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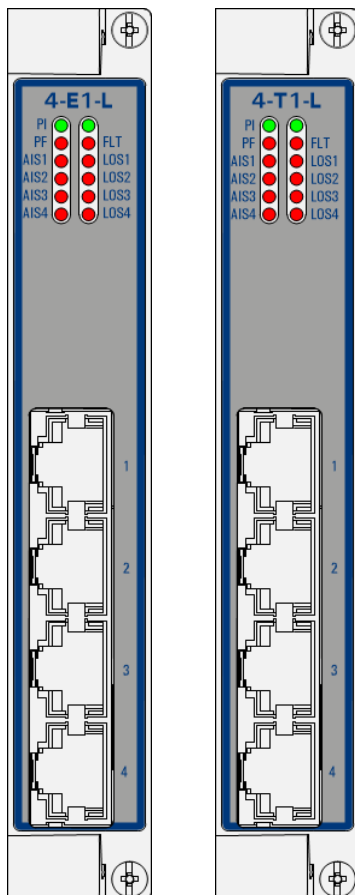
A **BELDEN** BRAND

User Manual

Installation

Dragon PTN

Interface Module PTN-4-E1-L/PTN-4-T1-L



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1. INTRODUCTION

1.1 General

This document is valid as of Dragon PTN Release 4.0DR.

E1 and T1 links are used worldwide to implement synchronous TDM links between two end points. These links typically transport voice and/or data using TDM. The application of E1 or T1 is country related. T1 is primarily used on the North American continent and Japan whereas E1 is used in most other areas. Both carriers differ with respect to the physical interface, the framing algorithm, signaling and network management.

The 4-E1-L/4-T1-L interface module (=IFM) provides four E1/T1 ports for connecting E1/T1 TDM links to the Dragon PTN network. 4-E1-L/4-T1-L refers to '4 ports – E1/T1 – LAN'.

Verify the 'Dragon PTN Bandwidth Overview' manual (Ref. [100] in Table 1) to see in which node and IFM slot this IFM can be used.

This IFM converts the E1/T1 framing from an E1/T1 link into MPLS-TP packets over the Dragon PTN network, and vice versa. The destination IFM must also compensate for possible jitter and network delays to keep everything synchronized. A packetized TDM service is called a Circuit Emulation Service (=CES). A maximum of 16 CESes can be configured per 4-E1-L/4-T1-L module.

These two IFMs are the successor of the 4-E1T1-L IFM.

- ▶ The 4-E1-L IFM is the same as 4-E1T1-L IFM configured in E1 mode;
- ▶ The 4-T1-L IFM is the same as 4-E1T1-L IFM configured in T1 mode;

The main supported features are:

- ▶ Packetizing of E1/T1 Framing
- ▶ LAN function
- ▶ Services
 - ▶ SAToP (=Structured Agnostic TDM over Packet) → all channels transparently;
 - ▶ CESoPSN (=CES over Packet Switched Network) → customized channel transport;
 - ▶ Hitless Switching / Single Path;
- ▶ Synchronization
 - ▶ SyncE;

A general E1/T1 example can be found in the figure below:

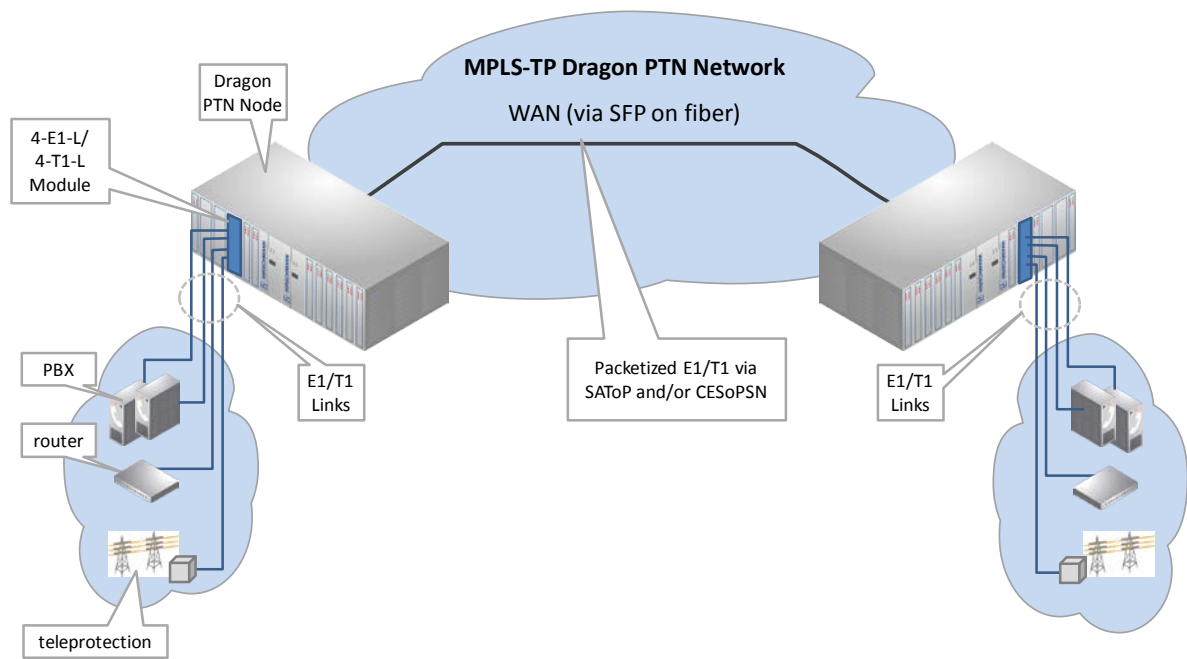


Figure 1 General E1/T1 Example

1.2 Manual References

Table 1 is an overview of the manuals referred to in this manual. ‘&’ refers to the language code, ‘*’ refers to the manual issue. All these manuals can be found in the HiProvision (=Dragon PTN Management System) Help function.

Table 1 Manual References

| Ref. | Number | Title |
|-------|----------------|---|
| [1] | DRA-DRM821-&-* | Dragon PTN and HiProvision Operation |
| [2] | DRA-DRM801-&-* | Dragon PTN Installation and Operation |
| [4] | DRA-DRM803-&-* | Dragon PTN Switching Module: PTN-CSM310-A |
| [5] | DRE-DRM809-&-* | Dragon PTN Interface Module: PTN-2-C37.94 |
| [6] | DRA-DRM810-&-* | Dragon PTN General Specifications |
| [7] | DRE-DRM818-&-* | Dragon PTN Interface Module: PTN-16-E1-L/ PTN-16-T1-L |
| [100] | DRA-DRM828-&-* | Dragon PTN Bandwidth Overview |

