWMP agent information on Device.

```
Device#show cwmp agent
 Agent status: Enabled
 Periodic Inform: Enabled
 Download files: Enabled
 Inform interval: 43200
 ACS URL: http://129.255.136.200:8080/openacs/acs
 ACS user name:
 ACS user password:
 Connection request URL: http://42.0.0.1:7547/00017A/HIT SW/00017a136922/cwmp
 Connection request user name:
 Connection request password:
 Default WAN device: vlan2
 Current WAN device: vlan2
 CA certificate: /flash/tr069/ca.pem
```

It can be seen that the default WAN device is VLAN2 and the current WAN device is VLAN2. It can be seen that the IP address of Device corresponding to 42.0.0.1 in the device management page of ACS.

#Check the CWMP agent information when the VLAN2 interface on Device fails.

```
Device#show cwmp agent
 Agent status: Enabled
 Periodic Inform: Enabled
 Download files: Enabled
 Inform interval: 43200
 ACS URL: http://129.255.136.200:8080/openacs/acs
 ACS user name:
 ACS user password:
 Connection request URL: http://43.0.0.1:7547/00017A/HIT SW/00017a136922/cwmp
 Connection request user name:
 Connection request password:
 Default WAN device: vlan2
 Current WAN device: vlan3
 CA certificate: /flash/tr069/ca.pem
```

It is indicated that the default WAN device is VLAN2 and the current WAN device is VLAN3. It can be seen that the IP address of Device corresponding to 43.0.0.1 in the device management page of ACS.

#After the VLAN2 interface on Device is restored, check the CWMP proxy information to find that both the default WAN device and the current WAN device are VLAN2. You can see the IP address of Device on the device management page of ACS is 42.0.0.1.

94 NETCONF

94.1 Overview

NETCONF（Network Configuration Protocol) is an XML-based network management protocol that provides a programmable approach of configuring and managing network devices. Through NETCONF, you can configure device parameters, retrieve parameter values, and get statistics information. All NETCONF packets are XML-based and feature powerful filtering capabilities. Each data item has a fixed element and position. This enables devices of the same vendor to use the same access mode and result display mode. The devices of different vendors can achieve the same effect by XML mapping. This feature facilitates third-party software development and NMS software customization in the multi-vendor, multi-device environment. With the help of such NMS software, NETCONF simplifies device configuration and improves device configuration efficiency.

94.2 NETCONF Basic Function Configuration

Table 94 NETCONF Basic Function Configuration Task List

Configuration Task	
NETCONF Server Functions Configuration	Enable the NETCONF Server Function
	NETCONF Client Session Idle Timeout Time Configuration
	Configuring the Maximum Number of NETCONF Sessions
Configuring the functions of NETCONF CALL-HOME	Configuring the functions of NETCONF CALL-HOME

94.2.1 NETCONF Server Functions Configuration

Configuration Condition

Before configuring the functions of NETCONF server, ensure that:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Interface network layer addresses have been configured so that NETCONF client nodes are reachable at the network layer.

Enable the NETCONF Server Function

Table 94 Enabling NETCONF Server Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the Global NETCONF Function	**netconf server enable**	Mandatory By default, the NETCONF function is disabled

NETCONF Client Session Idle Timeout Time Configuration

Table 94 Configuring NETCONF Client Timeout Disconnection Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the Global NETCONF Function	**netconf client idle-time**	Mandatory By default, the NETCONF client session idle timeout time is 3600 seconds

Function of Configuring the Maximum Number of NETCONF Sessions

Table 94 Configuring the Maximum Number of NETCONF Sessions

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Function of configuring the maximum number of NETCONF sessions	**netconf server max-session session-num**	Optional By default, the maximum number of sessions supported by NETCONF is 4

94.2.2 Configuring the Functions of NETCONF CALL-HOME

Configuration Condition

Before configuring the functions of NETCONF server, ensure that:

- The link layer protocol has been configured to ensure normal communication at the link layer.
- Interface network layer addresses have been configured so that NETCONF client nodes are reachable at the network layer.

Configuring the Functions of NETCONF CALL-HOME

The configured CALL-HOME terminal can automatically connect to the configured terminal after the NETCONF service is enabled, thus establishing a NETCONF SSH connection without the client actively connecting to the NETCONF server.

Table 94-6 NETCONF CALL-HOME Function Configuration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configuring the functions of NETCONF CALL-HOME	**netconf call-home client** *client-name* **ssh** *endpoint-name* **address** *host-name* **[port** *port-num* **]**	Mandatory By default, there is no call-home client

94.2.3 NETCONF Monitoring and Maintaining

Table 94 NETCONF Monitoring and Maintaining

Command	Description
debug netconf [**all** | **cmf** | **conf** | **database** | **dbm** | **plugin** | **server** | **ssh** | **yang**]	Open NETCONF debugging switch
show netconf session	Display the current NETCONF client connection session information

94.3 NETCONF Typical Configuration Example

94.3.1 Configure the NETCONF server

Network Requirements

- Device1 and Device2 are NETCONF server devices, which are routed through the unicast routing protocol to the controller.
- The controller monitors and manages Device1 and Device2 via NETCONF.

Network Topology

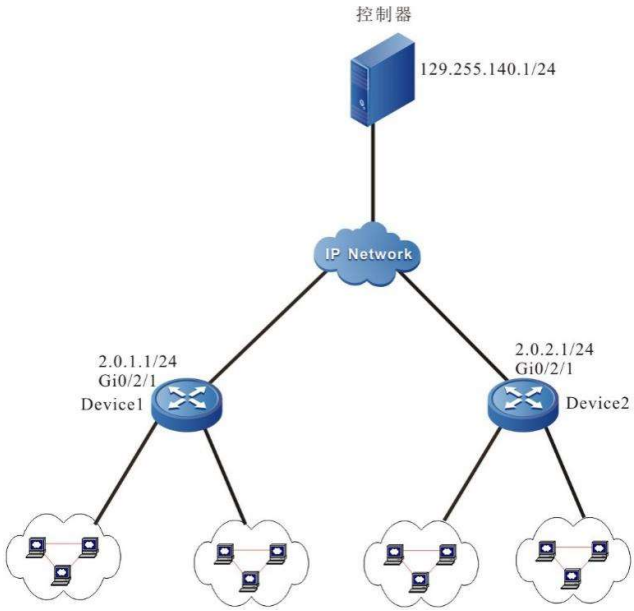


Figure 94 Network Topology for Configuring the NETCONF Server

Configuration Steps

A NETCONF connection is established between the configuration controller and the device, and then the controller configures and manages the device via NETCONF. The configuration of Device2 is similar to that of Device1, which shall not be repeated here.

Step 1: Configure IP addresses for the ports. (Omitted)

Step 2: Configure NETCONF users

#Create netconf users on the device with the username "admin" and password "admin@123".

Device1#configure terminal

Device1(config)#local-user admin class manager

Device1(config-user-manager-admin)#service-type netconf ftp

Device1(config-user-manager-admin)#password 0 admin@123

Device1(config-user-manager-admin)#privilege 15

Device1(config-user-manager-admin)#exit

Step 3: Configure the device to enable the NETCONF server functions.

#Configure the NETCONF server enabling function on the device.

Device1(config)#netconf server enable

Step 4: Configure the controller.

#Open the controller, click on "Network Planning", select "Network Discovery", click on "Add Node", and configure the NETCONF parameters: "IP Address", "Name", "Account" and "Password". "IP address", where the parameters on "name", "account" and "password" must be configured the same as those on the device. Click OK to establish normal communication between the device and the controller.

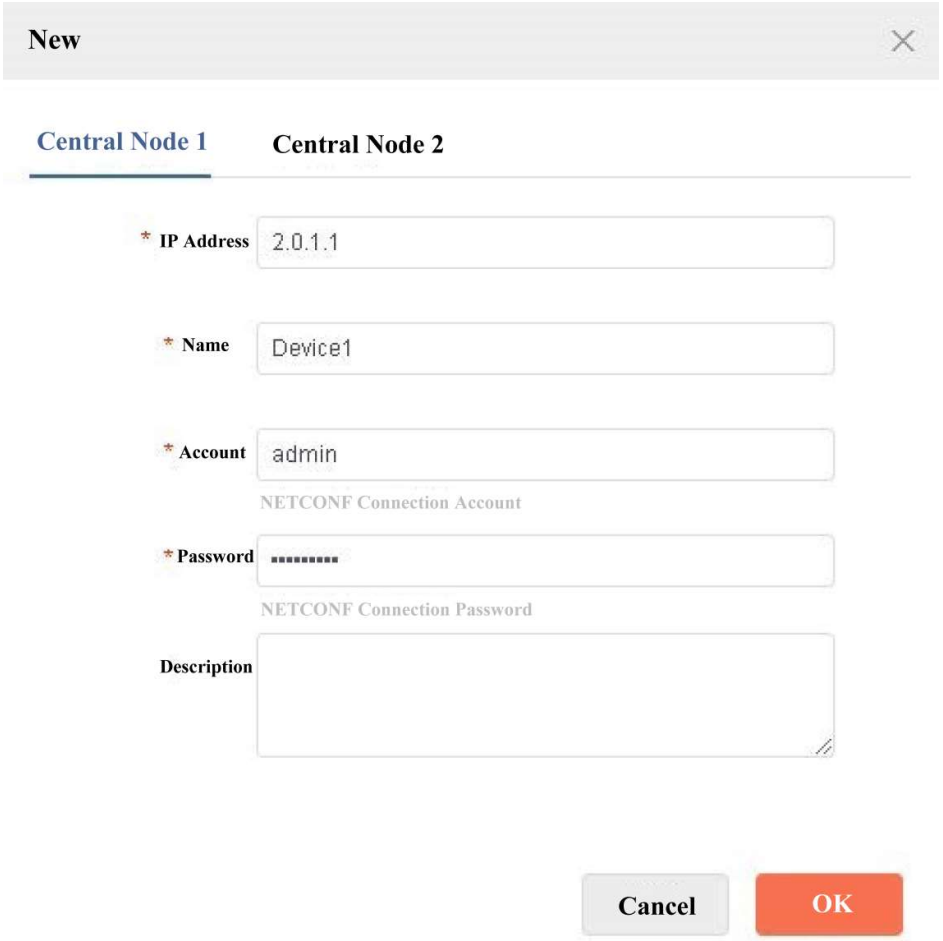


Figure 94 Controller Deployment Diagram

Step 5: Check the results.

#Connections established between the device query controller and the device NETCONF server.

Device1#show netconf session

---

session id: 1

transport: SSH

user name: admin

source host: 129.255.140.1

login time: 2019-06-1T20:29:05Z

in rpcs: 1

in bad rpcs: 0

out rpc errors: 0

out notifications: 0

95 Telemetry

95.1 Overview

Telemetry is a technology that remotely collects data from network devices at high speed. It adopts the Push Mode to obtain rich monitoring data on the network device in a timely manner, so that it can quickly achieve network fault location and efficient and intelligent network operation and maintaining.

With the growing size of the network, traditional network monitoring methods (such as SNMP and CLI) are becoming less and less efficient and can no longer meet the needs of high-performance network monitoring. With the emergence of Telemtry technology, it is able to achieve higher accuracy and more real-time monitoring data collection for super large-scale networks, as well as rapid positioning and resolution of network problems, making it an important big data platform for network quality tuning and providing strong support for the requirements and development of intelligent network operation and maintaining in the future.

The Telemetry function consists of two main parts:

- Static Subscription

  Telemetry static subscription means that the device acts as the client, the collector acts as the server, and the device initiates the connection to the collector for data collection and uploading.

- Dynamic Subscription

  Telemetry dynamic subscription means that the device acts as the server and the collector acts as the client to initiate the connection to the device, and the device does the data collection and uploading.

95.2 Telemetry Function Configuration

Table 95 Telemetry Function Configuration List

Configuration Task	
Configure Telemetry static subscriptions.	Configure sensors.
	Configure collectors.
	Configure subscriptions.
	Enable subscriptions.
Configuring Telemetry dynamic subscriptions.	Configurd the GRPC server.

95.2.1 Configure Telemetry Static Subscriptions

Configuration Condition

None

Configure Sensors

When users configure Telemetry static subscription sampling data, they need to create a sampling sensor group, then specify the sampling path information, and configure the required sampling path for the sensor according to the specified sampling path information.

Table 95 Configuring Sensors

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the sensor group mode.	**telemetry sensor-group** *sensor-name*	Mandatory If this group does not exist, it is created directly before entering the group mode, otherwise it enters the group module directly.
Configure sensor paths.	**sensor-path** *path-name*	Mandatory

Configuring Target Collectors

When users configure Telemetry to statically subscribe to sample data, they need to create the upload target group and then specify target collectors to which the sample data is to be uploaded.

Table 95 Configuring Target Collectors

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the sensor group mode.	**telemetry destination-group** *destination-name*	Mandatory If the group exists, it will go directly into the group mode.
Configure the destination address.	**ipv4-address** [**vrf vrf-name**] *ip-address* **port** *port-num*	Mandatory Vrf uses global by default. The port takes values in the range of 1 to 65535.

Creating the Subscription

When users configure Telemetry to statically subscribe to sampling data, they need to create a subscription, associate the configured upload target group with the sampling sensor group, and finish uploading data after enabling.

Table 95 Creating Subscriptions

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the subscription group mode,	**telemetry subscription** *subscription-name*	Mandatory
Configure the source interface that sends subscriptions.	**source-interface** *interface-name*	Optional By default, the output interface will be

Step	Command	Description
		determined based on the route and the primary IP address of the output interface will be used as the source IP address for sending
Configure associated sensor groups.	**sensor-group** *sensor-name* **[sample-interval** *sample-interval*]	Mandatory If the sensor group does not exist, you need to configure the sensor group first. The default value of sample-interval is 10000 milliseconds.
Configure the associated uploading destination group.	**destination-group** *destination-name*	Mandatory If the target group does not exist, you need to configure the uploading target group first.
Configure to enable subscriptions.	**subscription enable**	Mandatory Complete data upload after being enabled.

