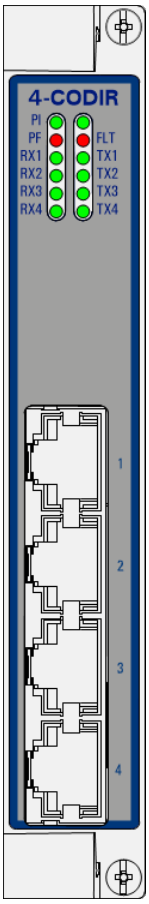
User Manual

Installation
Dragon PTN
Interface Module PTN-4-CODIR



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1. INTRODUCTION

1.1 General

This document is valid as of Dragon PTN Release 3.0DR.

The 4-CODIR interface module (=IFM) can transport four 64 kbps links, point-to-point over the Dragon PTN network according the ITU G.703 standard, see §2.2.2 for more information.

4-CODIR refers to '4 ports – Codirectional Interface'. The term 'Codirectional' is used to describe an interface in which the information and its associated timing signal are transmitted into the same direction. The information and timing signal are both embedded in the same data stream, there is no separate clock transmission. The receiver will derive the clock from the incoming data stream. See figure below.

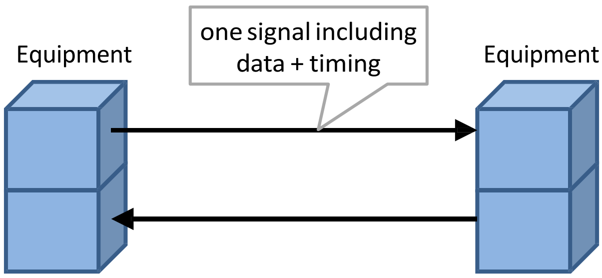

Figure 1 Codirectional Interface

This IFM converts the incoming data from the 64 kbps 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 4 CESs can be configured per 4-CODIR module.

NOTE: A 64kbps link = E0 link; An E1 link can carry 32 E0 links.

This IFM can be used in any IFM slot of any node. An IFM slot overview can be found in Ref. [3] in Table 1.

The main supported features are:

- Packetizing of 64 kbps data
- Codirectional
- LAN function
- Services
  - SAToP (=future) (=Structured Agnostic TDM over Packet);
  - CESoPSN (=CES over Packet Switched Network);
  - Hitless Switching / Single Path ;

A general 64 kbps CODIR example can be found in the next figure:

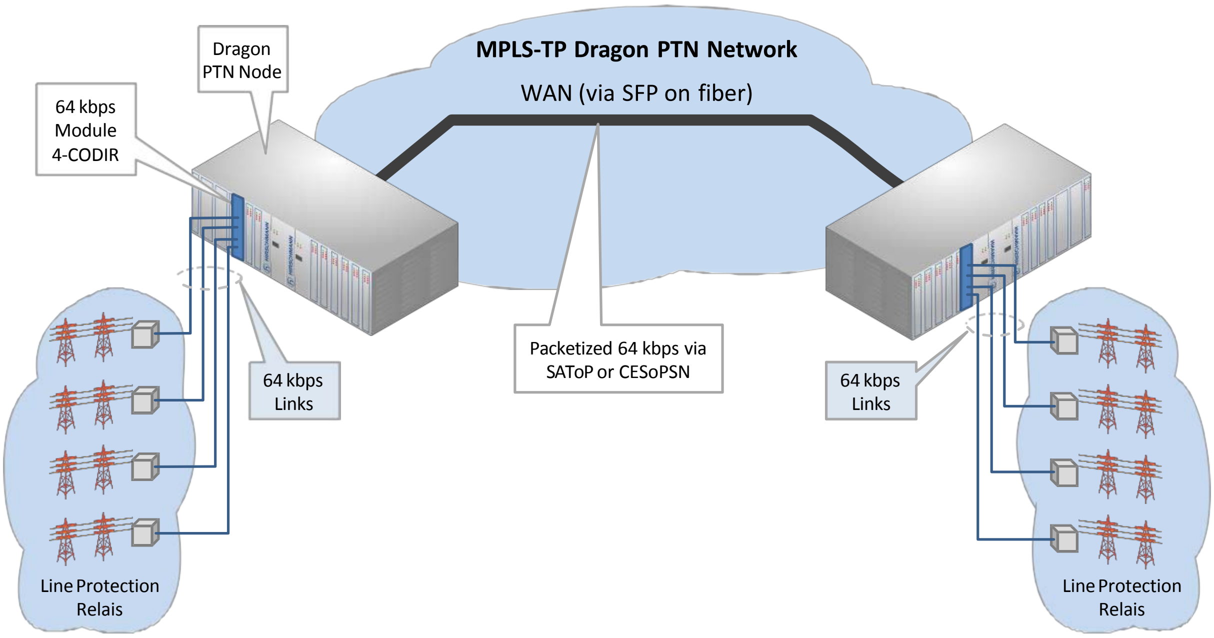

Figure 2 General 64 kbps Example

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
[3]	DRB-DRM802-&-*	Dragon PTN Nodes: PTN2210, PTN2209, PTN2206, PTN1104
[4]	DRB-DRM803-&-*	Dragon PTN Switching Module: PTN-CSM310-A
[5]	DRE-DRM805-&-*	Dragon PTN Interface Module: PTN-4-E1-L/PTN-4-T1-L
[6]	DRA-DRM810-&-*	Dragon PTN General Specifications
[7]	DRE-DRM818-&-*	Dragon PTN Interface Module: PTN-16-E1-L/PTN-16-T1-L

2. MODULE DESCRIPTION

2.1 Front Panel

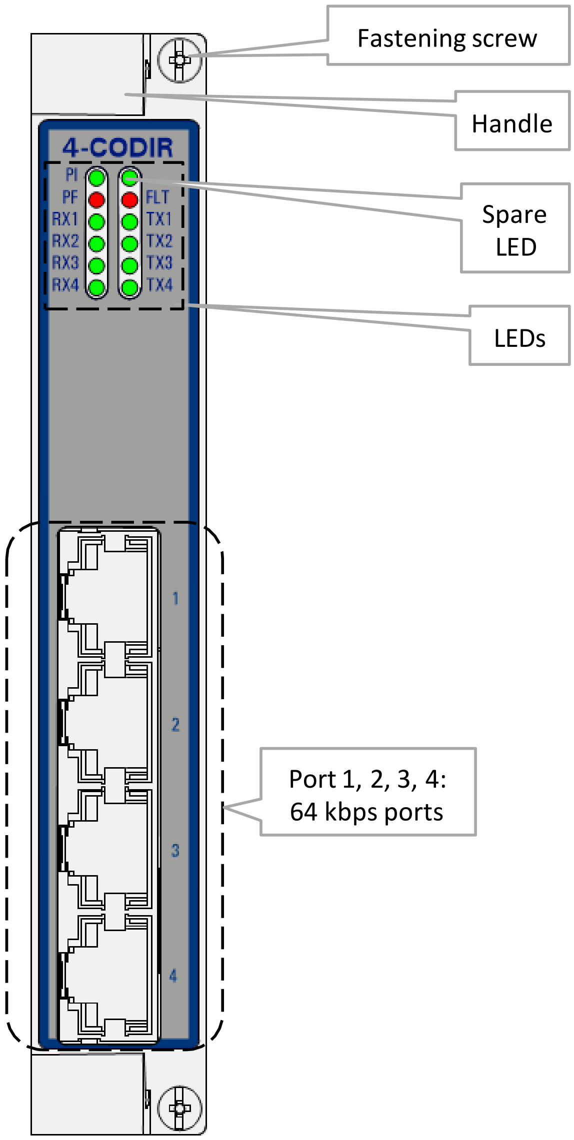

Figure 3 Front Panel

2.1.1 Handle

a. Insert the Module into the Node

Take the front panel handles to insert or slide the module into the Dragon PTN node. Push the module thoroughly into the node's backplane. Next, tighten the two fastening screws in the front panel corners.

b. Remove the Module from the Node

Untighten the two fastening screws in the front panel corners. Take the front panel handles to pull out and finally remove the module from the Dragon PTN node.