2. MODULE DESCRIPTION

2.1 Front Panel

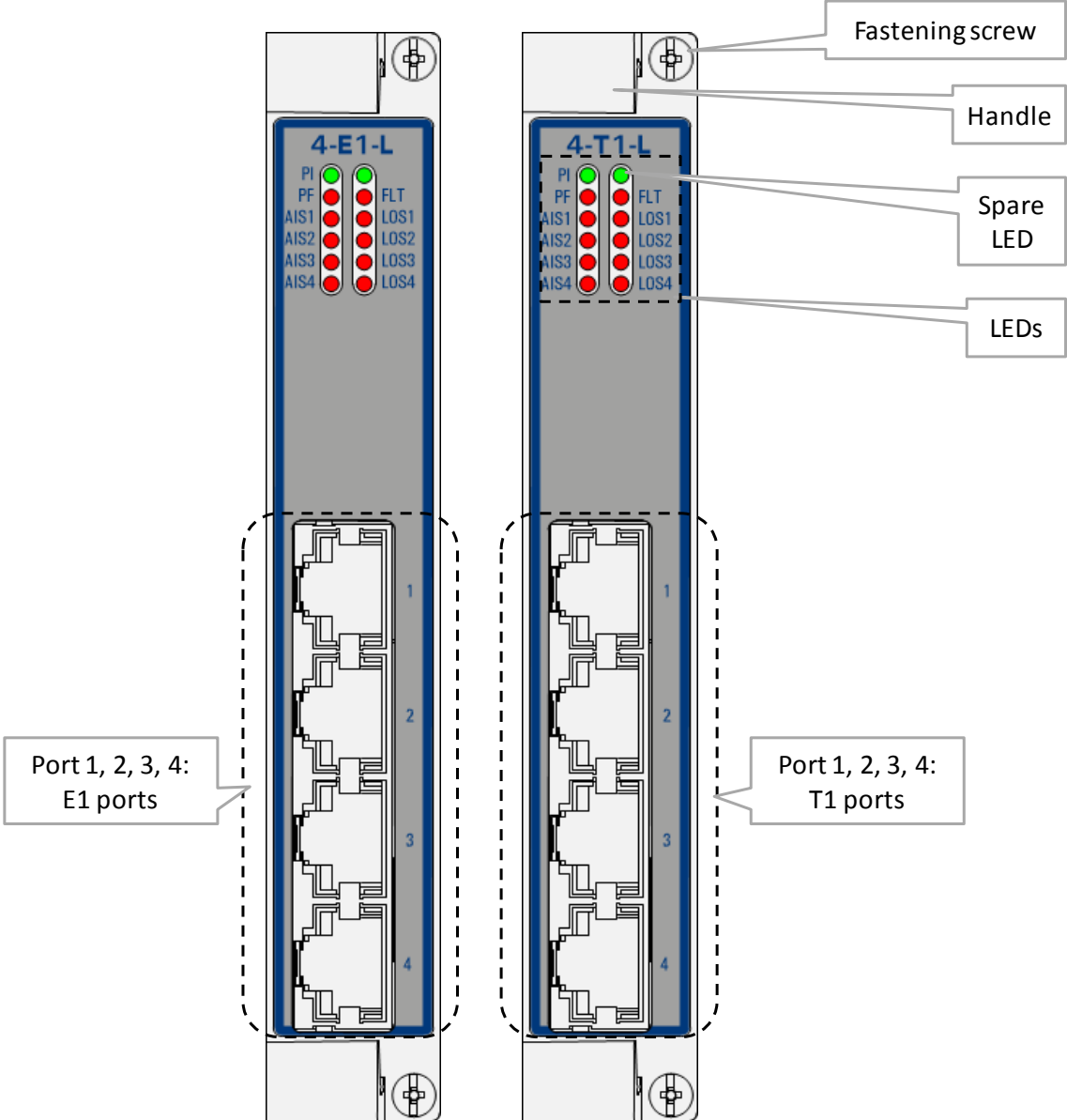


Figure 2 Front Panel

2.1.1 Insert/Remove Module into/from Node

See ‘Dragon PTN Installation and Operation Manual’ Ref.[2].

2.1.2 LEDs

The meaning of the LEDs depends on the mode of operation (= boot or normal) in which the 4-E1-L/4-T1-L module currently is running. After plugging in the module or rebooting it, the module turns into the boot operation, see Table 2. After the module has gone through all the cycles in the table below (=rebooted successfully), the module turns into the normal operation, see LEDs in Table 3.

Table 2 LED Indications In Boot Operation

| Cycle | PI | PF | FLT | Spare LED | AIS[1..4] | LOS[1..4] |
|-------|----|-----|---------------|-----------|-----------|-----------|
| 1 | x | --- | Slow blinking | --- | --- | --- |
| 2 | x | --- | Fast blinking | --- | --- | --- |
| 3 | x | --- | --- | --- | --- | --- |
| 4 | x | --- | x | x | x | x |

x : LED is lit / --- : LED is not lit
 The sub cycle times may vary. The entire boot cycle time [1→ 4] takes approximately 2 minutes.

Table 3 LED Indications In Normal Operation

| LED | Color | Status |
|---------------------|----------------|---|
| PI (=Power Input) | Not lit, dark | +12V power input to the board not OK |
| | Green | +12V power input to the board OK |
| PF (=Power Failure) | Not lit, dark | power generation on the board itself is OK |
| | Red | power generation on the board itself is erroneous |
| FLT (=Fault) | Not lit, dark | no other fault or error situation, different from PF, is active on the module |
| | Red | a fault or error situation, different from PF, is active on the module |
| Spare | Not lit, Green | spare |
| AIS<port n°> | Not lit, dark | - no service on this port - service on this port: no alarms detected on backplane (=network) side, everything fine |
| | Red, lit | service on this port: no network traffic or TX AIS detected on backplane (=network) side |
| | Red, blinking | other errors different from TX AIS detected on backplane (=network) side |
| LOS<port n°> | Not lit, dark | - no service on this port - service on this port: local E1/T1 traffic on this front port is OK |
| | Red, lit | service on this port: local E1/T1 signal is lost on this front port |
| | Red, blinking | AIS, LOF or RAI received on this front port |

2.1.3 E1/T1 RJ-45 Ports and Cables

The 4-E1-L/4-T1-L module provides four of these ports and each port connector has eight pins. Each port provides one tip/ring pair. See the table and figure below for an overview and description. The cables below can be ordered to connect these ports.

- ▶ E1 cable (120 Ω): ordering number 942 256-201;
- ▶ T1 cable (100 Ω): ordering number 942 256-200;

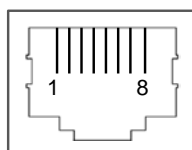


Figure 3 E1/T1 RJ-45 Connector

Table 4 E1/T1 RJ-45 Connector: Pin Assignments

| Pin Number | Description | Cable Wire Colors |
|------------|--------------------|-------------------|
| 1 | Rx (Receive) RING | OG |
| 2 | Rx (Receive) TIP | WH/OG |
| 3 | Not connected | - |
| 4 | Tx (Transmit) RING | BU |
| 5 | Tx (Transmit) TIP | WH/BU |
| 6, 7, 8 | Not connected | - |

2.2 Functional Operation

2.2.1 General

An application network (e.g. LAN1) can be connected to the MPLS-TP Dragon PTN network via one of the 4 E1/T1 interface ports. The 4-E1-L/4-T1-L module can interface with 4 E1/T1 lines. In Figure 1, a common functional setup is shown.

In Figure 4 below, a more detailed functional setup is shown. A LAN1 network interfaces the Dragon PTN node via the E1/T1 ports on the 4-E1-L/4-T1-L module. The 4-E1-L/4-T1-L converts this traffic into Ethernet traffic on the backplane. The Central Switching Module (= CSM, see Ref. [4],[4b] in Table 1) converts this Ethernet traffic into packetized E1/T1 MPLS-TP and transmits it via an Ethernet IFM (e.g. 4-GC-LW) onto the Dragon PTN MPLS-TP network. The packetizing of E1/T1 occurs via CES: SAToP (see §2.2.5) or CES: CESoPSN (see §2.2.6) technique.

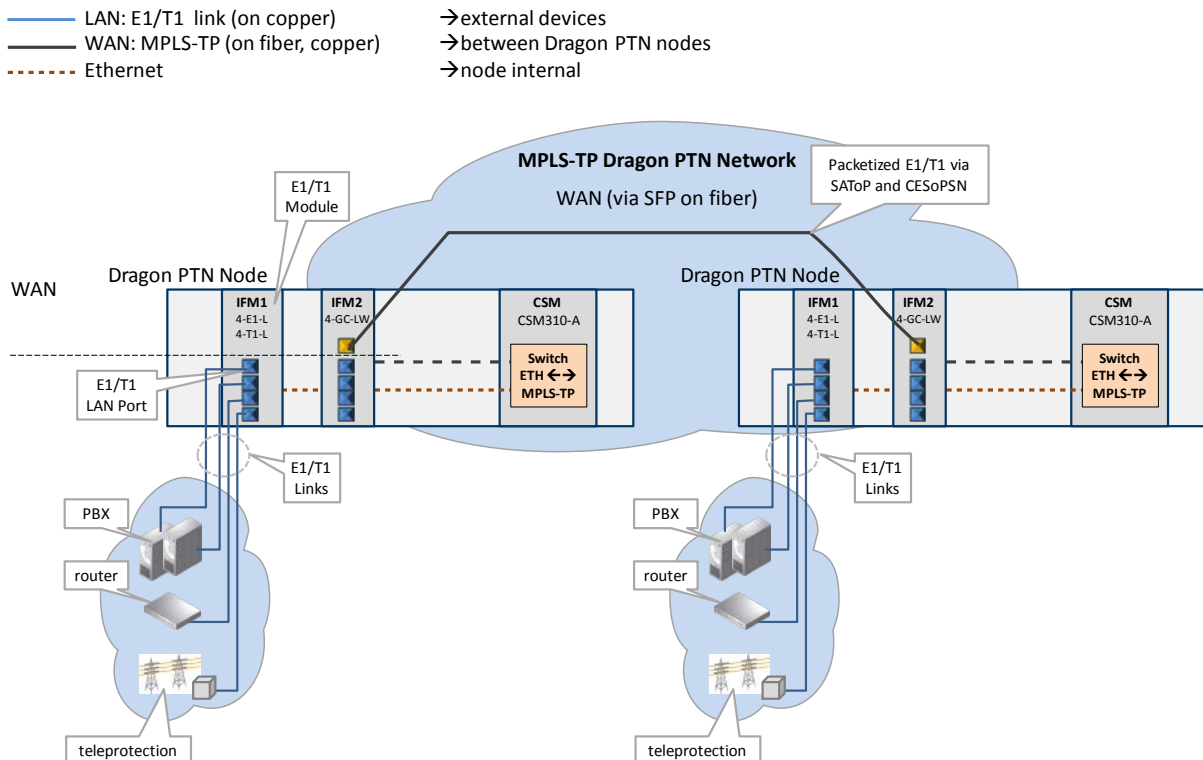


Figure 4 Detailed Function E1/T1 Example

2.2.2 E1 Framing

E1 is a 2.048 Mbps bi-directional (full duplex) link through which the data is transported in a digital way in frames. One frame consists of 32 time slots (Figure 5). Time slot 0 is used for framing and synchronization, and time slot 16 for signaling. The bandwidth of one time slot is 64 kbps (=8 bits/125 μs). One frame thus consists of 32*8 = 256 bits and lasts 125 μs. Typically 16 frames are packed together in one multiframe.