95.2.2 Configuring Telemetry Dynamic Subscriptions

Configuration Condition

None

Enable GRPC Server

Dynamic subscription is when the device side is acting as the server, therefore, the GRPC server function of the device should be enabled, if you need to complete the dynamic subscription data upload, you need the collector to act as the client, and connect it to the the device side.

Table 95 Configuring GRPC Servers

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable GRPC Server	**grpc server [port** *port-num***]**	Mandatory The default value of the **port** is 51700.

95.2.3 Telemetry Monitoring and Maintaining

Table 95 Telemetry Monitoring and Maintaining

Command	Description
show telemetry sensor-group [*sensor-name*]	View the sampling sensor information, the display includes the configured sampling path information.
show telemetry destination [*destination-name*]	View the uploading destination group information, including the configured uploading destination address information.
show telemetry subscription [*subscription-name*]	View subscription information, displaying information about the configured associated sensor group and target group.
show telemetry sensor-path	View Telemetry sensor sample paths, display includes information on supported sample paths.
show telemetry dynamic-subscription [*dynamic-subscription-name*]	View Telemetry dynamic subscription statistics, displaying information including dynamically subscribed sensor path information.

95.3 Typical Configuration Example of Telemetry

95.3.1 Configure Telemetry Static Subscriptions

Network Requirements

- Device acts as a Telemetry client and actively sends data to the server.
- The Telemetry service is enabled on the server and actively listens on port 30000.

Network Topology

Figure 95 Network Topology for Static Subscription

Configuration Steps

Step 1: Enable Telemetry service on server and configure to listen on port 30000, omitted.

Step 2: Configure the static subscription function Telemetry.

#Create a sample group sensor and configure the sample path as dmm/memInfo, which is used to count memory usage and other situation data.

```
Device#configure terminal
Device(config)#telemetry sensor-group sensor
Device(config-telemetry-sensor-group-sensor)#sensor-path dmm/memInfo
Device(config-telemetry-sensor-group-sensor)#exit
```

#Create a target group, configure the target address to be the address of the server, and configure the port to be the port the server is listening on.

```
Device(config)#telemetry destination-group dest
Device(config-telemetry-destination-group-dest)#ipv4-address 1.1.1.2 port 30000
Device(config-telemetry-destination-group-dest)#exit
```

#Configure the subscription group, refer to the sensor combination target group configured above, and enable the subscription function.

```
Device(config)#telemetry subscription sub
Device(config-telemetry-subscription-sub)#sensor-group sensor sample-interval 10000
```

```
Device(config-telemetry-subscription-sub)#destination-group dest
Device(config-telemetry-subscription-sub)#subscription enable
```

Step 3: Check the result.

#The device can receive memory statistics via Telemetry every 10s on the collector.

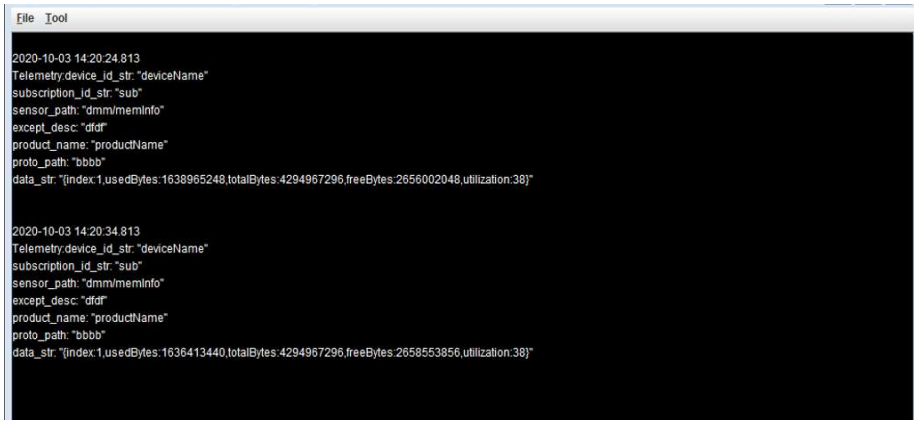


Figure 95 Memory Usage Statistics Received by the Collector

95.3.2 Configuring Telemetry Dynamic Subscriptions

Network Requirements

- Client acts as a Telemetry client and is used to send Telemetry data requests to the device and display the data replied by the device.
- Device acts as the Telemetry server to respond to requests from the device.

Network Topology

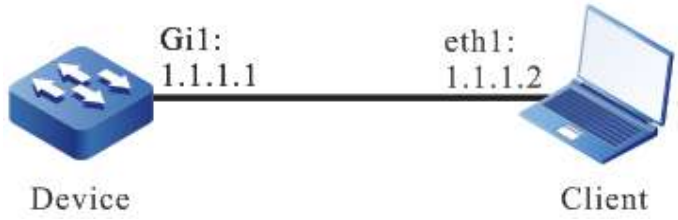


Figure 95 Network Topology for Dynamic Subscription of Telemetry

Configuration Steps

Step 1: Enable GRPC service on the device.

```
Device#configure terminal
Device(config)#grpc server
```

Step 2: The Telemetry data request is placed on the client, omitted.

Step 2: Check the result.

#Show on the device to see dynamic subscription connections.

```
Device#show telemetry dynamic-subscription

1.Telemetry dynamic-subscription Information:
 ---------------------------------------------------------------------
 Subscription-name     : dynSubs96183
 Subscription-id       : 96183
 Request-id            : 3874318141
 Encoding              : JSON
 Sample-interval(ms):  : 10000
 Subscription-state:   : Subscribed
 ---------------------------------------------------------------------
 Sensor group information:
 ---------------------------------------------------------------------
 Sample-interval(ms)     Sample-path
 ---------------------------------------------------------------------
 10000                   dmm/memInfo

 ---------------------------------------------------------------------
```

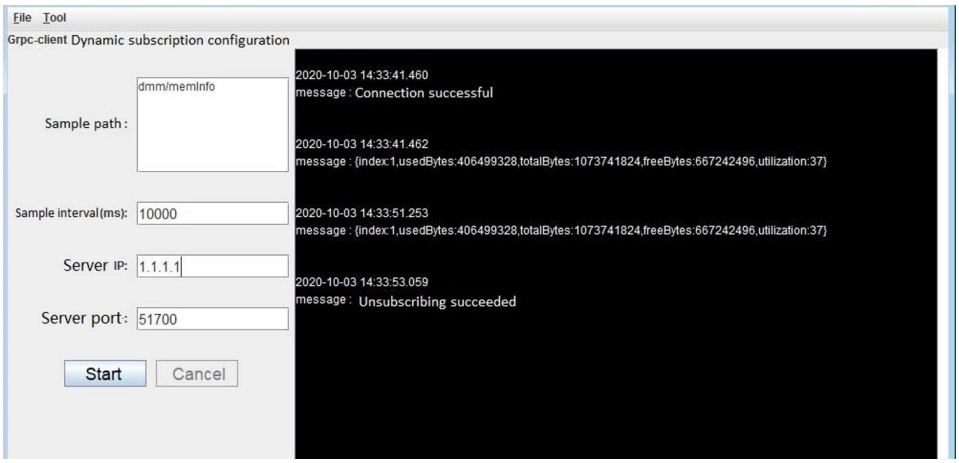


Figure 95 Information on Data Transmission of Clients

96 VST

96.1 Overview

With the ever-increasing requirements of users for reducing costs and improving equipment reliability, we have proposed a technology that combines multiple physical switches into one virtual switch, namely Virtual Switching Technology (VST).

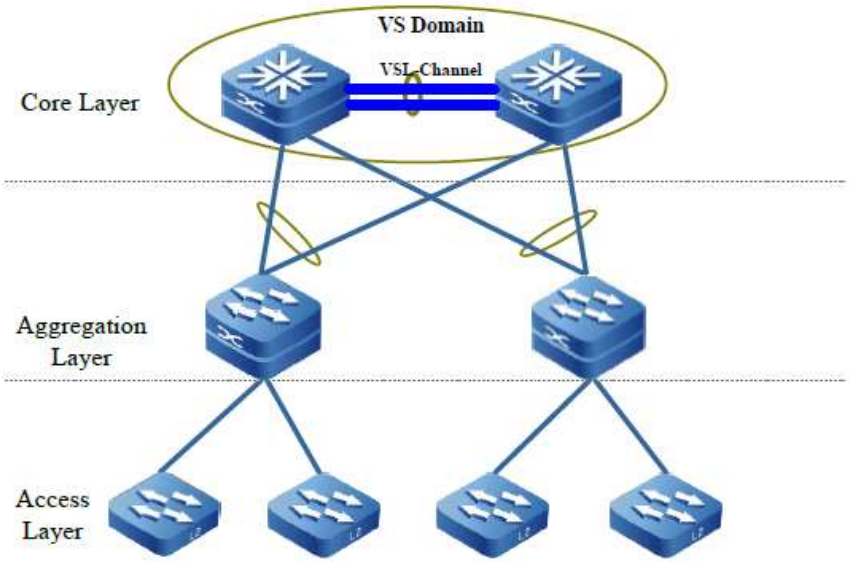


Figure 1 VST Physical Network View

As shown in Figure 1-1, two devices at the core layer are connected via a virtual switching link interface to form one VS Domain (virtual switching domain, also called stack system); the devices at the aggregation layer are uplinked to VS Domain via link aggregation; the VS Domain at the core layer is one virtual device to other network devices.

Compared with the traditional L2 spanning tree and L3 VRRP/VBRP technology, this technology has the following advantages:

- Exponential Increase in Bandwidth under Efficient Use

In the traditional solution, due to the operation of STP/RSTP/MSTP, one of the original two uplinks will be in the forwarding status and the other link in the backup status; multiple devices become one single logical device by the use of the virtual switching technology, and therefore, it is no longer necessary to block some links; two links form one aggregation group, which can be used to forward data, thereby effectively using the bandwidth of these links without causing the waste of bandwidth resources. In addition, the cross-device and cross-board aggregation link allow for both redundant links and dynamic load balancing, thereby effectively utilizing all bandwidth.

- High reliability

Virtual switching system is composed of multiple member devices. The master control device is responsible for the operation, management, and maintenance of the entire virtual switching system, while

other member devices are in the backup status. Once the master control device fails, there will be no rely on the convergence of STP/RSTP/MSTP, VRRP/VBRP and other protocols, and the system will quickly elect the new master control device from other member devices in the backup status, ensuring that the business of the virtual switching system experiences no interruption, and improved reliability is provided when member failure occurs.

- Network Topology Simplification

The virtual device formed by means of the virtual switching technology is equivalent to a single device in the network. It is connected to the peripheral devices via aggregation links. Because there is no L2 loop, there is no need to configure the STP/RSTP/MSTP protocol. Various control layer protocols run on one virtual device, thereby reducing the interaction of numerous protocol packets between the devices and shortening the routing convergence time.

- Centralized Management

After two or more devices form stack system, the member device control plane in the virtual switching system is in the backup status, but its data plane is active. Users can log in to the virtual switching system via the port of any member device to carry out centralized management on the entire virtual device,without connecting to each member device for separate management.

96.1.1 Basic Concepts

Virtual Switch Domain

Virtual switch domain is composed of one or more member devices. The member devices in the same virtual switch domain must have the same domain ID configuration. The domain ID uniquely determines one virtual switch domain. When the virtual switch domain MAC address is obtained using the virtual MAC address mode, the virtual switch domain ID uniquely determines the MAC address. Therefore, in the same LAN, the domain IDs between multiple stack systems cannot be the same.

Virtual Switch Member Device

Each physical device in the virtual switch domain is also called virtual switch member device. In the same stack domain, the member ID uniquely determines one member device.

Virtual Switch Link Interface and its Member Port

By binding the multiple physical ports together which are stacking capable, one virtual switch link interface (VSL-Channel) can be formed. The virtual switch link interface is logical link channel for internal protocol packet interaction and service data forwarding between member devices in the stack system, and each physical port therein is called virtual switch link member port.

The member devices join the same virtual switch domain, interconnect with each other via the virtual switch link interface, and finally form one virtual switch device.

LMP

LMP (Link Manage Protocol) is used to manage the virtual switch link interface and its member ports.

RRP

RRP (Role Resolution Protocol) is used for the role resolution of member devices in the stack system.

TDP

TDP (Topology Discovery Protocol) is used to advertise the information of the member devices in the stack system to ensure information consistency for all member devices in the stack system.

96.2 VST Function Configuration

Table 1 VST Function Configuration List

Configuration Task	
Configure virtual switch member device	Configure virtual switch member device domain ID
	Configure virtual switch member device ID
	Configure virtual switch member device priority
Configure virtual switch link interface	Create virtual switch link interface
	Configure to add the port to the virtual switch link interface
Configure device running mode	Configure device running mode

96.2.1 Configure Virtual Switch Member Device

Before the device joins the virtual switch stack domain or after it has joined the virtual switch stack domain, you can configure the device accordingly, including modifying its member ID, domain ID, and priority.

Note

- In the stack mode, after modifying the member ID or domain ID of the virtual switch member device, the newly configured member ID or domain ID will not take effect immediately. The corresponding configuration will only take effect after the corresponding virtual switch member device saves the configuration and reboots.

Configuration Condition

None

Configure Virtual Switch Member Device Domain ID

Table 2 Configuring Virtual Switch Member Device Domain ID

Step	Command	Description
Enter the virtual switch member configuration mode	**switch virtual member** *member-id*	-
Configure virtual switch member device domain ID	**domain** *domain-id*	Mandatory By default, the domain ID of the virtual switch member device is 100

Caution

- In the stack mode, when adding a virtual switch member device to the virtual switch domain, you must ensure that the domain ID of every virtual switch member device is the same, otherwise the virtual switch member device will not be able to join the same virtual switch domain.
- In the stack mode, after the domain ID is modified, the new domain ID will not take effect immediately. The new domain ID will only take effect after the virtual switch member device saves the configuration and reboots.