2.1.2 LEDs

The meaning of the LEDs depends on the mode of operation (= boot or normal) in which the 4-CODIR 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	RX[1..4]	TX[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
RX<port n°>	Not lit, dark	No service programmed on port<n>
	Green, lit	Service programmed on port<n>, data received on front port<n>
	Green, blinking	Service programmed on port<n>, no data received on front port<n>
TX<port n°>	Not lit, dark	No service programmed on port<n>, no TX AIS sent
	Green, lit	Service programmed on port<n>, data received on backplane (=network) side
	Green, blinking	Service programmed on port<n>, no data received on backplane (=network) side

2.1.3 RJ-45 Ports and Cables

The 4-CODIR module provides four of these ports and each port connector has eight pins. Each port provides one tip/ring pair. See the figure and table below for an overview and description. The 120 Ω E1 cable (942 256-201) can be ordered to connect these ports.

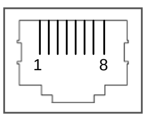

Figure 4 RJ-45 Connector

Table 4 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 front ports. The 4-CODIR module can interface with four 64kbps lines. In Figure 2, a common functional setup is shown.

In Figure 5 below, a more detailed functional setup is shown. A LAN1 network interfaces the Dragon PTN node via the front ports on the 4-CODIR module. The 4-CODIR converts this traffic into Ethernet traffic on the backplane. The Central Switching Module (=CSM310-A) converts this Ethernet traffic into packetized MPLS-TP and transmits it via an Ethernet IFM (e.g. 4-GC-LW) onto the Dragon PTN MPLS-TP network. The packetizing of 64 kbps occurs via CES: SAToP (=future) (see §2.2.3) or CES: CESoPSN (see §2.2.4) technique.