NOTE: Multiframe = future support;

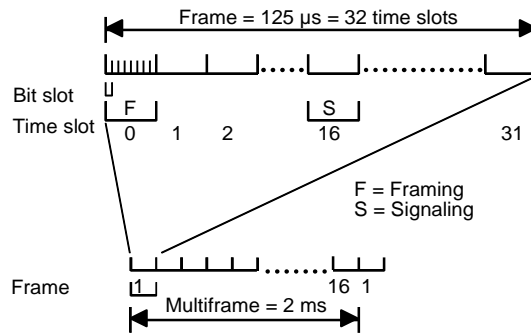


Figure 5 E1 Framing

2.2.3 T1 Framing

T1 is a 1.544 Mbps bi-directional (full duplex) link through which the data is transported in a digital way in frames. One frame consists of 24 time slots + 1 bit (Figure 6). The extra bit is used for framing. The bandwidth of one time slot is 64 kbps (8 bits). One frame thus consists of (24*8)+1 = 193 bits and lasts 125 μs. Depending of the framing algorithm applied either 12 or 24 frames are packed together in one multiframe. Signaling bits are transported in the Least Significant Bit of the time slots in each multiframe agreed upon (in-band).

NOTE: Multiframe = (E)SF (=Extended) Super Frame) = future support;

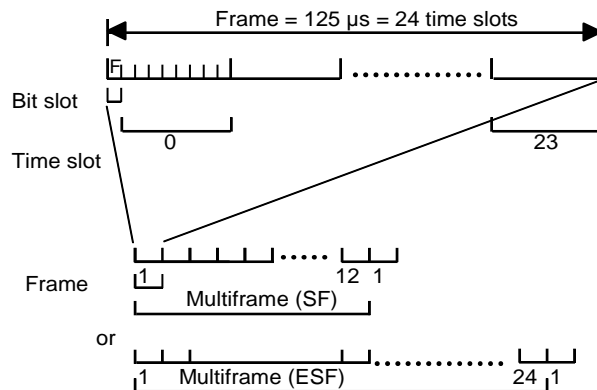


Figure 6 T1 Framing

2.2.4 AMI, HDB3 and B8ZS Coding

AMI, HDB3 and B8ZS are different types of line coding. HDB3 is used in E1 whereas B8ZS is used in T1 communications systems. The 4-E1-L/4-T1-L module supports HDB3 for E1 and B8ZS for T1. HDB3 and B8ZS is an enhancement of AMI. For this reason, AMI is mentioned here as well.

As the E1/T1 link has no separate clock transmission, the receiver will derive the clock from the incoming data stream. A minimum density of logical ones is required in order to guarantee a faultless clock recovery. This is achieved basically by AMI which encodes the data stream with bipolar violations. A more enhanced and better encoding is HDB3 and B8ZS which enhance the AMI stream by replacing successive zeros:

- ▶ E1 → HDB3: replace four successive zeros with a fixed bit pattern '000V' or 'B00V';
- ▶ T1 → B8ZS: replace eight successive zeros with a fixed bit pattern '000VB0VB';

A 'B' and 'V' can either be '-' or '+'. Which pattern is used depends on the amount of '+' and '-' already received from send on the link. The choice is such that the number of pluses (+) between two successive violations (V) is odd.

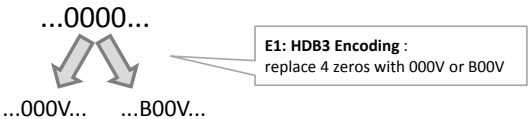


Figure 7 HDB3 Encoding



Figure 8 T1: B8ZS Encoding

2.2.5 CES: SAToP

SAToP is a point-to-point CES which sends transparently the entire E1/T1 frame from the source to the destination E1/T1 port over the MPLS-TP network. The entire frame = all data + synchronization + alignment timeslots = 32 timeslots for E1 and 24 timeslots for T1. As a result, maximum one SAToP service can be configured per port.

NOTE: Each end-point or E1/T1 port must be located in a different node. Future: end-points can also be located intra-module or intra-node.

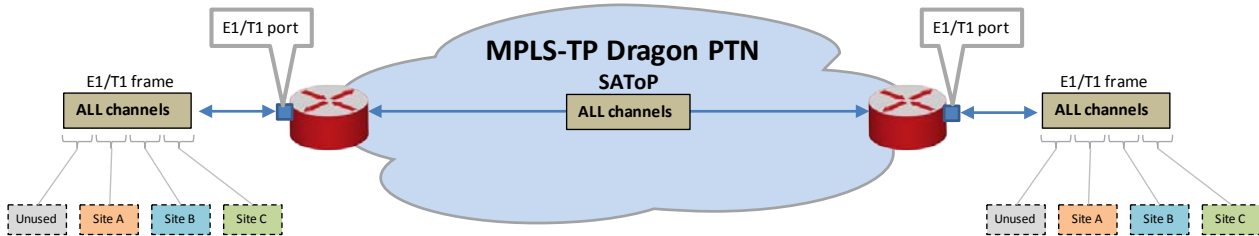


Figure 9 General SAToP Example

In the figure below, a more detailed example has been worked out.

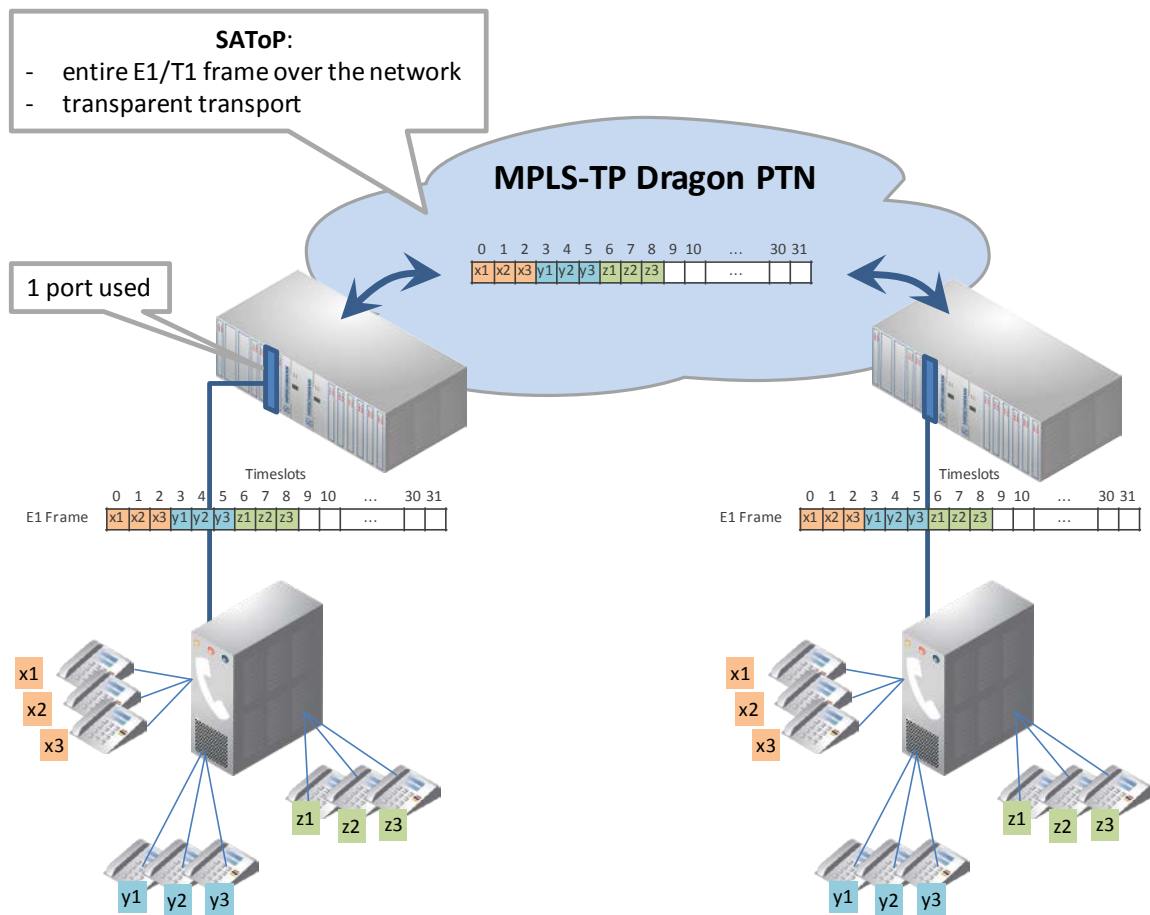


Figure 10 Detailed E1 SAToP Example

2.2.6 CES: CESoPSN

CESoPSN is a point-to-point CES which only sends a selection of channels or timeslots over the MPLS-TP Dragon PTN network. In HiProvision (=Dragon PTN Management System), the operator selects which timeslots of the input frame (E1 or T1) must be transported. This customized transportation of timeslots through the network results in a more efficient bandwidth use.