Configure Virtual Switch Member Device ID

For configuring the virtual switch member device ID, there are two corresponding cases: In the first case, the device has never been configured with the virtual switch member device ID and requires a virtual switch member device ID to be configured; In the second case, the device has been configured with a virtual switch member device ID and requires it to be modified into the new virtual switch member device ID. Therefore, there are two commands to configure the virtual switch member device ID. One is to

configure the virtual switch member device ID, and the other is to modify the virtual switch member device ID, as shown in Table 1-3.

Table 3 Configuring VST Member Device ID

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure virtual switch member device ID	**switch virtual member** *member-id*	Mandatory By default, the device has no virtual switch member device ID
Modify virtual switch member device ID	**switch virtual member** *member-id* **rename** *member-id-new*	Optional

Caution

- In the stack mode, after modifying the virtual switch member device ID, you must save the configuration and reboot the system before the new virtual switch member device ID takes effect.
- In the stack mode, after modifying the virtual switch member device ID, you must save the configuration and reboot the system before the new virtual switch member device ID takes effect.In one virtual switch domain, the member ID of each virtual switch member device is unique, and it cannot happen that the member IDs of two virtual switch member devices are the same, otherwise the virtual switch member devices cannot be stacked normally.

Configure Virtual Switch Member Device Priority

When multiple virtual switch member devices join the same virtual switch domain, the priority of each virtual switch member device can be configured to increase the possibility of the virtual switch member device being selected as the master control device. The higher the priority value, the more preferred.

Table 4 Configuring Virtual Switch Member Device Priority

Step	Command	Description
Enter the virtual switch member configuration mode	**switch virtual member** *member-id*	-

Step	Command	Description
Configure virtual switch member device priority	**priority** *priority-num*	Mandatory By default, the priority of the virtual switch member device is 100

Note

- The virtual switch master control devices in the virtual switch domain are selected based on the following resolution rules:

1. The virtual switch master control device is given priority; if there are multiple virtual switch master control devices, the second step comparison is performed; if there is no virtual switch master control device, the third step comparison is performed, otherwise the comparison ends;
2. Those as the virtual switch master control device having a long run time are given priority; if the master control devices have the same run time, the third step comparison is performed, otherwise the comparison ends;
3. Those higher priority are given priority; if the priorities are the same, the fourth step comparison is performed, otherwise the comparison ends;
4. Those having small member ID are given priority.

96.2.2 Configure Virtual Switch Link Interface

The virtual switch link interface (VSL-Channel) is one logical interface. Centralized management for multiple physical ports is achieved by binding together these physical ports that support stacking. Any operation on the virtual switch link interface will affect every physical member port at the same time.

Configuration Condition

None

Create Virtual Switch Link Interface

Table 5 Creating Virtual Switch Link Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Create virtual switch link interface	**vsl-channel** *vsl-channel-id*	Mandatory In stand-alone mode, vsl-channel-id is a one-dimensional value that represents a virtual switch link interface ID. In the stack mode, it is a two-dimensional value. The first dimension is a virtual switch member ID, and the second dimension is a virtual switch link interface ID.

Caution

- Upon deletion of the virtual switch link interface, all member ports in the virtual switch link interface will exit the virtual switch link interface, and all the member ports' configurations are restored to the default status. Before deleting the virtual switch link interface, please confirm that there will be no loops in the network after deletion.

Configure to Add the Port to the Virtual Switch Link Interface

Table 96-6 Configuring to Add the Port to the Virtual Switch Link Interface

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure to add the port to the virtual switch link interface	**vsl-channel** *vsl-channel-id* **mode on** [**type extern**]	Mandatory

Note

- All member ports in the virtual switch link interface must have the same port capability level.

96.2.3 Configure Device Running Mode

The current device supports two running modes, that is, stand-alone mode and stack mode. The device can form one virtual switch domain with other virtual switch member devices only when it runs in the stack mode.

Configuration Condition

None

Configure Device Running Mode

Table 96-7 Configuring Device Running Mode

Step	Command	Description
Enter the privileged user mode.	**enable**	-
Configure device running mode	**switch mode** { **stand-alone** | **virtual** }	Mandatory By default, the device runs in the stand-alone mode

Note

- When the running mode of the device changes, the device will reboot and run in the new configuration mode after the reboot.
- The different running modes of the device correspond to their respective independent boot configuration files.
- Before switching the device to run in the stack mode, you must ensure that the virtual switch member device ID has been configured, otherwise switching cannot be performed.

96.2.4 VST Monitoring and Maintaining

Table 96-8 VST Monitoring and Maintaining

Command	Description
show switch virtual	Show the basic information of the virtual switch domain
show switch virtual local config	Show the basic configuration information of the local virtual switch member device
show switch virtual local current	Show the basic running information of the local virtual switch member device
show switch virtual member *member-id* [**config** | **current**]	Show the basic information of the virtual switch member device
show switch virtual topo	Show the information about the forwarding path from the local virtual switch member device to other virtual switch member devices in the virtual switch domain
show switch vsl-channel [*vsl-channel-id*]	Show the information about the virtual switch link interface in the virtual switch domain

96.3 VST Typical Configuration Example

96.3.1 Configure the Devices to Form Chain Stack System

Network Requirements

- It is realized that Device0 and Device1 form chain stack system, in which Device0 becomes the master control device.

Network Topology

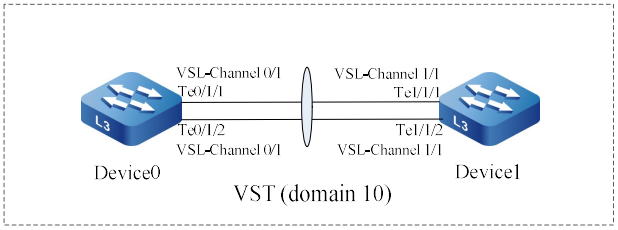


Figure 2 Configuring the Devices to Form Chain Stack System

Configuration Steps

Step 1: Configure Device0.

#On Device0, Configure the virtual switch member device ID as 0, and configure the domain ID as 10 and the priority as 255.

```
Device0#configure terminal
Device0(config)#switch virtual member 0
Do you want to modify member id(Yes|No)?y
% Member ID 0 config will take effect only after the exec command 'switch mode virtual' is issued
Device0(config-vst-member-0)#domain 10
% Domain ID 10 config will take effect only after the exec command 'switch mode virtual' is issued
Device0(config-vst-member-0)#priority 255
Device0(config-vst-member-0)#exit
```

#On Device0, create virtual switch link interface 1, and add ports tengigabitethernet1/1 and tengigabitethernet1/2 to the virtual switch link interface 1.

```
Device0(config)#vsl-channel 1
Device0(config-vsl-channel-1)#exit
Device0(config)#interface tengigabitethernet 1/1-1/2
Device0(config-if-range)#vsl-channel 1 mode on
Device0(config-if-range)#exit
```

#Save the configuration on Device0.

```
Device0#write
Are you sure to overwrite /flash/startup (Yes|No)?y
Building Configuration...done
Write to startup file ... OK
Write to mode file... OK
```

Step 2: Configure Device1.

#On Device1, Configure the virtual switch member device ID as 1, and configure the domain ID as 10 and the priority as 200.

```
Device1#configure terminal
Device1(config)#switch virtual member 1
Do you want to modify member id(Yes|No)?y
% Member ID 1 config will take effect only after the exec command 'switch mode virtual' is issued
Device1(config-vst-member-1)#domain 10
% Domain ID 10 config will take effect only after the exec command 'switch mode virtual' is issued
Device1(config-vst-member-1)#priority 200
Device1(config-vst-member-1)#exit
```

#On Device1, create virtual switch link interface 1, and add ports tengigabitethernet1/1 and tengigabitethernet1/2 to the virtual switch link interface 1.

```
Device1(config)#vsl-channel 1
Device1(config-vsl-channel-1)#exit
Device1(config)#interface tengigabitethernet 1/1-1/2
Device1(config-if-range)#vsl-channel 1 mode on
Device1(config-if-range)#exit
```

#Save the configuration on Device1.

```
Device1#write
Are you sure to overwrite /flash/startup (Yes|No)?y
Building Configuration...done
Write to startup file ... OK
Write to mode file... OK
```

Step 3: Configure Device0 and Device1 to run in the stack mode.

#Configure Device0 to run in the stack mode.

```
Device0#switch mode virtual
This command will convert all interface names to naming convention "interface-type member-number/slot/interface" ,
Please make sure to save current configuration.Do you want to proceed? (yes|no)?y
Converting interface names Building configuration...
Copying the startup configuration to backup file named "startup-backupalone"...
Please wait...system reloading is in progress!
 ok
Reset system!
Jul 30 2014 17:36:14: %SYS-5-RELOAD: Reload requested
```

#Configure Device1 to run in the stack mode.

```
Device1#switch mode virtual
This command will convert all interface names to naming convention "interface-type member-number/slot/interface" ,
Please make sure to save current configuration.Do you want to proceed? (yes|no)?y
Converting interface names Building configuration...
Copying the startup configuration to backup file named "startup-backupalone"...
Please wait...system reloading is in progress!
 ok
Reset system!
                    Jul 30 2014 17:36:20: %SYS-5-RELOAD: Reload requested
```

Step 4: Check the result.

#Check on Device0, chain stack system has been formed, and Device0 is the master control device.

```
Device0#show switch virtual
Codes: L - local-device,I - isolate-device

Virtual Switch Mode       : VIRTUAL
Virtual Switch DomainId   : 10
Virtual Switch mac-address : 0001.7a6a.001b

---------- VST MEMBER INFORMATION ----------
CODE MemberID Role   Pri  LocalVsl       RemoteVsl
---- -------- ------ ---- --------------- ---------------
L   0       Master 255  vsl-channel 0/1 vsl-channel 1/1

    1       Member 200  vsl-channel 1/1 vsl-channel 0/1
```

97 MAD

97.1 Overview

When the virtual switch link interface in the stack system fails, the stack system splits into multiple virtual switch domains, and multiple virtual switch master control devices (hereinafter referred to as master control devices) with the same global configuration appear. This case is called Multi-Active. Since the logical devices from splitting are exactly the same as the original logical device in terms of global configuration, network configuration conflicts will occur, resulting in traffic anomalies. In order to avoid the impact of this case on the business, MAD (Multi-Active Detection) is proposed.

The current stack system supports two MAD modes: MAD LACP and MAD Fast-Hello, which can meet different networking requirements.

The MAD status includes two statuss: Active status and Recovery status. Active status means normal working status, and Recovery status means disabled status. In the disabled status, all L2/3 Ethernet interfaces and VLAN interfaces except the virtual switch link member ports and reserved ports will be shut down by MAD.

When the device receives the MAD packet, it compares the data in the packet with the data of the local logic device. If the VS Domain ID (the virtual switch domain ID of the sender) in the packet is the same as that of the local logical device, and the Master ID in the packet (the member ID of the master control device in the virtual switch domain where the sender is located) is differed from that of the local logical device, it is considered that multi-active has occurred, and multi-active resolution has begun. According to certain resolution rules, only one logical device in the same virtual switch domain remains in the Active status, and other logical devices enter the Recovery status.

Intermediate device must be used in MAD LACP networking, and intermediate device or direct connection can be used in MAD Fast-Hello networking. If the direct connection mode is used, ensure that there is a direct line between any two virtual switch member devices for multi-active detection, that is, ensure full connection.

97.2 MAD Function Configuration

Table 97-1 MAD Function Configuration List

Configuration Task	
Configure MAD LACP function	Configure MAD LACP function

Configuration Task	
Configure MAD Fast-Hello function	Configure MAD Fast-Hello function
Configure reserved port	Configure reserved port
Configure restoring MAD status to Active status	Configure restoring MAD status to Active status

97.2.1 Configure MAD LACP Function

MAD LACP Multi-active detection extends the LACP packet fields to achieve multi-active detection and resolution.

Configuration Condition

None

Configure MAD LACP Function

Table 97-2 Configuring MAD LACP Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Create dynamic aggregation group	**link-aggregation** *link-aggregation-id* **mode lacp**	Mandatory By default, the aggregation group is not created.
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	-
Enable MAD LACP Function	**mad enable**	Mandatory By default, the MAD LACP function is not enabled

Note

- Only the dynamic aggregation group supports enabling the MAD LACP function.
- The intermediate device used in networking must be Our device that supports the LACP

Step	Command	Description
	packet transparent transmission function.	

97.2.2 Configure MAD Fast-Hello Function

MAD Fast-Hello multi-active detection protocol packets are customized by our company and directly carry data required by multi-active detection and resolution.

Configuration Condition

None

Configure MAD Fast-Hello Function

Table 97-3 Configuring MAD Fast-Hello Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the MAD Fast-Hello packet sending period in normal mode	**mad fast-hello normal interval** *interval-time*	Optional By default, the MAD Fast-Hello packet sending period in normal mode is 2000 milliseconds
Configure the MAD Fast-Hello packet sending period in aggressive mode	**mad fast-hello aggressive interval** *interval-time*	Optional By default, the MAD Fast-Hello packet sending period in aggressive mode is 500 milliseconds
Configure the duration of aggressive mode	**mad fast-hello aggressive duration** *duration-time*	Optional By default, the duration of aggressive mode is 120 seconds
Enter the VLAN configuration mode	**vlan** *vlan-id*	-
Configure controlling VLAN	**mad fast-hello control-vlan**	Mandatory

Step	Command	Description
		By default, no control VLAN is configured
Enter the global configuration mode.	**exit**	-
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	-
Configure the port link type to the Trunk type	**switchport mode trunk**	Mandatory By default, the port link type is the Access type.
Shut down the spanning tree function on the port	**no spanning-tree enable**	Mandatory By default, the spanning tree function is enabled on the port
Configure control port	**mad fast-hello vlan** *vlan-id*	Mandatory By default, no control port is configured

Note

- The control VLAN and control port for MAD Fast-Hello can only be used exclusively for MAD Fast-Hello multi-active detection, and no other services can be configured.
- Shutting down the spanning tree function of the port on the MAD Fast-Hello control port is required.