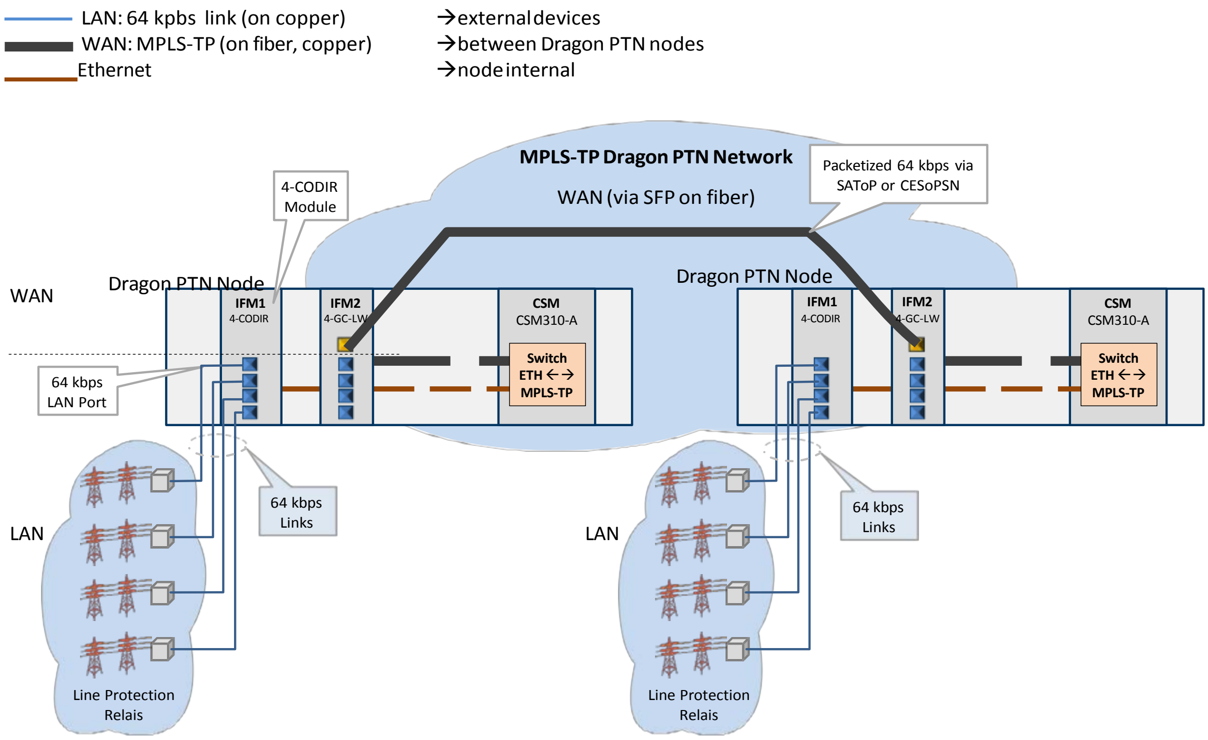

Figure 5 Detailed Function 64 kbps Example

2.2.2 ITU-T G.703 Code Conversion 64kbps

The ITU-T G.703 standard defines for the 64 Kbps codirectional interface the following five steps for AMI coding (step1->5) / decoding (step5->1) a binary data stream:

1. (network side) A 64 kbps bit period is divided into four unit intervals;
2. A binary one is coded as a block of the following four bits: 1100;
3. A binary zero is coded as a block of the following four bits: 1010;
4. The binary signal is converted into a three-level signal by alternating the polarity of consecutive blocks; This is the AMI encoding or Alternate Mark Inversion.
5. (front side) The alternation in polarity of the blocks is violated every eighth block. The violation block marks the last bit in an octet.

The figure below illustrates these conversion rules. The physical interface consists of four signals (Transmit, Tip, Transmit Ring, Receive Tip and Receive Ring). A 64 kbps Tip-Ring pair is a balanced twisted pair (120 Ω). The data transmission through a pair is bipolar and AMI, i.e. an impulse on the line corresponds to a logical “1” (mark) and a space with a logical “0”.

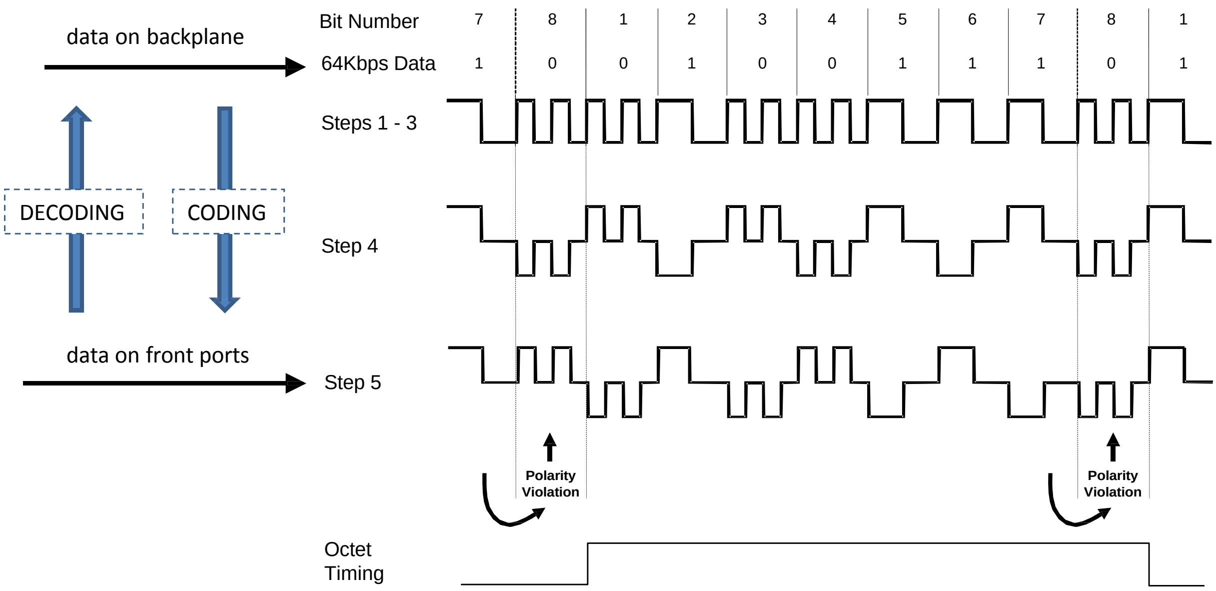

Figure 6 ITU-T G.703 Code Conversion 64 kbps

2.2.3 CES: SAToP (Future)

SAToP is a point-to-point CES which sends transparently an entire E1 frame from the source to the destination 4-CODIR over the MPLS-TP network. One timeslot is used for transporting the 64 kbps channel 'X'. The entire frame = all data + synchronization + alignment timeslots = 32 timeslots. One SAToP service can be configured per port.