The destination module will receive the transported channels from the Dragon PTN network, and regenerate all the other missing timeslots itself (empty or dummy timeslots, synchronization). As a result, the destination sends out the entire regenerated frame (E1 or T1) on its port.

Each end-point or port (E1 or T1) must be located in a different node.

CESoPSN services can be configured:

- ▶ Between two or more E1 ports, see below;
- ▶ Between two or more T1 ports, see below;
- ▶ Between a C37.94 and an E1 port, see below;
- ▶ Between a C37.94 and a T1 port, see below;

a. Between Two or More E1 Ports

Multiple CESs per port can be configured to transport an amount of timeslots between two or more E1 ports. In HiProvision, the operator selects the timeslots individually to be transported per CES. On both the source and destination side, the same amount of timeslots must be selected. The selected timeslots from the source side can be mapped onto the timeslots from the destination side.

The timeslot order does not change during the mapping. The first selected source timeslot will be mapped automatically onto the first selected destination timeslot etc....

See some examples in the figures below.

NOTE: In E1, timeslot 0 cannot be transported;

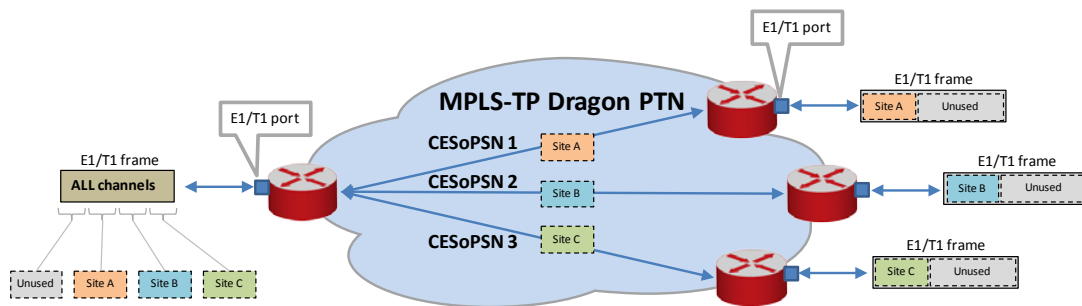


Figure 11 General CESoPSN Example

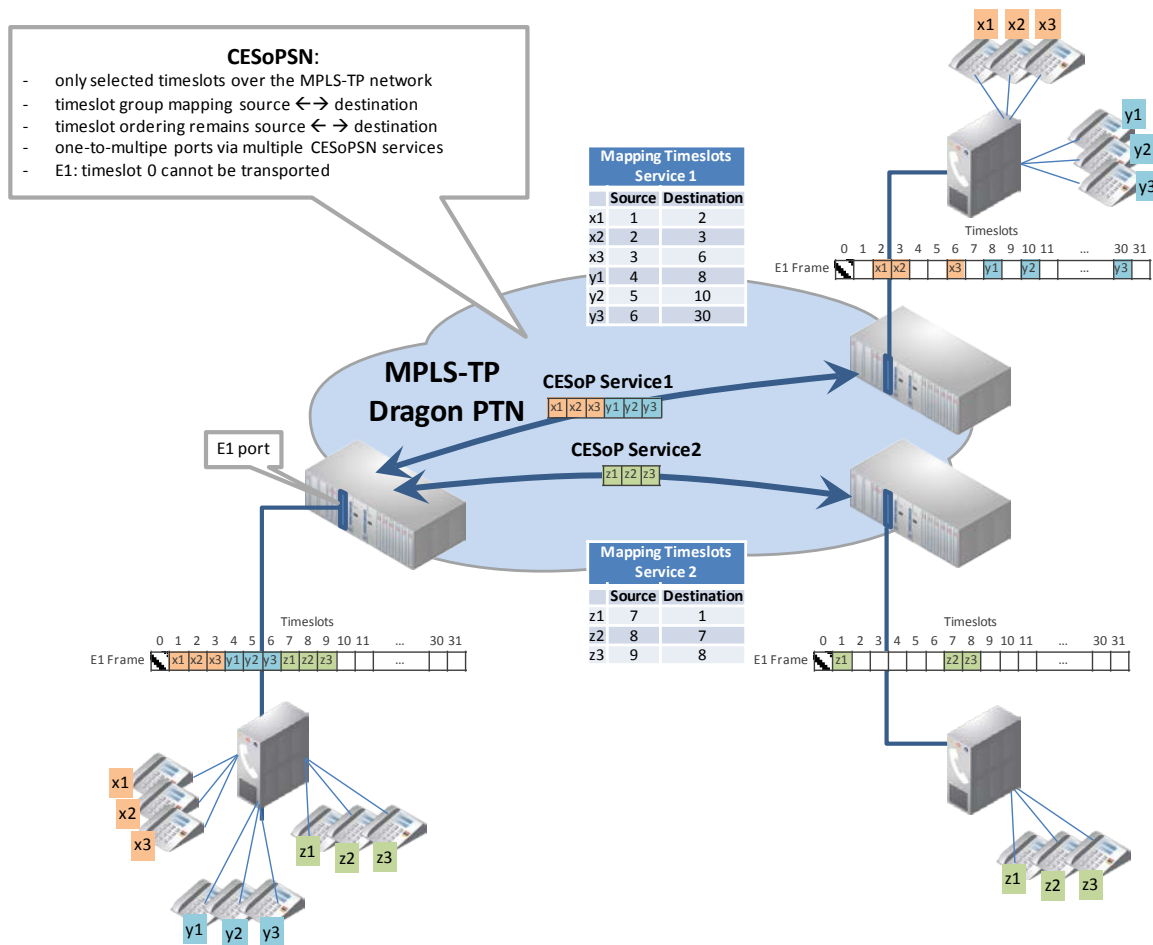


Figure 12 Detailed E1 CESoPSN Example

b. Between Two or More T1 Ports

Similar to §2.2.6a.

c. Between a C37.94 and an E1 Port

See Ref.[5], [7] in Table 1.

d. Between a C37.94 and a T1 Port

See Ref.[5], [7] in Table 1.

2.2.7 Start Sending Data

It can be configured when a SAToP service starts sending data. See 'send data' in the 'Dragon PTN and HiProvision Operation' Manual (=Ref. [1]) for more information.

2.2.8 SAToP Compared With CESoPSN

Table 5 Comparison: SAToP ↔ CESoPSN

| | SAToP | CESoPSN |
|--|---|---|
| amount of services/port | 1 | 16; 16 is also the maximum per IFM; |
| amount of used timeslots or channels/service | always 32 for E1 and 24 for T1, including synchronization and alignment data. | must be configured, amount on input = amount on output; timeslot 0 is never transported; |
| timeslot mapping | just port to port configuration, 'timeslot x' on the input side will always be 'timeslot x' on the output side. | time slot mapping between input side and output side must be configured, 'timeslot x' on the input side could be mapped to 'timeslot y' on the output side; Per CESoPSN service, the timeslots on the input side must be part of the same port, the timeslots on the output side must be part of the same port. All the data channels on an input port can be mapped on different CESoPSN services, which can have different destination ports. |

2.2.9 Hitless Switching

Hitless Switching is a feature within SAToP/CESoPSN that provides a safe E1/T1 redundant connection where no data or synchronization is lost when switching from the active to the backup path or vice versa, e.g. because of cable break. The total delay over the network remains nearly constant during switch-over. Redundancy via Hitless Switching is obtained via completing the list below:

- ▶ creating two independent point-to-point tunnels without protection;
- ▶ setting the Hitless Switching on at service creation time in HiProvision.

NOTE: See Ref.[1] for the creation of tunnels and services;

On the source side, with Hitless Switching enabled, the E1/T1 IFM duplicates each packet on a second tunnel (e.g. Tunnel y, see figure below). Each packet also contains a 16 bit sequence number. Different tunnels mean different paths through the network, with each path its own delay. Different delays result in a slow and a fast path.

On the destination side, with Hitless Switching enabled, the E1/T1 IFM buffers the fastest path and forwards packets from the slowest path on the E1/T1 link. Packets will be processed according a packet sequence number.

Hitless Switching is a redundant mechanism but differs from Protection Switching, see the table below for an overview. So if redundancy is needed in the service, either choose Hitless Switching or Protection Switching, mixing up both mechanisms is not allowed. Depending on the choice, settings must be done at tunnel creation time and/or service creation time.

When Hitless Switching has been enabled, the CES can only start up with two links up, coming out of a two-links-down situation (except when Single Path has been enabled, see §2.2.10).

See §2.2.11 for a delay comparison within CES depending on the enabled sub features, see also further on.