97.2.3 Configure Reserved Port

When MAD is in the Recovery status, the reserved port will not be shut down by MAD. You can configure the ports and interfaces (such as management ports) that need to be in UP status for special purposes as reserved ports.

Configuration Condition

None

Configure Reserved Port

Table 97-4 Configuring Reserved Port

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enter the L2/L3 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. The subsequent configuration takes effect only on the current interface after you enter the L2/L3 Ethernet interface configuration mode, only on the aggregation group after you enter the aggregation group configuration mode, and only on the current port after you enter the interface configuration mode
Enter Aggregation Group Configuration Mode	**link-aggregation** *link-aggregation-id*	
Enter the interface configuration mode	**interface vlan** *vlan-id*	
Configure reserved port	**mad exclude recovery**	Mandatory By default, no reserved port is configured

Note

- The aggregation group that has MAD LACP enabled cannot be configured as reserved port.

97.2.4 Configure Restoring MAD Status to Active Status

Configuration Condition

None

Configure Restoring MAD Status to Active Status

Table 97-5 Configuring Restoring MAD status to Active status

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure restoring MAD status to Active status	**mad restore**	Mandatory By default, MAD is in Active status

Note

- When the MAD changes to Recovery status, MAD does not process the shut-down ports and interfaces. When the MAD is restored to Active status, only the shut-down ports and interfaces are started up.

97.2.5 MAD Monitoring and Maintaining

Table 97-6 MAD Monitoring and Maintaining

Command	Description
show mad exclude recovery interface [**switchport** | **vlan**]	Show the reserved port configured
show mad fast-hello	Show MAD Fast-Hello information
show mad lacp	Show MAD LACP information
show mad status	Show MAD status

97.3 Typical Configuration Example of MAD

97.3.1 Configure MAD LACP Function

Network Requirements

- Device0 and Device1 form a stack system with Device0 as the master control device, and PC 1 accesses the IP Network through the stack system;
- After the MAD LACP function is configured, PC 1 can access the IP Network properly after

Device1 is separated from the stack system due to a fault of the virtual switch link interface. Service exceptions due to network configuration conflicts are not caused.

Network Topology

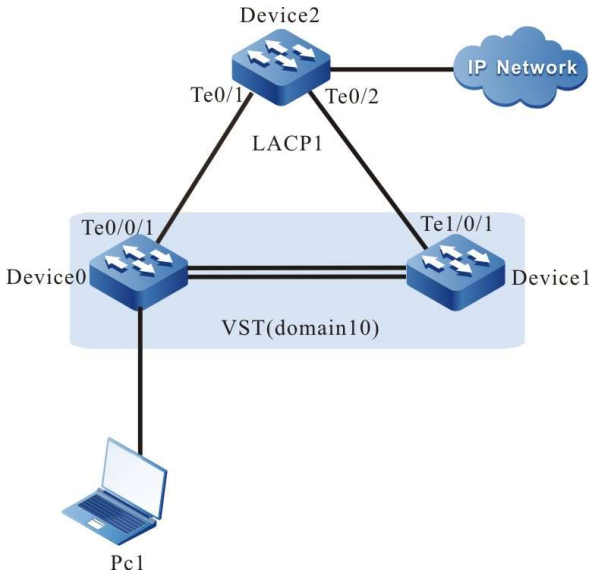


Figure 97 Network Topology for Configuring MAD LACP

Configuration Steps

Step 1: Device0 and Device1 form a stack system with Device0 as the master control device.

Omitted

Step 2: Configure the MAD LACP function on Device0.

#On Device0, create VLAN 2 and dynamic aggregation group 1, configure the link type of the aggregation group 1 to Trunk to allow services of VLAN 2 to pass.

```
Device0#configure terminal
Device0(config)#vlan 2
Device0(config-vlan2)#exit
Device0(config)#link-aggregation 1 mode lacp
Device0(config)#link-aggregation 1
                Device0(config-link-aggregation1)#switchport mode trunk
                Device0(config-link-aggregation1)#switchport trunk allowed vlan add 2
                Device0(config-link-aggregation1)#exit
```

#On Device0, add ports tengigabitethernet0/0/1 and gigabitethernet1/0/1 into the aggregation group 1.

```
Device0(config)#interface tengigabitethernet 0/0/1,1/0/1
Device0(config-if-range)#link-aggregation 1 active
Device0(config-if-range)#exit
```

#Enable the MAD LACP function on the aggregation group 1 of Device0.

```
Device0(config)#link-aggregation 1
Device0(config-link-aggregation1)#mad enable
```

```
Device0(config-link-aggregation1)#exit
```

Step 3: Configure Device2.

#On Device2, create VLAN 2 and dynamic aggregation group 1, configure the link type of the aggregation group 1 to Trunk to allow services of VLAN 2 to pass.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
Device2(config)#link-aggregation 1 mode lacp
Device2(config)#link-aggregation 1
                    Device2(config-link-aggregation1)#switchport mode trunk
                    Device2(config-link-aggregation1)#switchport trunk allowed vlan add 2
                    Device2(config-link-aggregation1)#exit
```

#On Device2, add ports tengigabitethernet0/1 and gigabitethernet0/2 into the aggregation group 1.

```
Device2(config)#interface tengigabitethernet 0/1,0/2
Device2(config-if-range)#link-aggregation 1 active
Device2(config-if-range)#exit
```

Step 4: Check the result.

#View the MAD LACP information on Device0.

```
Device0#show mad lacp
------------MAD-LACP INFORMATION--------------
  Link-aggregation       Mad state
 -----------------       -----------------
        1              enable
```

#After Device1 is separated from the stack system due to the fault of the virtual switch link interface, the MAD status of the stack system using Device0 as the master control device changes to Active status, and the MAD status of the stack system using Device1 as the master control device changes to Recovery status.

```
Device0#show mad status
 MAD status: active

Device1#show mad status
 MAD status: recovery
```

#PC 1 can access the IP Network.

97.3.2 Configure MAD Fast-Hello Function

Network Requirements

- Device0 and Device1 form a stack system with Device0 as the master control device;
- After the MAD Fast-Hello function is configured, and after Device1 is separated from the stack system due to the fault of the virtual switch link interface, service exceptions due to network configuration conflicts will not be caused.

Network Topology

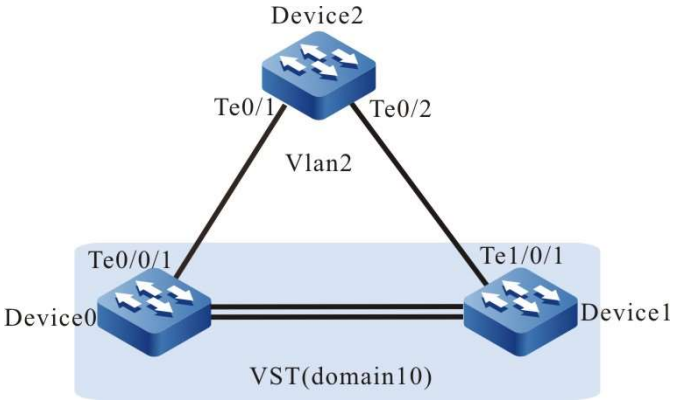


Figure 97-2 Network Topology for Configuring MAD Fast-Hello

Configuration steps Step 1: Device0 and Device1 form a stack system with Device0 as the master control device.

Omitted

Step 2: Configure the MAD Fast-Hello function on Device0.

#Create VLAN 2 on Device0 and configure it as MAD Fast-Hello control VLAN.

```
Device0#configure terminal
Device0(config)#vlan 2
Device0(config-vlan2)#mad fast-hello control-vlan
Device0(config-vlan2)#exit
```

#Configure on Device0, the like types of ports tengigabitethernet0/0/1 and tengigabitethernet1/0/1 as Trunk, and join the MAD Fast-Hello control VLAN.

```
Device0(config)#interface tengigabitethernet 0/0/1,1/0/1
Device0(config-if-range)#switchport mode trunk
Device0(config-if-range)#mad fast-hello vlan 2
Device0(config-if-range)#exit
```

#On Device0, shut down the spanning tree function of the ports tengigabitethernet0/0/1 and gigabitethernet1/0/1.

```
Device0(config)#interface tengigabitethernet 0/0/1,1/0/1
Device0(config-if-range)#no spanning-tree enable
Device0(config-if-range)#exit
```

Step 3: Configure Device2.

#On Device2, create VLAN 2, configure the link types of ports tengigabitethernet0/1 and gigabitethernet0/2 as Trunk to allow services of VLAN 2 to pass.

```
Device2#configure terminal
Device2(config)#vlan 2
Device2(config-vlan2)#exit
Device2(config)#interface tengigabitethernet 0/1,0/2
Device2(config-if-range)#switchport mode trunk
Device2(config-if-range)#switchport trunk allowed vlan add 2
Device2(config-if-range)#exit
```

#On Device2, shut down the spanning tree function of the ports tengigabitethernet0/1 and gigabitethernet0/2.

```
Device2(config)#interface tengigabitethernet 0/1,0/2
Device2(config-if-range)#no spanning-tree enable
Device2(config-if-range)#exit
```

Step 4: Check the result.

#View MAD Fast-Hello enabling on Device0.

```
Device0#show mad fast-hello
 MAD Fast-Hello Information:
  Normal interval     : 2000 ms(default: 2000)
  Aggressive interval : 500  ms(default: 500)
  Aggressive duration : 120  s (default: 120)
  Control vlan        : 2
  --------------- -------------
  Interface       Control vlan
  --------------- -------------
   te0/0/1        2
   te1/0/1        2
```

#After Device1 is separated from the stack system due to the fault of the virtual switch link interface, the MAD status of the stack system using Device0 as the master control device changes to Active status, and the MAD status of the stack system using Device1 as the master control device changes to Recovery status.

```
Device0#show mad status
 MAD status: active

Device1# show mad status
 MAD status: recovery
```

Step 1:

Step 1: Device0 and Device1 form a stack system with Device0 as the master control device.

Omitted

Step 1: Device0 and Device1 form a stack system with Device0 as the master control device.

Omitted

98 MVST

98.1 Overview

At present, VST (Virtual Switching Technologies, which will combine crosswise multiple physical devices into one virtual device) technology because of its high reliability, ease of management and other characteristics gradually become a necessary networking technology to LAN. VST technology realizes the centralized management of multiple devices at the same level, but there is still the problem of decentralized management of devices on the multi-level network. Especially in the typical two-level local area network, the access layer uses numerous access devices that are enormous in amount and highly dispersed and need sequential maintenance and management, making the management work be cumbersome. Additionally, assigning each of these devices an IP address will consume a lot of IP address resources, which is undoubtedly a waste with IP address resources running short at present.

To solve the above problems, MVST (Mix Virtual Switching Technology, vertical management virtualization technology) technology is proposed. As shown in the figure below, VST technology is used for the core layer of LAN to virtualize multiple devices into one logical device, while Mix Virtual Switching Technology (MVST), a vertical management virtualization technology, is used for the vertical layer. MVST virtualizes all devices of the entire LAN into one logical device, constituting a centralized management domain (MVST domain). The management domain provides one external management IP address and the ability to manage and access each device on the LAN. In this way, ''one network and one device'' is truly achieved, one network has one IP, and the entire LAN can be readily managed with one device, thereby simplifying management.

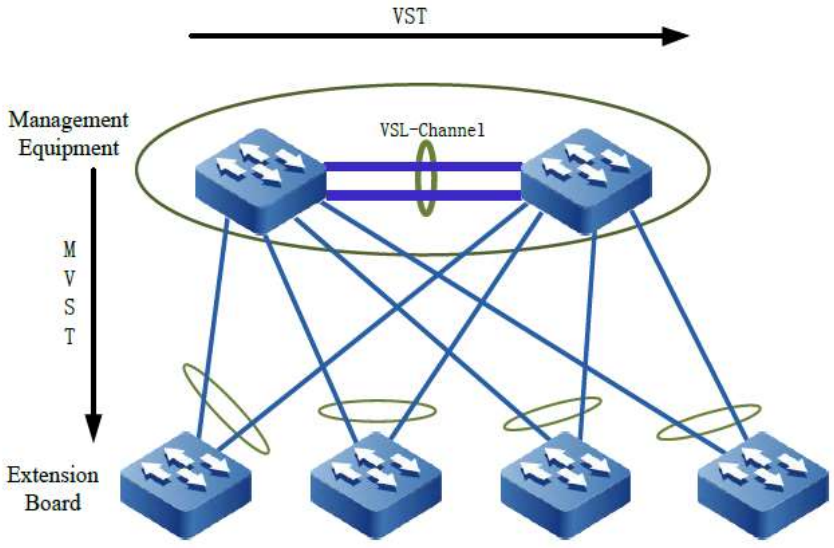


Figure 3-1 MVST Physical Network View

MVST defines three device roles depending on the different statuses and functions of devices in the LAN.

- Management device (MVST master) : responsible for configuring, managing, and monitoring all devices on the LAN.
- Extension board (MVST Slave slot): extension board for LAN that can be centrally configured and managed by the management device.
- Candidate board (MVST Candidate): not added to the MVST domain, but qualified to be extension board.

The management device in the MVST domain uses the MVST detection protocol to discover extension boards and uses the MVST topology collection protocol to collect information about each extension card in the MVST domain and draw a LAN topology. The management device adds the joined devices to the MVST domain based on the topology.

After the extension board is added to the MVST domain, users can log in to the control interface of the management device using the IP address of the management device to centrally manage the entire LAN. In addition to general configuration management, MVST technology provides the following features:

1) Template-based Configuration

In application scenarios, some common basic configurations need to be applied to all extension boards in the MVST domain. You can edit these configurations to a configuration template, and then the management device issues the configuration template to the extension boards, so the extension boards are completed with the common basic configurations.

2) autoconfiguration

The management device backs up the startup configuration file of the extension board to the local storage medium. When the extension board is faulty and needs to be replaced with a new one, the new extension board is directly connected to the LAN through the same port without any configuration. The management device automatically sends the backup configuration file to the extension board. After the extension board is configured, the network is quickly restored.

3) One-click Configuration

The management device can start up Dot1x, storm control, DHCP Snooping, and Arp-check functions of all extension boards in the MVST domain by one click.

4) Auto upgrade

The management device prepares the IOS of the extension board in advance. When the extension board joins the MVST domain, the management device automatically detects the consistency between the current running version of the extension board and the auto upgrade version. The background performs auto upgrade in case of inconsistency. Log information is printed if the user visual interface is shown. During the upgrade process of the extension board, the user can still manage the management device or extension board to achieve both upgrade and configuration.

5) Password Dynamic Management

The login passwords of all extension boards in the MVST domain are dynamically generated by the management device. After the extension board successfully joins the MVST domain, the management device generates a dynamic password and sends the password to the extension board. During the operation of the extension board, if you need to log in directly through the console, the login password can only be obtained through the management device, which strengthens the security of the local area network.

98.2 MVST Function Configuration

Table 3-1 MVST Function Configuration List

Configuration Task	
Configure MVST basic functions	Configure the management device
	Configure extension boards
Configure MVST parameters	Configure sending interval for inspection packets
	Configure neighbor aging time
	Configure the keepalive interval of extension boards
	Configure connection status timeout for extension boards
	Configure topology parameters
Configure MVST features	Configure the upgrade function
	Configure the template function
	Configure the auto binding configuration function
	Configure personalized configuration
	Configure the device group function
	Configure the log function

98.2.1 Configure Basic Functions of MVST

When the users need to manage devices in a certain domain through MVST technology, they can configure MVST. In the various configuration tasks of MVST, the MVST function must be enabled before other function configurations can take effect.

Configuration Condition

None

Configure the Management Device

The management device is the nerve center of MVST. It provides one management tunnel for the MVST domain, through which the administrator realizes the centralized management of the devices in the specified domain.

Table 3-2 Configuring the Management Device

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the MVST function	**mvst enable**	Mandatory By default, the MVST function is disabled
Configure the specified device as the management device for the MVST domain	**mvst master**	Mandatory By default, no management device is specified
Configure MVST domain name	**mvst domain-name** *domain-name*	Optional By default, the MVST domain name is "mvst-1"
Create MVST dedicated aggregation port	**mvst link-aggregation**	Create MVST link aggregation port
Add aggregation group members	**mvst interface** *interface-name join* **link-aggregation** *link-aggregation-id* **active**	Add member ports to the MVST aggregation port

Step	Command	Description
Enter the layer-2 Ethernet interface configuration mode.	**interface** *interface-name*	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**Interface link-aggregation** *link-aggregation-id*	
Configure the downlink port to enable MVST inspection	**mvst inspection**	Mandatory By default, the port's MVST inspection function is disabled

Configure Extension Boards

When the users want to manage a certain device through MVST, they can configure the device as an extension board of the MVST domain. The case-type device enables the MVST function, and starts up the MVST inspection function under port or link aggregation.

Table 3-3 Configuring Extension Boards

Step	**Command**	Description
Enter the global configuration mode.	**configure terminal**	-
Enable the MVST function	**mvst enable**	Mandatory By default, the MVST function is disabled
Enter the layer-2 Ethernet interface configuration mode.	**interface interface-name**	At least one option must be selected. After you enter the layer-2 Ethernet interface configuration mode, the subsequent

		configuration takes effect only on the current port. After you enter the aggregation group configuration mode, the subsequent configuration takes effect only within the aggregation group.
Enter Aggregation Group Configuration Mode	**Interface link-aggregation link-aggregation-id**	
Configure the downlink port to enable MVST inspection	**mvst inspection**	Mandatory By default, the port's MVST inspection function is disabled

98.2.2 Configure MVST Parameters

Configuration Condition

Before configuring MVST parameters, do the following for the first time:

- Configure the management device.

Configure Sending Interval for Inspection Packets

The device that enables the MVST function periodically sends inspection packets to discover the devices connected to it, and extracts key information from the inspection packets to form its own neighbor device information table.

Table 3-4 Configuring Sending Interval for Inspection Packets

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure sending interval for MVST inspection packets	**mvst inspection timer** *timer-value*	Mandatory By default, the interval for sending MVST

Step	Command	Description
		inspection packets is 10 seconds

Configure Neighbor Aging Time

The neighbor aging time refers to the survival time of the local device information on the neighbor device, enabling the neighbor device to delete the local device information after the local device survival time expires.

Table 3-5 Configuring Neighbor Aging Time

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the aging time of local device information in neighbor devices	**mvst inspection aging-time** *aging-time-value*	Mandatory By default, the aging time of local device information in neighbor devices is 30 seconds

Configure the Keepalive Interval of Extension Boards

After the extension board joins the MVST domain, the management device and the extension board start to exchange keepalive packets. By default, keepalive packets are exchanged every 8 seconds. If the management device cannot receive 3 keepalive packets of the extension board continuously, the extension board will be transitioned from the Active (online) status to the Connect (connect) status.

Table 3-6 Configuring the Keepalive Interval of Extension Boards

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the keepalive interval of extension boards	**mvst handtime** *handtime-value*	Mandatory By default, the keepalive interval of extension boards is 8 seconds

Configure Connection Status Timeout for Extension Boards

If the management device receives a keepalive packet sent by the extension board within the valid time of the connection state, it will transition the extension board from the Connect status to the Active status; if it has not received the keepalive packet sent by the extension board, it transitions the extension board from the Connect status to the Disconnect status.

The management device no longer sends the keepalive packet to the extension board in the Disconnect status until it receives the keepalive packet sent by the extension board again.

Table 3-7 Configuring Connection Status Timeout for Extension Boards

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure Connect status timeout for extension boards	**mvst holdtime** *holdtime-value*	Mandatory By default, the Connect status timeout of the extension board is 80 seconds

Configure Topology Parameters

After the MVST domain is established, the management device regularly collects the topology information of the entire MVST domain through the topology request packet. When the topology request packet spreads across the network, numerous network devices will receive the topology request packet at the same time and send topology response packets at the same time, which may cause network congestion. In order to alleviate this problem, after the management device waits for the delay time for the device to forward the topology collection request packet on each port, the second port starts to forward the topology request packet, and so on, until the last port finishes forwarding.

Table 3-8 Configuring Topology Parameters

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the topology collection period	**mvst topo hello-time** *hello-time-value*	Mandatory

Step	Command	Description
		By default, the topology collection period is 30 seconds.
Configure the management device port to delay the topology collection time	**mvst topo port-delay-time** *port-delay-time-value*	Optional By default, delay time for the management device port to collect topology is 100ms

98.2.3 Configure MVST Features

Configuration Condition

Before configuring MVST features, do the following:

- Configure MVST basic functions

Configure the Upgrade Function

The upgrade function refers to the management device upgrading the system image file or Monitor file of the extension board.

There are two manners to upgrade the system image file or Bootloader file of the extension board:

1. Auto upgrade. When the extension board successfully joins the MVST domain, the management device automatically checks the consistency between the current running version of the extension board and the version in the auto upgrade configuration. The extension board is automatically upgraded in case of inconsistency.

2. Manual upgrade. Users can upgrade the system image file or Bootloader file of the extension board in real time by way of the command line according to the real-time requirements.

Table 3-9 Configuring the Upgrade Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure auto upgrade	**mvst auto update image** { *path/image-name* | *image-name* } [*ip-address* { **ftp** *user-*	Mandatory By default, there is no auto upgrade configuration.

Step	Command	Description
	name user-password | **tftp** } [**reload [write]]**	
Enter the privileged user mode.	**exit**	-
Configure manual upgrade for extension boards	**mvst update slave-slot** *slave-slot-id* { **image** | **bootloader** } { *path/filename* | *filename* } [*ip-address* { **ftp** *user-name user-password* | **tftp** } [**reload**] | **reload**] or **mvst update device-group** *device-group-id* { **image** | **bootloader** } { *path/filename* | *filename* } [*ip-address* { **ftp** *user-name user-password* | **tftp** } [**reload**] | **reload**]	Optional

Note

- Before configuring auto upgrade, you need to make sure that the version file exists.

Configure the Template Function

The template function facilitates batch configuration management, which brings convenience to network maintenance. Users can edit the common basic configuration into one txt text file according to the network operation and maintenance requirements, the management device then issues this text file to the extension board, and the extension board completes the common basic configuration.

Table 3-10 Configuring the Template Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-

Step	Command	Description
Specify a configuration template	**mvst configure template** *template-name*	Mandatory By default, no configuration template is specified.
Configure the management device to issue the configuration template to the extension board	**mvst apply configure template {service-group** *service-group-id* **| slave-slot {** *slave-slot-id* | **all } }**	Optional

Note

- After the management device has issued the configuration template to the extension board, it should execute the command **write slave-slot** or **write device-group** to enable all extension boards to save the current configuration information to the startup configuration file.

Configure the Auto Binding Configuration Function

The management device backs up the startup configuration files of all extension boards in the MVST domain to the local storage medium through the auto binding configuration function. When the extension board needs to be replaced due to failure or other reasons, the new extension board can be automatically configured through the startup configuration file backed up.

Table 3-11 Configuring the Auto Binding Configuration Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the port to bind to the startup configuration file	**mvst bind startup interface** {*interface-list* **| link-aggregation** *link-aggregation-id*} **| all**	Mandatory By default, the port is not bound to the startup configuration file.

Configure Personalized Configuration

The extension board in the MVST domain will undertake different network services due to the network environment in which they are located, so the configuration of the extension board needs to be personalized. The administrator can log in to the virtual configuration interface of the extension board through the management device to complete the configuration management for the extension board.

Table 3-12 Configuring Personalized Configuration

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configuration to manage extension boards	**configure slave-slot** *slave-slot-id*	Mandatory Log in to the virtual configuration interface of the extension board
Enter the privileged user mode.	**exit**	-
Configure the extension board to save the current configuration information to the startup configuration file	**write slave-slot** *slave-slot-id*	Optional

Configure the Device Group Function

When all extension boards in a device group need to achieve the same function, batch configuration management can be completed by configuring the device group. The administrator can log in to the virtual configuration interface of the device group configuration prototype through the management device to complete the configuration management for the device group.

Table 3-13 Configuring the Device Group Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the device group	**configure device-group** *device-group-id* **slave-slot** *slave-slot-id*	Mandatory The administrator logs in to the virtual

Step	Command	Description
		configuration interface of the device group configuration prototype
Enter the privileged user mode.	**exit**	-
Configure all extension boards in the device group to save the current configuration information to the startup configuration file	**write device-group** { *device-group-id* | **all** }	Optional

Configure the Service Group Function

When all extension boards in a service group need to achieve the same function, batch configuration management can be completed by configuring the service group, such as configuring the same configuration template. The administrator can log in to the service group interface through the management device to manage the configuration of the service group.

Table 3-14 Configuring the Service Group Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the service group	**Mvst service-group** *service-group-id*	Mandatory Create and enter the service group
Add Members	**In service configuration mode** **slave-slot** *slave-slot-id*	Mandatory Add the extension board to the service group
Specify a service group configuration template	**configure template** */flash/filepath*	Optional Specify all next extension boards in the service group to

Step	Command	Description
		execute the same configuration template
Enter the privileged user mode.	**exit**	-

Configure the Log Function

The MVST log function means that the extension board sends the log information of the local device to the management device. The administrator can modify the range of log levels sent by the extension board to the management device in real time according to the requirements of the network environment.

Table 3-15 Configuring the Log Function

Step	Command	Description
Enter the global configuration mode.	**configure terminal**	-
Configure the log level sent by the extension board to the management device	**mvst slave-slot logging** [*logging-level1 logging-level2*]	Mandatory By default, the log level sent by the extension board to the management device is 0-5

98.2.4 MVST Monitoring and Maintaining

Table 3-16 MVST Monitoring and Maintaining

Command	Description
show mvst auto-update config	Show auto upgrade configuration information
show mvst device-group [*device-group-id*]	Show the configuration execution information of the specified device group

Command	Description
show mvst servcie-group [*servcie -group-id*]	Show the information of service group or specified business group
show mvst inspection	Show neighbor information of this device
show mvst inspection opened	Show the port with the MVST inspection function started up
show mvst inspection queue	Show MVST inspection packet-receiving queue information
show mvst slave-slot	Show the information of extension boards in the MVST domain
show mvst slave-slot *slave-slot-id* **command**	Show some key running information of the specified extension board
show mvst slave-slot logging	Show the range of log levels sent by the extension boards to the management device
show mvst slave-slot password	Show the login password table for the extension boards
show mvst slave-slot { *slave-slot-id* **use–info | use-info }**	Show the use information of the extension board numbers
show mvst startup bind info	Show port binding information
show mvst statistics	Show MVST packet receiving and sending statistics
show mvst summary	Show summary information of MVST domain
show mvst topo config	Show topology parameter configuration information
show mvst topo information [**slave-slot** *slave-slot-id*]	Show topology information
show mvst tunnel	Show the information of the tunnel between the management device

Command	Description
	and the extension boards in the MVST domain
show mvst upgrade-information { **device-group** *device-group-id* | **slave-slot** { **all |** *slave-slot-id* } }	Show the upgrade status information of the extension board
show mvst write-information device-group { { *device-group-id* **| all** } | **slave-slot** *slave-slot-id* }	Show the status information of the extension board about saving the current configuration
show running-config slave-slot *slave-slot-id*	Show configuration information of the current configuration of the extension board
show startup-config slave-slot *slave-slot-id*	Show the content of the startup configuration file of the extension board

98.3 Typical Configuration Example of MVST

98.3.1 Configure Auto Upgrade Inspection

Network Requirements

- Device1 and Device2 form a stack system as MVST management device, Device3, Device4, and Device5 are used as extension boards, and the last two ports of the extension boards are connected to the MVST management device;
- The management device configures auto upgrade inspection. When Device3, Device4, and Device5 are added as extension boards to the MVST domain, the extension boards can be automatically upgraded.

Network Topology

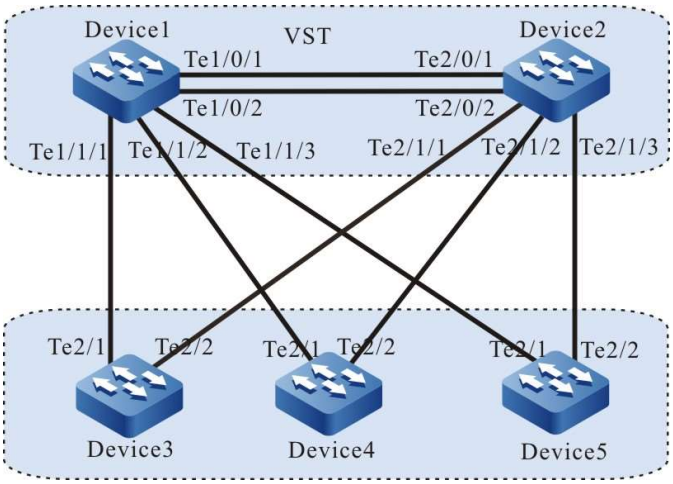


Figure 3-2 Configuring Auto Inspection Upgrade

Configuration Steps

Step 1: Configure the VST system.

#On Device1, configure the virtual switch member device ID as 1, and configure the domain ID as 10 and the priority as 255.