Table 6 Difference Between Hitless and Protection Switching

| | E1/T1 Protection Switching | E1/T1 Hitless Switching |
|------------------------|-----------------------------------|---|
| required tunnel type | 1 point-to-point tunnel | 2 point-to-point tunnels |
| tunnel protection type | 1:1; | none; the redundancy is created via two independent point-to-point tunnels. |
| service parameter | Hitless Switching = disabled | Hitless Switching = enabled |
| at switch-over | possible data loss | no data or synchronization loss |
| total delay | less than hitless switching | more than protection switching |

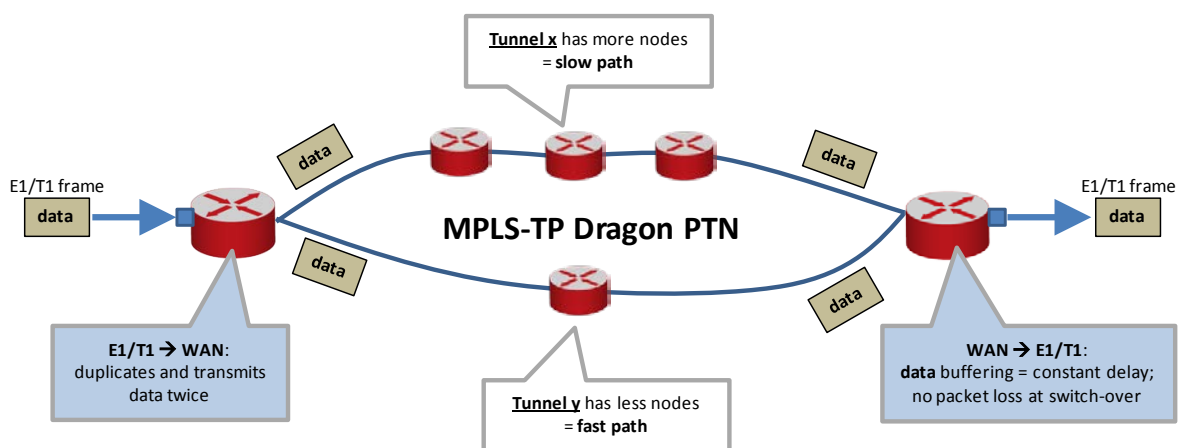


Figure 13 Hitless Switching

2.2.10 Single Path

The Single Path feature is a sub feature of Hitless Switching (see §2.2.9). It influences the start-up behavior of the Hitless Switching mechanism:

- ▶ enabled: The CES can already start up with only one link up, coming out of a two-links-down situation;
 - ▶ if the fastest path came up first:
 - ▶ the CES starts up according to the fastest path;
 - ▶ possible CES interrupt or minor packet loss when the slowest path comes up later on;
 - ▶ if the slowest path came up first:
 - ▶ the CES starts up according to the slowest path;
 - ▶ no CES interrupt or packet loss when the fastest path comes up later on;

See §2.2.11 for a delay comparison within CES depending on the enabled sub features, see also further on.

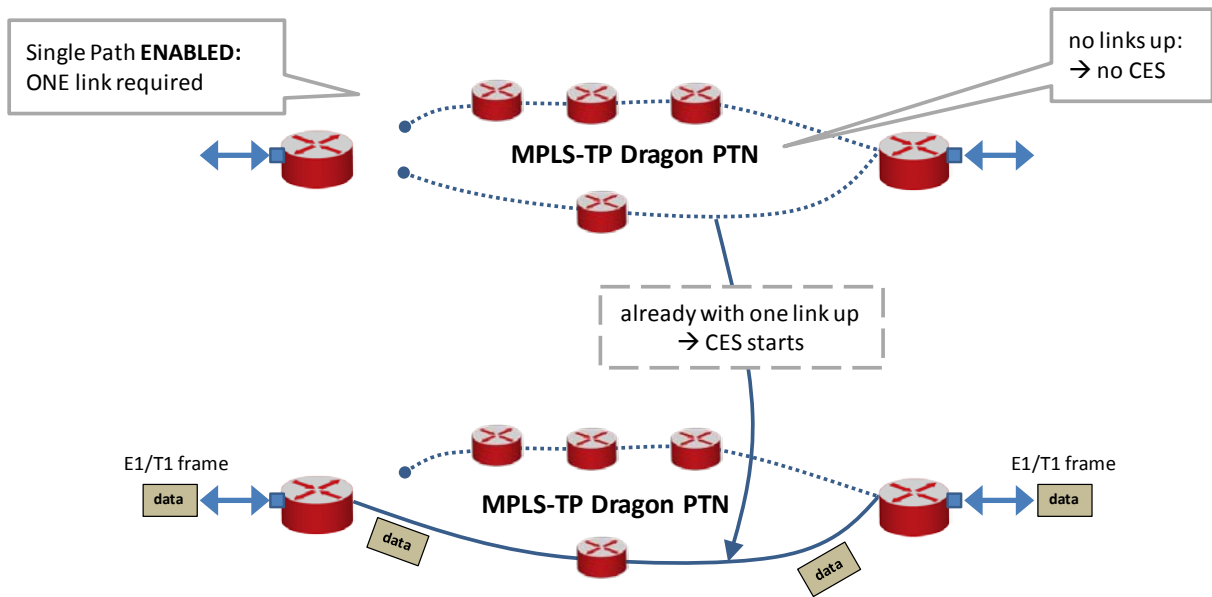


Figure 14 Single Path Enabled

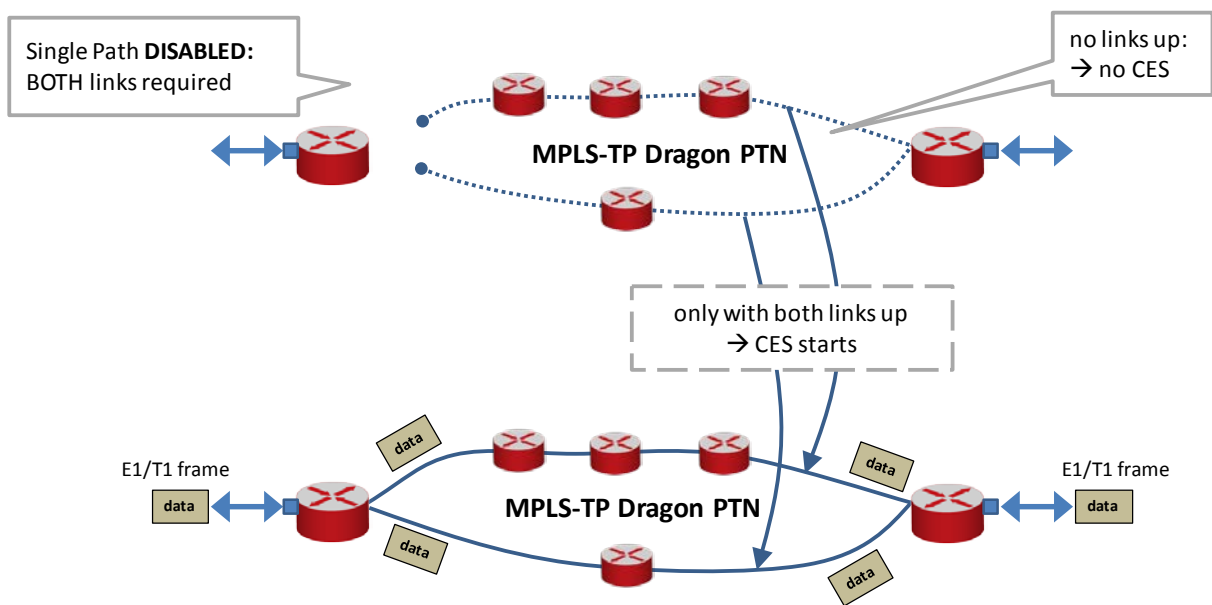


Figure 15 Single Path Disabled

2.2.11 Delay Comparison in CES (Features)

A CES with Hitless Switching has a higher delay than a CES without Hitless Switching.

2.2.12 I/O with the Central Switching Module (=CSM)

The 4-E1-L/4-T1-L module receives E1/T1 traffic via its front panel ports and converts this into Ethernet traffic which is forwarded to the CSM via the backplane. The CSM does all the processing on this data (synchronization, CRC checks, conversions, switching...). The CSM converts this data into MPLS-TP packets and transmits it via an Ethernet IFM (e.g. 4-GC-LW) onto the WAN. On the destination side, the same processing occurs in reverse order.

2.2.13 Synchronization / Clock Distribution / Network Timing

CAUTION: Make sure to configure/verify the clocking parameters below.

The Dragon PTN network provides a number of mechanisms to perform synchronization / clock distribution / network timing per CES. The CSM synchronizes all the included IFMs in the node.

The application endpoints in a 'Circuit Emulation: E1' service can communicate in a synchronized way. The same counts for a 'Circuit Emulation: T1' service. Which synchronization method can be used depends on:

- ▶ the 'Clock source' port setting of the two endpoints;
- ▶ the 'Differential Clocking' setting in the E1/T1 service;
- ▶ the Clock Source bundle ID in case of CESopSN;
- ▶ SyncE availability in the endpoint nodes;

The figures below show relevant end-to-end clocking configurations for this IFM. The PRC (=Primary Reference Clock) is a very stable high quality clock that can be used as a reference clock delivered via SyncE to the node:

- ▶ A, D = Application ports;
- ▶ B, C = IFM front ports;

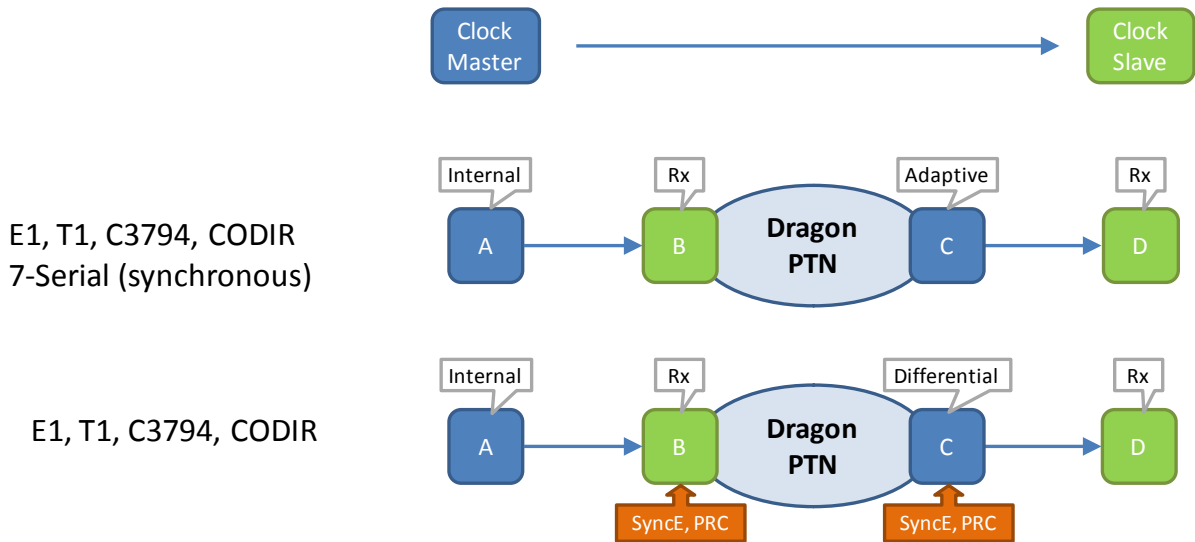


Figure 16 Clocking: Application D Slaves to Application A via Dragon PTN

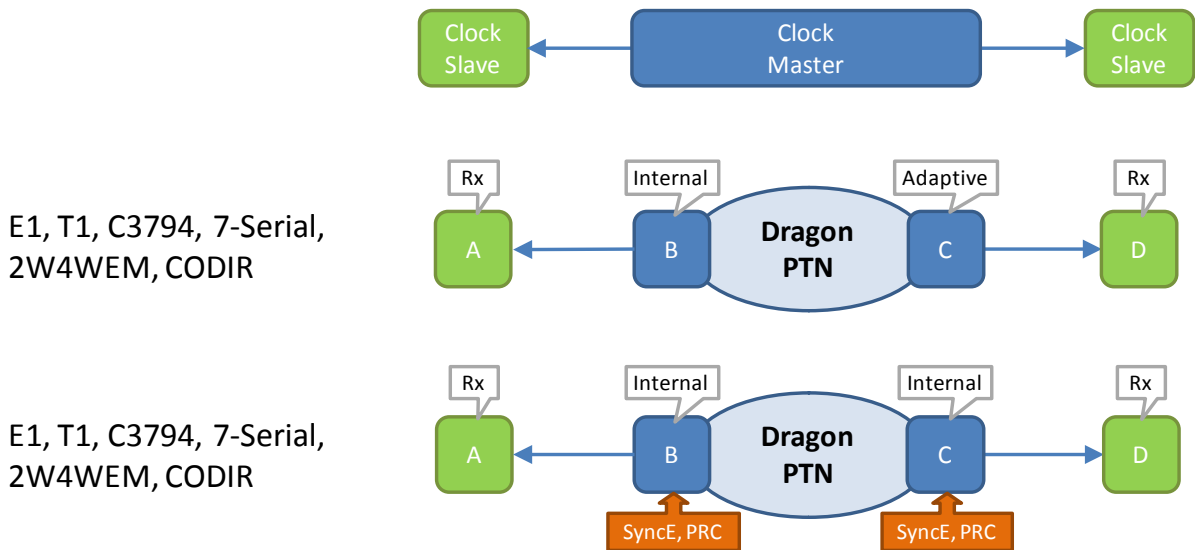


Figure 17 Clocking: Both Applications A and D Slave to Dragon PTN Clock Master

Table 7 Clocking Parameters on Port & Service Level

| Port A: Clock Source | Port B: Clock Source | Service: Differential Clocking | Port C: Clock Source | Port D: Clock Source | Description |
|--|-------------------------------------|---|--|-------------------------------------|--|
| Application D slaves to application A via Dragon PTN | | | | | |
| 'Internal Clock' | 'Rx Clock' | Unchecked | 'Adaptive/ Differential' | 'Rx Clock' | <p>Node (B) recovers the clock from the incoming data stream from Application (A) and uses it to decode/encode the packet stream.</p> <p>Node (C) recovers the clock from the incoming packet stream from the network and uses it to encode/decode the data stream. Application (D) slaves its clock to this stream.</p> |
| 'Internal Clock' | 'Rx Clock' + SyncE | Checked | 'Adaptive/ Differential' + SyncE | 'Rx Clock' | <p>Node (B) recovers the clock from the incoming data stream from Application (A) and uses it to decode/encode the packet stream. Node (B) embeds extra RTP timing information in that packet stream when forwarding it on the Dragon PTN network.</p> <p>Node (C) generates the clock based on the PRC and the embedded RTP timing information in the incoming packet stream.</p> <p>The generated clock is used to encode/decode the data stream. Application (D) slaves its clock to this stream.</p> |
| Both Applications A and D slave to Dragon PTN Clock Master | | | | | |
| 'Rx Clock' | 'Internal Clock' | Unchecked | 'Adaptive/ Differential' | 'Rx Clock' | <p>Node (B) transmits packets to node (C) based on an Internal Clock. This clock is delivered by the local oscillator on the IFM. Node (C) recovers the clock from the incoming packet stream from the network and uses it to encode/decode data streams.</p> <p>Both applications (A) and (D) slave their clock to the data streams delivered by node (B) and (C).</p> |
| 'Rx Clock' | 'Internal Clock' + SyncE | Unchecked | 'Internal Clock' + SyncE | 'Rx Clock' | <p>Both nodes (B) and (C) encode/decode the data stream to/from the end applications based on the 'Internal Clock' on the IFM. This clock is delivered by the CSM and is based on a PRC delivered via SyncE.</p> <p>Both applications (A) and (D) slave their clock to the data streams delivered by node (B) and (C).</p> |
| E1/T1 port: CESoPSN Clock Source Bundle Id | | | | | |
| <p>Fill out the 'Clock Source Bundle id': Each E1/T1 CESoPSN service that is created in HiProvision will automatically get a 'bundle ID' assigned. The value of this 'Bundle ID' can be found in HiProvision → Network → Services → Monitoring Properties → Circuit Emulation. This value must be filled out in the 'CESoPSN Clock Source Bundle ID' port property to indicate to which CESoPSN service this port must slave its clock (=adaptive).</p> | | | | | |

NOTE: SyncE: See the manuals in Ref.[1] and Ref.[4] for more detailed information;

2.2.14 Short Haul/Long Haul

Long E1/T1 links (>200m, Long Haul) have more signal attenuation than shorter links (<200m, Short Haul). As a result, the signal levels or sensitivity ('0' or '1') on the receiver side must be configured according to the used link: Long Haul or Short Haul.

In HiProvision, a Short Haul parameter can be checked for Short Haul links and unchecked (=default) for Long Haul links. This parameter can be set on port level in the IFM or at service creation.

2.2.15 Test and Loopback Self Tests

Test and Loopback self tests can be performed in CESes, e.g. when configuring or troubleshooting a CES. Following two functions can be used in a programmed CES:

- ▶ Loopbacks: on backplane or front port, direction towards line (=application) or network can be configured;
- ▶ BERT: test traffic generation and verification via Bit Error Ratio Tester.

CAUTION: enabling self tests disables or disturbs normal service traffic on a port!

For more information and configuration settings, see 'Test and Loopback' in Ref.[1] in Table 1.