```
Device1#configure terminal
Device1(config)#switch virtual member 1
Do you want to modify member id(Yes|No)?y
% Member ID 1 config will take effect only after the exec command 'switch mode virtual' is issued
Device1(config-vst-member-1)#domain 10
% Domain ID 10 config will take effect only after the exec command 'switch mode virtual' is issued
Device1(config-vst-member-1)#priority 255
Device1(config-vst-member-1)#exit
```

#On Device1, create virtual switch link interface 1, and add ports tengigabitethernet0/1 and tengigabitethernet0/2 to the virtual switch link interface 1.

```
Device1(config)#vsl-channel 1
Device1(config-vsl-channel-1)#exit
Device1(config)#interface tentengigabitethernet 0/1
Device1(config-if-tentengigabitethernet0/1)#vsl-channel 1 mode on
Device1(config-if-tentengigabitethernet0/1)#exit
Device1(config)#interface tentengigabitethernet 0/2
Device1(config-if-tentengigabitethernet0/2)#vsl-channel 1 mode on
Device1(config-if-tentengigabitethernet0/2)#exit
```

#Save the configuration on Device1.

```
Device1#write
Are you sure to overwrite /flash/startup (Yes|No)?y
```

```
Building Configuration...done
Write to startup file ... OK
Write to mode file... OK
```

#On Device2, configure the virtual switch member device ID as 1, and configure the domain ID as 10 and the priority as 200.

```
Device2#configure terminal
Device2(config)#switch virtual member 2
Do you want to modify member id(Yes|No)?y
% Member ID 2 config will take effect only after the exec command 'switch mode virtual' is issued
Device2(config-vst-member-2)#domain 10
% Domain ID 10 config will take effect only after the exec command 'switch mode virtual' is issued
Device2(config-vst-member-2)#priority 200
Device2(config-vst-member-2)#exit
```

#On Device2, create virtual switch link interface 1, and add ports tengigabitethernet1/1 to the virtual switch link interface 1.

```
Device2(config)#vsl-channel 1
Device2(config-vsl-channel-1)#exit
Device2(config)#interface tentengigabitethernet 0/1
Device2(config-if-tentengigabitethernet0/1)#vsl-channel 1 mode on
Device2(config-if-tentengigabitethernet0/1)#exit
Device2(config)#interface tentengigabitethernet 0/2
Device2(config-if-tentengigabitethernet0/2)#vsl-channel 1 mode on
Device2(config-if-tentengigabitethernet0/2)#exit
```

#Save the configuration on Device2.

```
Device2#write
Are you sure to overwrite /flash/startup (Yes|No)?y
Building Configuration...done
Write to startup file ... OK
Write to mode file... OK
```

#Configure Device1 to run in the stack mode.

```
Device1#switch mode virtual
This command will convert all interface names to naming convention "interface-type member-number/slot/interface" ,
Please make sure to save current configuration.Do you want to proceed? (yes|no)?y
Converting interface names Building configuration...
Copying the startup configuration to backup file named "startup-backupalone"...
Please wait...system reloading is in progress!
ok
Reset system!
%SYS-5-RELOAD: Reload requested
```

#Configure Device2 to run in the stack mode.

```
Device2#switch mode virtual
This command will convert all interface names to naming convention "interface-type member-number/slot/interface" ,
Please make sure to save current configuration.Do you want to proceed? (yes|no)?y
Converting interface names Building configuration...
Copying the startup configuration to backup file named "startup-backupalone"...
Please wait...system reloading is in progress!
ok
Reset system!
%SYS-5-RELOAD: Reload requested
```

#After reboot. Check on Device1, chain stack system has been formed, and Device1 is the master control device of the stack system.

```
Device1#show switch virtual
Codes: L - local-device,I - isolate-device

Virtual Switch Mode        : VIRTUAL
Virtual Switch DomainId    : 10
Virtual Switch mac-address : 0001.7a6a.0255

---------- VST MEMBER INFORMATION ----------
CODE MemberID Role   Pri  LocalVsl       RemoteVsl
------------------------------------------------------------------------------
L    1        Master 255  vsl-channel 1/1    vsl-channel 2/1
     2        Member 200  vsl-channel 2/1  vsl-channel 1/1
```

Step 2: Configure the basic functions of MVST.

#Configure the stack system as MVST management device on Device1.

```
Device1(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device1(config)#mvst master
Device1(config)#mvst domain-name test
```

#Configure stack system link aggregation on Device1 and start up MVST inspection.

```
Device1(config)#mvst link-aggregation 1 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/1,2/1/1 join link-aggregation 1 active
Device1(config)#interface link-aggregation 1
Device1(config-link-aggregation1)#mvst inspection
Device1(config-link-aggregation1)#exit
Device1(config)#mvst link-aggregation 2 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/2,2/1/2 join link-aggregation 2 active
Device1(config)#interface link-aggregation 2
```

```
Device1(config-link-aggregation2)#mvst inspection
Device1(config-link-aggregation2)#exit
Device1(config)#mvst link-aggregation 3 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/3,2/1/3 join link-aggregation 3 active
Device1(config)#interface link-aggregation 3
Device1(config-link-aggregation3)#mvst inspection
Device1(config-link-aggregation3)#exit
```

#Enable MVST function on Device3.

```
Device3#configure terminal
Device3#configure terminal
Device3(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device3(config)#mvst link-aggregation 1 mode lacp
Device3(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 1 active
Device3(config)#interface link-aggregation 1
Device3(config-link-aggregation1)#mvst inspection
Device3(config-link-aggregation1)#exit

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 1 successfully.
```

#Enable MVST function on Device4.

```
Device4#configure terminal
Device4(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device4(config)#mvst link-aggregation 2 mode lacp
Device4(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 2 active
Device4(config)#interface link-aggregation 2
Device4(config-link-aggregation2)#mvst inspection
Device4(config-link-aggregation2)#exit

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 2 successfully.
```

#Enable MVST function on Device5.

```
Device5#configure terminal
Device5(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device5(config)#mvst link-aggregation 3 mode lacp
Device5(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 3 active
Device5(config)#interface link-aggregation 3
Device5(config-link-aggregation3)#mvst inspection
Device5(config-link-aggregation3)#exit
```

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 3 successfully.

Step 3: Configure auto upgrade inspection.

#Configure auto upgrade inspection on Device1, specify the version of the extension board to be upgraded, and add clear, reload, and write parameters.

Device1(config)# mvst auto update image /flash/sp26-g-9.6.0.1(R).pck reload write

#Check the configuration result on Device1.

Device1(config)# show mvst auto-update config

OPTION Codes:

R -- Reload slave slot when update slave slot successfully

W -- Save slave slot current configuration to startup-config

ID	OPTION	IMAGE-NAME	IMAGE-PATH
1	None	sp25-g-9.6.1.1(R).pck	/flash/sp25-g-9.6.1.1(R).pck
2	R	sp23-g-9.6.1.1(R).pck	/flash/sp23-g-9.6.1.1(R).pck
3	RW	sp26-g-9.6.0.1(R).pck	/flash/sp26-g-9.6.0.1(R).pck

Step 4: connect the extension boards Device3, Device4, and Device5 to the MVST domain, and allow auto upgrade if the inspected current version of Device3 is inconsistent with the version to be upgraded. Skip auto upgrade if the inspected versions of Device4 and Device5 are inconsistent.

#Connect Device3, Device4, and Device5 to the MVST domain in turn, and after the devices are connected, check the MVST result on Device1.

#Check the MVST result on Device1, you can see that Device3, Device4, and Device5 are added to the MVST domain in the form of extension boards. The slots are Slave-slot0, Slave-slot1, and Slave-slot2, and their host names change to switch-ss0, switch-ss1, switch-ss2.

Device1#show mvst topo information

---

role	domain-name	interface	mac	device-type	host-name
Slave-slot	test	link-aggregation 1	0001.7a63.bd76	NSS4330-56TXF(V1)	switch-ss0
Slave-slot	test	link-aggregation 2	0001.7a64.72aa	NSS4330-56TXF(V1)	switch-ss1
Slave-slot	test	link-aggregation 3	0001.7a63.bd43	NSS4330-56TXF(V1)	switch-ss2
Master	test		0001.7a6a.0258	NSS5810-50TXFP(V1)	Device1

#On Device1, you can check the upgrade status of the extension board in real time. Device3 is in the upgrade status. After Device3 is successfully upgraded, restart it. Device4 and Device5 are not upgraded.

```
Device1#show mvst upgrade-information slave-slot all

Slave slot upgrade information:

-------------------------------------------------------------------------------------------------------------------------

ss-id  upgrade-type  upgrade-status     start-time          over-time     hostname

-------------------------------------------------------------------------------------------------------------------------

0     image       downloading       JAN/27/2015 14:58:24          switch-ss0

1     none        none                                    switch-ss1

2     none        none                                    switch-ss2
```

#Device3 is upgraded successfully. Save the configuration and reboot.

```
Device1#

%MVST-UPDATE_NOTIFY-5: Update slave slot 0 image successfully.

%MVST-WRITE_RESULT-5: The slave slot 0 write to startup file successfully.

%MVST-NOTIFY_RELOAD-3: Slave slot 0 mpu is going to reload.
```

98.3.2 Configure Auto Issue of Common Template

Network Requirements

- Device1 and Device2 form a stack system as MVST management device, Device3, Device4, and Device5 are used as extension boards, and the last two ports of the extension boards are connected to the MVST management device;
- Configure Device3 as a template switch and use its configuration as a common template configuration. When Device4 and Device5 are connected to the MVST domain, the configuration template will be automatically issued;
- Change the configuration of Device3 , recollect it as a common configuration template, and force it to be issued to Device4 and Device5.

Network Topology

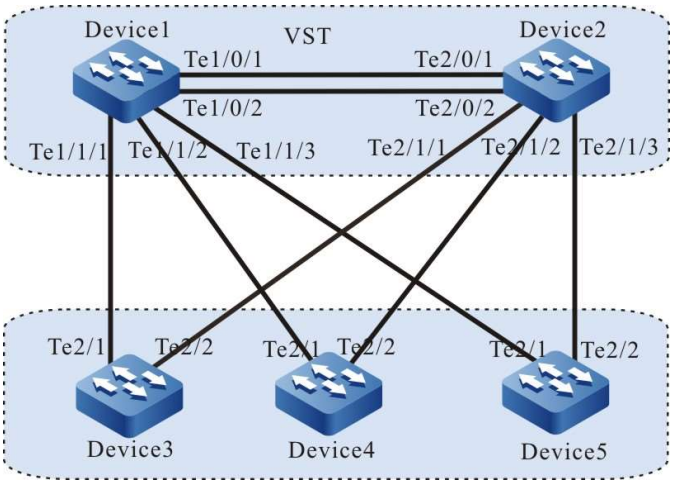


Figure 3-3 Configuring Auto Issue of Common Template

Configuration Steps

Step 1: Configure the VST system.

#On Device1, configure the virtual switch member device ID as 1, and configure the domain ID as 10 and the priority as 255.

```
Device1#configure terminal
Device1(config)#switch virtual member 1
Do you want to modify member id(Yes|No)?y
% Member ID 1 config will take effect only after the exec command 'switch mode virtual' is issued
Device1(config-vst-member-1)#domain 10
% Domain ID 10 config will take effect only after the exec command 'switch mode virtual' is issued
Device1(config-vst-member-1)#priority 255
Device1(config-vst-member-1)#exit
```

#On Device1, create virtual switch link interface 1, and add ports tengigabitethernet0/1 and tengigabitethernet0/2 to the virtual switch link interface 1.

```
Device1(config)#vsl-channel 1
Device1(config-vsl-channel-1)#exit
Device1(config)#interface tentengigabitethernet 0/1
Device1(config-if-tentengigabitethernet0/1)#vsl-channel 1 mode on
Device1(config-if-tentengigabitethernet0/1)#exit
Device1(config)#interface tentengigabitethernet 0/2
Device1(config-if-tentengigabitethernet0/2)#vsl-channel 1 mode on
Device1(config-if-tentengigabitethernet0/2)#exit
```

#Save the configuration on Device1.