2.3 Onboard Interfaces

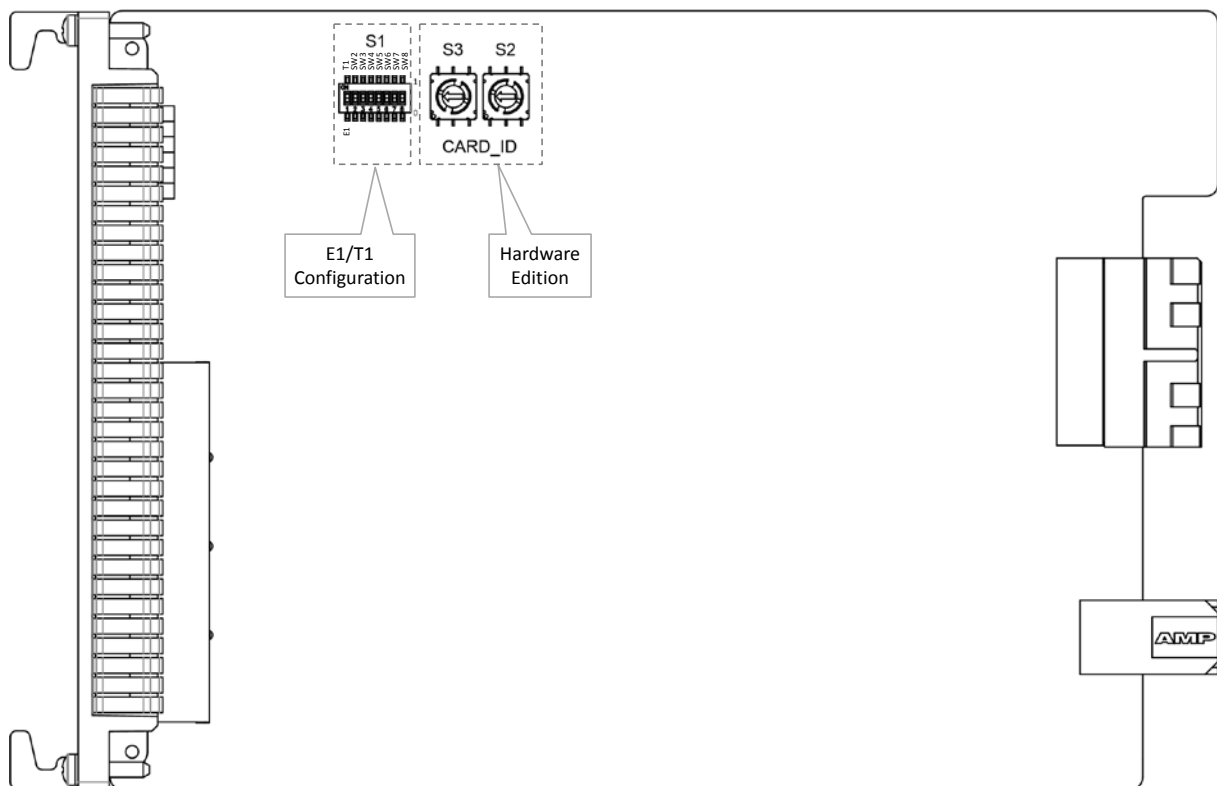


Figure 18 4-E1-L/4-T1-L: Side View

2.3.1 Straps

No user relevant straps.

2.3.2 DIP Switches

a. Hardware Edition

The Hardware Edition (Figure 18) is set in decimal code using rotary switches S2 to S3 (=most significant). It can be read out as well via HiProvision. This edition has been factory set and **MUST NOT BE CHANGED!** Example: Setting S3='0' and S2='5' indicates Hardware Edition '5' (dec).

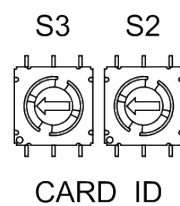


Figure 19 Hardware Edition

b. E1/T1 Configuration

The E1/T1 configuration of the 4-E1-L/4-T1-L module is factory set by the S1 DIP switch (Figure 18 and Figure 20) and must not be changed. The configuration can be read out via HiProvision.

- ▶ E1: all the ports operate as E1 ports, use the '4-E1-L' IFM in HiProvision;
- ▶ T1: all the ports operate as T1 ports, use the '4-T1-L' IFM in HiProvision.

For more information on E1/T1 framing see §2.2.2/§2.2.3.



Figure 20 E1/T1 Configuration

3. TDM FRAMES/PACKET

3.1 General

The amount of TDM Frames per Ethernet packet is an important setting because it influences the amount of consumed bandwidth and delay through the network. The more TDM Frames/Packet, the less bandwidth is used but the bigger the total delay through the network.

In HiProvision, it can be configured how many TDM Frames/Packet can be encoded. In the table below, find the minimum and maximum TDM Frames/Packet according the configured CES and the amount of used timeslots.

NOTE: Default TDM Frames/Packet = 4;

Table 8 TDM Frames/Packet

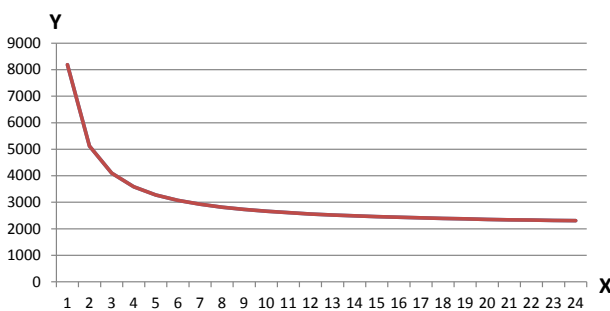
| CES | Amount of Timeslots | | Min. TDM Frames/Packet | | Max. TDM Frames/Packet (no hitless/hitless switching) | |
|---------|---------------------|-----------|------------------------|----|---|-------|
| | E1 | T1 | E1 | T1 | E1 | T1 |
| SAToP | always 32 | always 24 | 1 | 1 | 24/10 | 24/10 |
| CESoPSN | 1 | 1 | 3 | 3 | 24/10 | 24/10 |
| CESoPSN | 2 | 2 | 2 | 2 | 24/10 | 24/10 |
| CESoPSN | 3 or 4 | 3 or 4 | 1 | 1 | 24/10 | 24/10 |
| CESoPSN | 5..31 | 5..24 | 1 | 1 | 24/10 | 24/10 |

3.2 Bandwidth

If only one TDM frame per packet is encoded, it generates a lot of header information on the network resulting in a lot of consumed bandwidth. Encoding more frames into one packet will decrease the amount of header information and as a result the consumed bandwidth as well. As of 8 frames per packet and higher, the bandwidth consumption stabilizes towards the minimum bandwidth consumption. See the graph below.

SAToP Bandwidth:

Y: Average Network Bandwidth (kbps)
X: TDM Frames / Ethernet Packet



CESoPSN Bandwidth:

Y: Average Network Bandwidth (kbps)
X: TDM Frames / Ethernet Packet

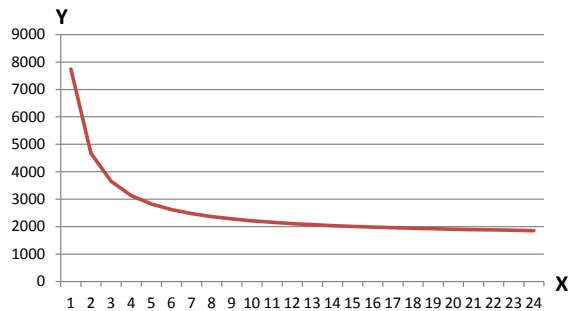


Figure 21 SAToP, CESoPSN Bandwidth

3.3 Delay

3.3.1 General

The total delay between two end points over the Dragon PTN network depends on:

- ▶ **P** (=Packetization Delay): Delay to encode E1/T1 input into MPLS-TP packets;
- ▶ **DP** (=Depacketization Delay): Delay to decode MPLS-TP packets into E1/T1 output;
- ▶ **DPh**: Extra Depacketizing Delay due to hitless switching;

- ▶ **Path Delay:** Delay from source to destination over the MPLS-TP network path; can be measured by HiProvision via OAM delay measurement for the specific service; Path Delay = Delay external network (if any) + $5\mu\text{s}/\text{km}$ + $10\mu\text{s}/\text{node}$;
- ▶ **Total Delay** = Total Network delay between two E1/T1 applications;
- ▶ **Total Delay** = (Packetization + Path + Depacketization + Hitless Switching) Delay;

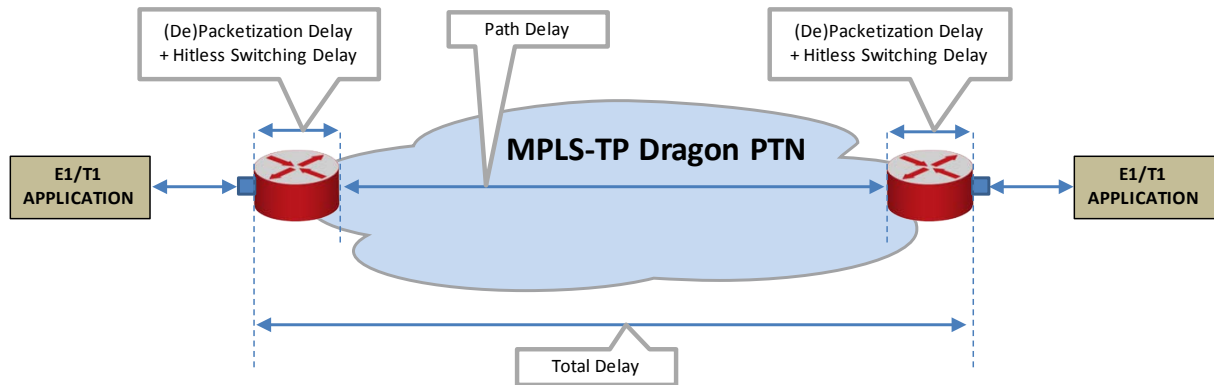


Figure 22 Delays

3.3.2 Delay Parameters

These delays in §3.3.1 depend on the selected service in HiProvision and its configured delay parameters. HiProvision offers the delay parameters listed below to tune the delay.