```
Device1#write
Are you sure to overwrite /flash/startup (Yes|No)?y
```

```
Building Configuration...done
Write to startup file ... OK
Write to mode file... OK
```

#On Device2, configure the virtual switch member device ID as 1, and configure the domain ID as 10 and the priority as 200.

```
Device2#configure terminal
Device2(config)#switch virtual member 2
Do you want to modify member id(Yes|No)?y
% Member ID 2 config will take effect only after the exec command 'switch mode virtual' is issued
Device2(config-vst-member-2)#domain 10
% Domain ID 10 config will take effect only after the exec command 'switch mode virtual' is issued
Device2(config-vst-member-2)#priority 200
Device2(config-vst-member-2)#exit
```

#On Device2, create virtual switch link interface 1, and add ports tengigabitethernet1/1 to the virtual switch link interface 1.

```
Device2(config)#vsl-channel 1
Device2(config-vsl-channel-1)#exit
Device2(config)#interface tentengigabitethernet 0/1
Device2(config-if-tentengigabitethernet0/1)#vsl-channel 1 mode on
Device2(config-if-tentengigabitethernet0/1)#exit
Device2(config)#interface tentengigabitethernet 0/2
Device2(config-if-tentengigabitethernet0/2)#vsl-channel 1 mode on
Device2(config-if-tentengigabitethernet0/2)#exit
```

#Save the configuration on Device2.

```
Device2#write
Are you sure to overwrite /flash/startup (Yes|No)?y
Building Configuration...done
Write to startup file ... OK
Write to mode file... OK
```

#Configure Device1 to run in the stack mode.

```
Device1#switch mode virtual
This command will convert all interface names to naming convention "interface-type member-number/slot/interface" ,
Please make sure to save current configuration.Do you want to proceed? (yes|no)?y
Converting interface names Building configuration...
Copying the startup configuration to backup file named "startup-backupalone"...
Please wait...system reloading is in progress!
ok
Reset system!
%SYS-5-RELOAD: Reload requested
```

#Configure Device2 to run in the stack mode.

```
Device2#switch mode virtual
This command will convert all interface names to naming convention "interface-type member-number/slot/interface" ,
Please make sure to save current configuration.Do you want to proceed? (yes|no)?y
Converting interface names Building configuration...
Copying the startup configuration to backup file named "startup-backupalone"...
Please wait...system reloading is in progress!
ok
Reset system!
%SYS-5-RELOAD: Reload requested
```

#Check on Device1, chain stack system has been formed, and Device1 is the master control device of the stack system.

```
Device1#show switch virtual
Codes: L - local-device,I - isolate-device

Virtual Switch Mode        : VIRTUAL
Virtual Switch DomainId    : 10
Virtual Switch mac-address : 0001.7a6a.0255

---------- VST MEMBER INFORMATION ----------
CODE MemberID Role   Pri     LocalVsl      RemoteVsl
--------------------------------------------------------------------------------
L    1        Master   255  vsl-channel 1/1  vsl-channel 2/1
     2        Member  200  vsl-channel 2/1  vsl-channel 1/1
```

Step 2: Configure the basic functions of MVST.

#Configure the stack system as an MVST management device.

```
Device1(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device1(config)#mvst master
Device1(config)#mvst domain-name test
```

#Configure stack system link aggregation and start up MVST inspection.

```
Device1(config)#mvst link-aggregation 1 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/1,2/1/1 join link-aggregation 1 active
Device1(config)#interface link-aggregation 1
Device1(config-link-aggregation1)#mvst inspection
Device1(config-link-aggregation1)#exit
Device1(config)#mvst link-aggregation 2 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/2,2/1/2 join link-aggregation 2 active
Device1(config)#interface link-aggregation 2
```

```
Device1(config-link-aggregation2)#mvst inspection
Device1(config-link-aggregation2)#exit
Device1(config)#mvst link-aggregation 3 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/3,2/1/3 join link-aggregation 3 active
Device1(config)#interface link-aggregation 3
Device1(config-link-aggregation3)#mvst inspection
Device1(config-link-aggregation3)#exit
```

#Enable MVST function on Device3.

```
Device3#configure terminal
Device3#configure terminal
Device3(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device3(config)#mvst link-aggregation 1 mode lacp
Device3(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 1 active
Device3(config)#interface link-aggregation 1
Device3(config-link-aggregation1)#mvst inspection
Device3(config-link-aggregation1)#exit

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 1 successfully.
```

#Enable MVST function on Device4.

```
Device4#configure terminal
Device4(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device4(config)#mvst link-aggregation 2 mode lacp
Device4(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 2 active
Device4(config)#interface link-aggregation 2
Device4(config-link-aggregation2)#mvst inspection
Device4(config-link-aggregation2)#exit

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 2 successfully.
```

#Enable MVST function on Device5.

```
Device5#configure terminal
Device5(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device5(config)#mvst link-aggregation 3 mode lacp
Device5(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 3 active
Device5(config)#interface link-aggregation 3
Device5(config-link-aggregation3)#mvst inspection
Device5(config-link-aggregation3)#exit
```

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 3 successfully.

#Add Device3 as an extension board to the MVST domain, and check the MVST result on Device1 after the device is added.

#Check the MVST result on Device1, you can see that Device3 joins the MVST domain in the form of an extension board, its slot is Slave-slot 0, and its host name changes to switch-ss0.

```
Device1#show mvst topo information
-------------------------------------------------------------------------------------------------------------------------
role       domain-name   interface          mac          device-type        host-name
-------------------------------------------------------------------------------------------------------------------------
Slave-slot  test         link-aggregation 1    0001.7a63.bd76  NSS4330-56TXF(V1)   switch-ss0
Master    test                        0001.7a6a.0258   NSS5810-50TXFP(V1)     Device1
```

Step 3: Use Device3 as a template switch and collect the common configuration template.

#Configure Device3.

```
Device1(config)#configure slave-slot 0
switch-ss0(config)#snmp-server host 1.1.1.1
switch-ss0(config)#snmp-server start
%SNMP-WARMSTART-5 SNMP agent on host switch-ss0 is undergoing a warm start
switch-ss0(config)#snmp-server enable traps vlan
switch-ss0(config)#link-aggregation 1
switch-ss0(config-link-aggregation1)#description management link
switch-ss0(config-link-aggregation1)#exit
switch-ss0(config)#vlan 100,200,300
```

#Check the configuration of the extension board Device3 on Device1.

```
Device1#show running-config slave-slot 0
hostname switch-ss0

vlan 100,200,300
link-aggregation 1
description management link
 no spanning-tree enable
 mvst inspection
 exit

snmp-server start
snmp-server view default 1.2 include
snmp-server view default 1.0.8802 include
```

```
snmp-server view default 1.1.2 include
snmp-server view default 1.3.111 include
snmp-server view default 1.3.6.1 include
snmp-server community public view default ro
snmp-server enable traps vlan
snmp-server host 1.1.1.1 traps community public version 2
```

#Save the configuration of Device3 on Device1.

```
Device1#write slave-slot 0
Are you sure to overwrite slave slot 0 /flash/startup (Yes|No)?y
Device1#
Jan  9 2015 16:32:34: %MVST-WRITE_RESULT-5: The slave slot 0 write to startup file successfully.
```

Step 4: automatically issue the configuration of Device3 as a common configuration template.

#Configure common configuration auto issue on Device1

```
Device1(config)#mvst configure template slave-slot 0
Are you sure to overwrite configure template /flash/mvst-template (Yes|No)?y
Get the slave slot 0 startup-config...OK
Write to /flash/mvst-template ....OK.
Device1(config)#
```

Step 5: add the extension board to the MVST domain to automatically load the configuration template.

#Connect the extension boards Device4 and Device5 to the MVST domain, you can see on Device1 the print information automatically issued by the configuration template.

```
Device1#
%MVST-Slave_slot_add-5:Slave slot 1 add to the MVST
%MVST-Slave_slot_add-5:Slave slot 2 add to the MVST.
%MVST-EXECUTE_COFNIG-5:Slave slot 1 is going to execute configure template /flash/mvst-template.
%MVST-EXECUTE_COFNIG-5:Slave slot 1 execute configure file successfully!
%MVST-EXECUTE_COFNIG-5:Slave slot 2 is going to execute configure template /flash/mvst-template.
%MVST-EXECUTE_COFNIG-5:Slave slot 2 execute configure file successfully!
```

#Check the MVST result on Device1. By default, the host names of Device4 and Device5 have the suffixes ss1 and ss2 added as switch-ss1 and switch-ss2 respectively.

```
Device1#show mvst topo information
-------------------------------------------------------------------------------------------------------------------------
role       domain-name     interface          mac          device-type           host-name
-------------------------------------------------------------------------------------------------------------------------
Slave-slot  test          link-aggregation 1  0001.7a63.bd76  NSS4330-56TXF(V1)     switch-ss0
Slave-slot  test          link-aggregation 2  0001.7a64.72aa  NSS4330-56TXF(V1)     switch-ss1
Slave-slot  test          link-aggregation 3  0001.7a63.bd43  NSS4330-56TXF(V1)     switch-ss2
Master      test                    0001.7a6a.0258   NSS5810-50TXFP(V1)      Device1
```

#Check the configuration of Device4 on Device1, the configuration is successfully issued.

```
Device1#show running-config slave-slot 1
hostname switch-ss1

vlan 100,200,300

link-aggregation 1
description management link
 no spanning-tree enable
 mvst inspection
 exit

snmp-server start
snmp-server view default 1.2 include
snmp-server view default 1.0.8802 include
snmp-server view default 1.1.2 include
snmp-server view default 1.3.111 include
snmp-server view default 1.3.6.1 include
snmp-server community public view default ro
snmp-server enable traps vlan
snmp-server host 1.1.1.1 traps community public version 2
```

#Check the configuration of Device5 on Device1, the configuration is successfully issued.

```
Device1#show running-config slave-slot 2
hostname switch-ss2

vlan 100,200,300

link-aggregation 1
description management link
 no spanning-tree enable
 mvst inspection
 exit

snmp-server start
snmp-server view default 1.2 include
snmp-server view default 1.0.8802 include
snmp-server view default 1.1.2 include
snmp-server view default 1.3.111 include
snmp-server view default 1.3.6.1 include
snmp-server community public view default ro
```

```
snmp-server enable traps vlan
snmp-server host 1.1.1.1 traps community public version 2
```

Step 6: forcibly issue the common configuration template.

#Modify the configuration of Device3 and add ACL configuration.

```
Device1(config)#configure slave-slot 0
switch-ss0(config)#ip access-list extended  test
switch-ss0(config-ext-nacl)#permit ip 192.168.0.1 0.0.0.255 any
switch-ss0(config-ext-nacl)#permit ip any any
switch-ss0(config-ext-nacl)#exit
switch-ss0(config)#end
switch-ss0#show access-list
ip access-list extended test
 10 permit ip 192.168.0.0 0.0.0.255 any
 20 permit ip any any
```

#Save the configuration of Device3 on Device1.

```
Device1#write slave-slot 0
Are you sure to overwrite slave slot 0 /flash/startup (Yes|No)?y
Device1#
%MVST-WRITE_RESULT-5: The slave slot 0 write to startup file successfully.
%MVST-COLLECT_STARTUP-5: Collect slave slot 0 startup begin.
%MVST-COLLECT_STARTUP-5: Collect slave slot 0 startup OK.
```

#Recollect startup of Device3 on Device1 as a new common configuration template.

```
Device1(config)#mvst configure template slave-slot 0
Are you sure to overwrite configure template /flash/mvst-template (Yes|No)?y
Get the slave slot 0 startup-config...OK
Write to /flash/mvst-template ....OK.
```

#Forcibly issue the common configuration template on Device1 to Device4. Information for successful issue is displayed.

```
Device1(config)#mvst apply configure template slave-slot 1
%MVST-EXECUTE_COFNIG-5: Slave slot 1 is going to execute configure template /flash/ mvst-template
%MVST-EXECUTE_COFNIG-5: Slave slot 1 execute configure file successfully!
```

#Check that the configuration of Device4 contains the latest ACL configuration.

```
Device1(config)#configure slave-slot 1
switch-ss1#show access-list
ip access-list extended test
 10 permit ip 192.168.0.0 0.0.0.255 any
 20 permit ip any any
```

98.3.3 Configure Auto Issue of Binding Configuration

Network Requirements

- Device1 and Device2 form a stack system as MVST management device, Device3, Device4, and Device5 are used as extension boards, and the last two ports of the extension boards are connected to the MVST management device;
- Perform differentiated configuration for Device3, Device4, and Device5, and bind configurations of the extension boards corresponding to link aggregation 1, link aggregation 2, and link aggregation 3 to the MVST management device;
- Simulating replacement with a brand new device Device6 after the failure of Device3, with the MVST management device capable of automatically issuing the previously collected configuration of Device3.
- Simulating that when link aggregation 1 of the MVST management device fails, link aggregation 4 needs to be created, and the configuration of Device3 bound to link aggregation group 1 is transitioned to link aggregation 4.

Network Topology

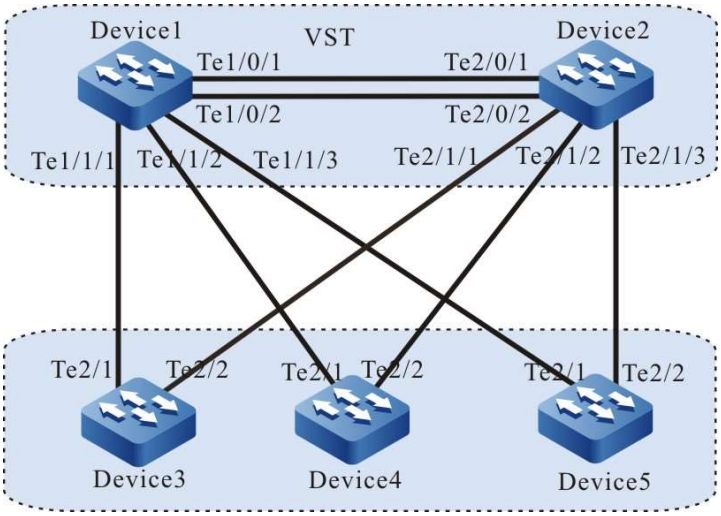


Figure 3-4 Configuring Auto Issue of Binding Configuration

Configuration Steps

Step 1: Configure the VST system.

#On Device1, configure the virtual switch member device ID as 1, and configure the domain ID as 10 and the priority as 255.