CAUTION: If you are not familiar with these parameters, keep the default values.

- ▶ **TDM Frames per Packet:** The lower the value, the lower the delay.
- ▶ **Jitter Buffer Size (μs):** advice: Set this value to 'Packetizing Delay + expected peak-to-peak jitter (μs)'; the default peak-to-peak jitter could be $250\ \mu\text{s}$; the expected peak-to-peak jitter (μs) must be measured in the network. If the packetizing delay 'P' $< 2000\ \mu\text{s}$, set the buffer size to at least $2000\ \mu\text{s}$. If the packetizing delay 'P' $> 2000\ \mu\text{s}$ (e.g. $2500\ \mu\text{s}$), set the buffer size to at least e.g. $2500\ \mu\text{s}$.

CAUTION: By default, the jitter buffer will reset once for optimal processing 15 seconds after a change in the service occurs. This reset will cause a minimal loss of data. See 'jitter buffer' in the 'Dragon PTN and HiProvision Operation' Manual (=Ref. [1]) for more information.

- ▶ **Maximum Network Path Delay Difference (μs)** (only for Hitless Switching): advice: Set this value to '(Two Paths nodes difference)*10 + expected peak-to-peak jitter (μs)'. If path1 has 17 nodes and path2 has 8 nodes, this is a difference of 9 nodes. You could set $\text{MaxNetwPathDelayDiff} = 9*10 + 250 = 340\ \mu\text{s}$;

3.3.3 Estimated Delay Calculation and Formulas

Table 9 shows formulas to calculate an estimated delay. Once you have the desired estimated delay, fill out the parameter values in HiProvision, which shows the calculated 'P+DP+DPh'.

Table 9 Estimated Delay Formulas

| Delay | No Hitless Switching | Hitless Switching (SATOP) | Hitless Switching (CESOP) |
|--------------|----------------------------|---------------------------------|----------------------------------|
| P | TDMFramesPerPacket * 125 | | |
| DP | (JitterBufferSize – P) / 2 | | |
| DPh | 0 | 2P + MaxNetwPathDelayDiff + 766 | 2P + MaxNetwPathDelayDiff + 1087 |
| Path Delay | measured by HiProvision | | |
| Total | P + DP + DPh + Path Delay | | |

3.3.4 Estimated Delay Examples

Below, fill out the example values in the formulas to find out the estimated total delay:

- ▶ TDMFramesPerPacket = 10
- ▶ JitterBufferSize = 4000 μs
- ▶ MaxNetwPathDelayDiff = 340 μs
- ▶ Pathdelay (measured by HiProvision) = 500 μs

Table 10 Estimated Delay (μs) Examples

| Delay | No Hitless Switching | Hitless Switching (SATOP) | Hitless Switching (CESOP) |
|--------------|--|---|---|
| P | <u>10</u> * 125 = 1250 | | |
| DP | <u>(4000 – 1250)</u> / 2 = 1375 | | |
| DPh | 0 | 2*1250 + <u>340</u> + 766 = 3606 | 2*1250 + <u>340</u> + 1087 = 3927 |
| Path Delay | <u>500</u> | | |
| Total | 1250 + 1375 + 0 + 500 = 3125 μs | 1250 + 1375 + 3606 + 500 = 6731 μs | 1250 + 1375 + 3927 + 500 = 7052 μs |

3.3.5 Differential Delay

Differential Delay is the difference in Path Delays between two end-points, measured in two opposite directions over the same path.

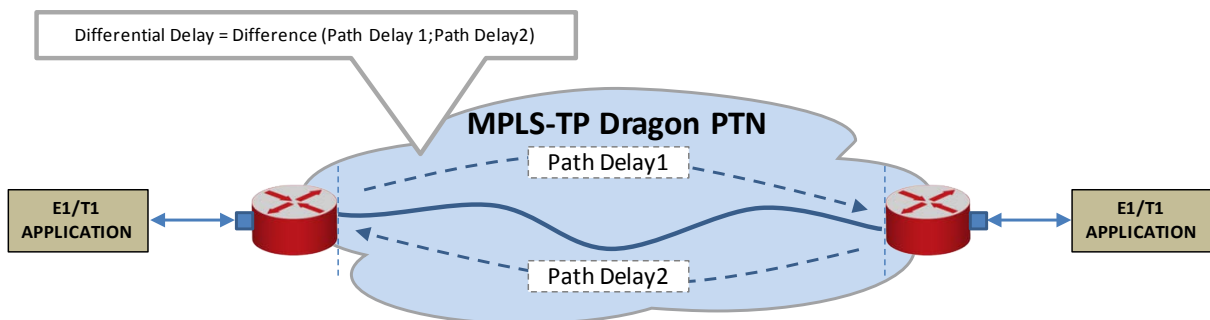


Figure 23 Differential Delay

When Differential Delay is very important for your application, we strongly advise to:

- ▶ Not use Hitless Switching with Single Path (§2.2.10), all the other modes are OK;
- ▶ Use SAToP (§2.2.5) when the differential delay must be as low as possible:
 - ▶ Maximum differential delay SAToP: 157 μs;
 - ▶ Maximum differential delay CESoPSN: 1125 μs;

3.4 Tuning CES = Tuning TDM Frames/Packet

Tuning the CES is mainly done by tuning the TDM Frames/Packet parameter. Tuning this parameter is a trade-off between bandwidth and delay. The more bandwidth is consumed the less the resulting network delay and vice versa. This tuning is application dependent. Check out whether bandwidth or delay is critical for an application or network. Based on these findings, bandwidth and delay parameters can be tuned.

Some examples according the information in §3.2 and §3.3:

- ▶ if bandwidth is not a problem, and a small delay is wanted → 1-3 TDM frames/packet;
- ▶ if less bandwidth is required and delay is not important → at least 4 TDM frames/packet;
- ▶ if less bandwidth and a small delay are wanted → 5 .. 10 TDM frames/packet.

4. COMPATIBILITY

The 4-E1-L/4-T1-L IFM is compatible with:

- ▶ 16-E1-L/16-T1-L IFM;
- ▶ 2-C37.94 IFM.

It means that:

- ▶ The E1 ports of a 4-E1-L, 16-E1-L and 2-C37.94 can be programmed in the same service;
- ▶ The T1 ports of a 4-T1-L, 16-T1-L and 2-C37.94 can be programmed in the same service;
- ▶ A C37.94 port and any E1 port on any IFM can be programmed in the same E1 CES service;
- ▶ A C37.94 port and any T1 port on any IFM can be programmed in the same T1 CES service;

5. MODULE SPECIFICATIONS

5.1 General Specifications

For general specifications like temperature, humidity, EMI ... see Ref.[6] in Table 1.

5.2 Other Specifications

Table 11 Other Specifications

| Description | Value |
|-------------------|---|
| Weight | 0.27 kg / 0.6 lb |
| MTBF | 95 years at 25°C/77°F |
| Power Consumption | 7.7W (measured at 25°C/77°F, with data transport) |
| Module Size | width: 20.32 mm / 0.8 inches height: 126 mm / 4.96 inches depth: 195 mm / 7.68 inches |

5.3 Ordering Information

- ▶ PTN-4-E1-L: 942 236-010
- ▶ PTN-4-T1-L: 942 236-011

6. ABBREVIATIONS

| | |
|----------------|--|
| AIS | Alarm Indication Signal |
| AMI | Alternate Mark Inversion |
| BERT | Bit Error Ratio Tester |
| CES | Circuit Emulation Service |
| CESoPSN | Circuit Emulation Service over Packet Switched Network |
| CSM | Central Switching Module |
| EMI | Electromagnetic Interference |
| ETH | Ethernet |
| FLT | Fault |
| HDB3 | High Density Bipolar of Order 3 |
| IEEE | Institute of Electrical and Electronics Engineers |
| IFM | InterFace Module |
| kbps | Kilobit per Second |
| LAN | Local Area Network |
| LOF | Loss of Framing |
| LOS | Loss Of Signal |
| Mbps | Megabit per Second |
| MPLS-TP | MultiProtocol Label Switching – Transport Profile |
| MTBF | Mean Time Between Failures |
| OAM | Operations, Administration and Maintenance |
| PBX | Private Branch Exchange |
| PF | Power Failure |
| PI | Power Input |
| PTN | Packet Transport Network |
| PTP | Point to Point |
| RAI | Remote Alarm Indication |
| SAToP | Structure Agnostic TDM over Packet |
| SF | Super Frame |
| SyncE | Synchronous Ethernet |
| TDM | Time Division Multiplex |
| WAN | Wide Area Network |