```
Device1#configure terminal
Device1(config)#switch virtual member 1
Do you want to modify member id(Yes|No)?y
% Member ID 1 config will take effect only after the exec command 'switch mode virtual' is issued
Device1(config-vst-member-1)#domain 10
```

```
% Domain ID 10 config will take effect only after the exec command 'switch mode virtual' is issued
Device1(config-vst-member-1)#priority 255
Device1(config-vst-member-1)#exit
```

#On Device1, create virtual switch link interface 1, and add ports tengigabitethernet0/1 and tengigabitethernet0/2 to the virtual switch link interface 1.

```
Device1(config)#vsl-channel 1
Device1(config-vsl-channel-1)#exit
Device1(config)#interface tentengigabitethernet 0/1
Device1(config-if-tentengigabitethernet0/1)#vsl-channel 1 mode on
Device1(config-if-tentengigabitethernet0/1)#exit
Device1(config)#interface tentengigabitethernet 0/2
Device1(config-if-tentengigabitethernet0/2)#vsl-channel 1 mode on
Device1(config-if-tentengigabitethernet0/2)#exit
```

#Save the configuration on Device1.

```
Device1#write
Are you sure to overwrite /flash/startup (Yes|No)?y
Building Configuration...done
Write to startup file ... OK
Write to mode file... OK
```

#On Device2, configure the virtual switch member device ID as 1, and configure the domain ID as 10 and the priority as 200.

```
Device2#configure terminal
Device2(config)#switch virtual member 2
Do you want to modify member id(Yes|No)?y
% Member ID 2 config will take effect only after the exec command 'switch mode virtual' is issued
Device2(config-vst-member-2)#domain 10
% Domain ID 10 config will take effect only after the exec command 'switch mode virtual' is issued
Device2(config-vst-member-2)#priority 200
Device2(config-vst-member-2)#exit
```

#On Device2, create virtual switch link interface 1, and add ports tengigabitethernet1/1 to the virtual switch link interface 1.

```
Device2(config)#vsl-channel 1
Device2(config-vsl-channel-1)#exit
Device2(config)#interface tentengigabitethernet 0/1
Device2(config-if-tentengigabitethernet0/1)#vsl-channel 1 mode on
Device2(config-if-tentengigabitethernet0/1)#exit
Device2(config)#interface tentengigabitethernet 0/2
Device2(config-if-tentengigabitethernet0/2)#vsl-channel 1 mode on
Device2(config-if-tentengigabitethernet0/2)#exit
```

#Save the configuration on Device2.

```
Device2#write
Are you sure to overwrite /flash/startup (Yes|No)?y
Building Configuration...done
Write to startup file ... OK
Write to mode file... OK
```

#Configure Device1 to run in the stack mode.

```
Device1#switch mode virtual
This command will convert all interface names to naming convention "interface-type member-number/slot/interface" ,
Please make sure to save current configuration.Do you want to proceed? (yes|no)?y
Converting interface names Building configuration...
Copying the startup configuration to backup file named "startup-backupalone"...
Please wait...system reloading is in progress!
ok
Reset system!
%SYS-5-RELOAD: Reload requested
```

#Configure Device2 to run in the stack mode.

```
Device2#switch mode virtual
This command will convert all interface names to naming convention "interface-type member-number/slot/interface" ,
Please make sure to save current configuration.Do you want to proceed? (yes|no)?y
Converting interface names Building configuration...
Copying the startup configuration to backup file named "startup-backupalone"...
Please wait...system reloading is in progress!
ok
Reset system!
%SYS-5-RELOAD: Reload requested
```

#Check on Device1, chain stack system has been formed, and Device1 is the master control device of the stack system.

```
Device1#show switch virtual
Codes: L - local-device,I - isolate-device

Virtual Switch Mode        : VIRTUAL
Virtual Switch DomainId    : 10
Virtual Switch mac-address : 0001.7a6a.0255

---------- VST MEMBER INFORMATION ----------
CODE MemberID Role    Pri  LocalVsl        RemoteVsl
------------------------------------------------------------------------------
L    1        Master   255  vsl-channel 1/1 vsl-channel 2/1
```

2 Member 200 vsl-channel 2/1 vsl-channel 1/1

Step 2: Configure the basic functions of MVST.

#Configure the stack system as an MVST management device.

```
Device1(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device1(config)#mvst master
Device1(config)#mvst domain-name test
```

#Configure stack system link aggregation and start up MVST inspection.

```
Device1(config)#mvst link-aggregation 1 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/1,2/1/1 join link-aggregation 1 active
Device1(config)#interface link-aggregation 1
Device1(config-link-aggregation1)#mvst inspection
Device1(config-link-aggregation1)#exit
Device1(config)#mvst link-aggregation 2 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/2,2/1/2 join link-aggregation 2 active
Device1(config)#interface link-aggregation 2
Device1(config-link-aggregation2)#mvst inspection
Device1(config-link-aggregation2)#exit
Device1(config)#mvst link-aggregation 3 mode lacp
Device1(config)# mvst interface tengigabitethernet 1/1/3,2/1/3 join link-aggregation 3 active
Device1(config)#interface link-aggregation 3
Device1(config-link-aggregation3)#mvst inspection
Device1(config-link-aggregation3)#exit
```

#Enable MVST function on Device3.

```
Device3#configure terminal
Device3#configure terminal
Device3(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device3(config)#mvst link-aggregation 1 mode lacp
Device3(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 1 active
Device3(config)#interface link-aggregation 1
Device3(config-link-aggregation1)#mvst inspection
Device3(config-link-aggregation1)#exit

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 1 successfully.
```

#Enable MVST function on Device4.

```
Device4#configure terminal
Device4(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
```

```
Device4(config)#mvst link-aggregation 2 mode lacp
Device4(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 2 active
Device4(config)#interface link-aggregation 2
Device4(config-link-aggregation2)#mvst inspection
Device4(config-link-aggregation2)#exit

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 2 successfully.
```

#Enable MVST function on Device5.

```
Device5#configure terminal
Device5(config)#mvst enable
%MVST-NOTIFY-5: MVST is enabled !
Device5(config)#mvst link-aggregation 3 mode lacp
Device5(config)# mvst interface tengigabitethernet 2/1,2/2 join link-aggregation 3 active
Device5(config)#interface link-aggregation 3
Device5(config-link-aggregation3)#mvst inspection
Device5(config-link-aggregation3)#exit

%MVST-NOTIFY-5: interface tengigabitethernet2/1 and interface tengigabitethernet2/2 join link-aggregation 3 successfully.
```

#Connect Device3, Device4, and Device5 to the MVST domain in turn, and check the MVST result after the devices are connected.

#Check the MVST result on Device1, you can see that Device3, Device4, and Device5 are added to the MVST domain in the form of extension boards. The slots are Slave-slot0, Slave-slot1, and Slave-slot2, and their host names change to switch-ss0, switch-ss1, switch-ss2.

```
Device1#show mvst topo information
-----------------------------------------------------------------------------------------------------------------------
role    domain-name    interface          mac          device-type          host-name
-----------------------------------------------------------------------------------------------------------------------
Slave-slot  test        link-aggregation 1  0001.7a63.bd76  NSS4330-56TXF(V1)    switch-ss0
Slave-slot  test        link-aggregation 2  0001.7a64.72aa  NSS4330-56TXF(V1)    switch-ss1
Slave-slot  test        link-aggregation 3  0001.7a63.bd43  NSS4330-56TXF(V1)    switch-ss2
Master    test                  0001.7a6a.0258  NSS5810-50TXFP(V1)      Device1
```

Step 3: Configure the function of auto issue of binding configuration.

#Perform differentiated configuration on Device3, Device4, and Device5.

```
Device1(config)#configure slave-slot 0
switch-ss0(config)#vlan 100
switch-ss0(config)#exit
switch-ss0#exit
```

```
switch-ss0>exit
Device1(config)#configure slave-slot 1
switch-ss1(config)#vlan 200
switch-ss1(config)#exit
switch-ss1#exit
switch-ss1>exit
Device1(config)#configure slave-slot 2
switch-ss2(config)#vlan 300
switch-ss2(config)#exit
switch-ss2#exit
switch-ss2>exit
```

#Save the configurations of Device3, Device4, and Device5 on Device1.

```
Device1#write slave-slot 0
Are you sure to overwrite slave slot 0 /flash/startup (Yes|No)?y
Device1#
Jan  9 2015 16:32:34: %MVST-WRITE_RESULT-5: The slave slot 0 write to startup file successfully.
Device1#write slave-slot 1
Are you sure to overwrite slave slot 0 /flash/startup (Yes|No)?y
Device1#
Jan  9 2015 16:32:34: %MVST-WRITE_RESULT-5: The slave slot 1 write to startup file successfully.
Device1#write slave-slot 2
Are you sure to overwrite slave slot 0 /flash/startup (Yes|No)?y
Device1#
Jan  9 2015 16:32:34: %MVST-WRITE_RESULT-5: The slave slot 2 write to startup file successfully.
```

#Configure the function of auto issue of binding configuration on Device1, and collect to the MVST management device, startup of the extension boards corresponding to link aggregation group 1, link aggregation group 2, and link aggregation group 3.

```
Device1(config)#mvst bind startup link-aggregation 1
Device1(config)#
Jan  9 2015 15:25:16: %MVST-COLLECT_STARTUP-5: Collect slave slot 0 startup begin.
Jan  9 2015 15:25:16: %MVST-COLLECT_STARTUP-5: Collect slave slot 0 startup OK.
Device1(config)#mvst bind startup link-aggregation 2
Device1(config)#
Jan  9 2015 15:25:16: %MVST-COLLECT_STARTUP-5: Collect slave slot 1 startup begin.
Jan  9 2015 15:25:16: %MVST-COLLECT_STARTUP-5: Collect slave slot 1 startup OK.
Device1(config)#mvst bind startup link-aggregation 3
Device1(config)#
Jan  9 2015 15:25:16: %MVST-COLLECT_STARTUP-5: Collect slave slot 2 startup begin.
Jan  9 2015 15:25:16: %MVST-COLLECT_STARTUP-5: Collect slave slot 2 startup OK.
```

#Check the result of auto issue of binding configuration on Device1. Startups numbered extension board 0, 1, and 2 are collected into the startup-lag1, startup-lag2, and startup-lag3 files in the USB.

```
Device1#show mvst startup bind info
-----------------------------------------------------
Interface            Bind-file-name
-----------------------------------------------------
link-aggregation 1     /usb/startup-lag1
link-aggregation 2     /usb/startup-lag2
link-aggregation 3     /usb/startup-lag3
```

#After enabling the MVST function for a brand new device Device6, join the link aggregation group 1 of the MVST management device to the MVST domain to replace Device3. Device6 is added to the MVST domain in the form of an extension board, and its slot is Slave-slot3. The print information about the configuration of auto issue startup-LAG1 is displayed.

```
Device1#
Jan  9 2015 16:54:46: %MVST-Slave_slot_add-5:Slave slot 3 add to the MVST.
Jan  9 2015 16:54:47: %MVST-EXECUTE_COFNIG-5: Slave slot 3 is going to execute configure file /usb/ startup-lag1.
Jan  9 2015 16:54:48: %MVST-EXECUTE_COFNIG-5: Slave slot 3 execute configure file successfully!
```

#Check the MVST result on Device1. Device6 joins the MVST domain in the form of an extension board. Its slot is Slave-slot3 and its host name changes to switch-ss3.

```
Device1#show mvst topo information
-------------------------------------------------------------------------------------------------------------------
role     domain-name     interface          mac           device-type         host-name
-------------------------------------------------------------------------------------------------------------------
Slave-slot  test         link-aggregation 4  0001.7a63.bd89   NSS4330-56TXF(V1)   switch-ss3
Slave-slot  test         link-aggregation 2  0001.7a64.72aa  NSS4330-56TXF(V1)   switch-ss1
Slave-slot  test         link-aggregation 3  0001.7a63.bd43  NSS4330-56TXF(V1)    switch-ss2
Master     test                    0001.7a6a.0258  NSS5810-50TXFP(V1)    Device1
```

#Check the configuration of Device6. Device6 has loaded the configuration of Device3, and VLAN100 has been created.

```
Device1#show run slave-slot 3
vlan 100
```

Step 3: Configure the function of transitioning auto issue of binding configuration.

#Configure link aggregation 4 on Device1

```
Device1(config)#interface tengigabitethernet 1/1/1,2/1/1
Device1(config-if-range)#link-aggregation 4 active
Device1(config-if-range)#exit
```

#Configure transitioning of auto issue of binding configuration on Device1, and transition the original configuration collected by link aggregation 1 to link aggregation 4.

```
Device1(config)#mvst bind startup link-aggregation 4
Device1(config)#mvst relocate configure interface link-aggregation 1 interface link-aggregation 4
interface link-aggregation1 file will cover interface link-aggregation4 file, are you sure to do it(Yes|No)?y
```

#Check on Device1 that the configuration migration is successful, and there is a configuration file named startup-lag4 in the USB.

```
Device1(config-fs)#cd /usb
Device1(config-fs)#dir
7256          JAN-09-2015  17:58:16   startup-lag4
```

#Delete startup of Device6 and reboot Device6 without saving the configuration. After the device is started, you can see on Device1 that Device6 has loaded the configuration of startup-lag4, which is consistent with the startup-lag1 configuration before the transition.

```
Device1#show run slave-slot 3
```

vlan 100