This way of transportation consumes more bandwidth over the Dragon PTN network than CESoPSN (see next paragraph), but has less differential delay than CESoPSN. If delay must be as low as possible, use SAToP instead of CESoPSN to transport your 64 k CESoPSN bps channel.

NOTE: Each end-point or 64 kbps port must be located in a different node. Future: end-points can also be located intra-module or intra-node.

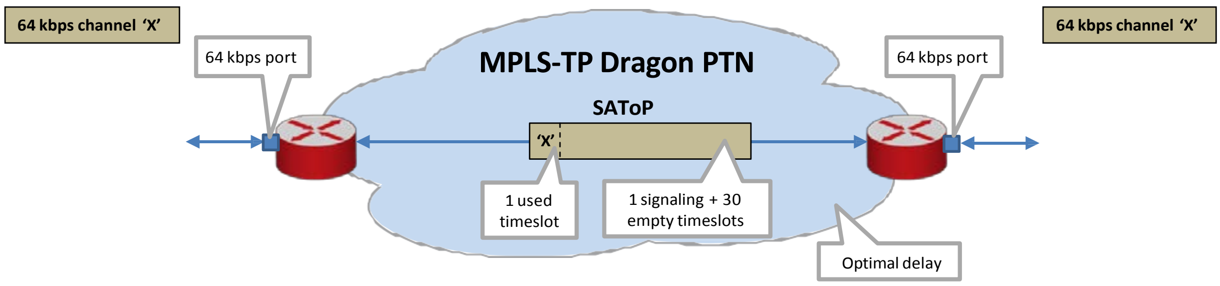

Figure 7 General SAToP Example

2.2.4 CES: CESoPSN

CESoPSN is a point-to-point CES which only sends one E1 timeslot including the 64 kbps channel, over the MPLS-TP Dragon PTN network. This way of transportation consumes less bandwidth over the Dragon PTN network than SAToP, but has more differential delay than SAToP. If delay is not an issue, use CESoPSN to transport your 64 kbps channel.

Each end-point or port must be located in a different node.

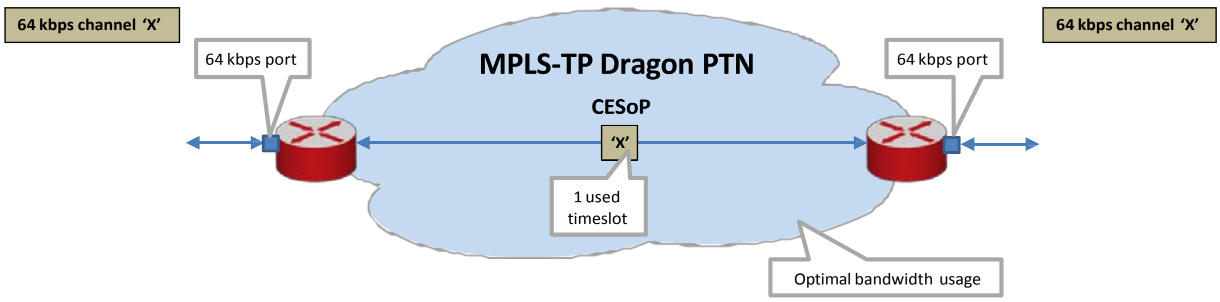

Figure 8 General CESoPSN Example

2.2.5 Hitless Switching

Hitless Switching is a feature within SAToP(future)/CESoPSN that provides a safe 64 kbps 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 4-CODIR IFM buffers the fastest path and forwards packets from the slowest path on the 64 kbps 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 §2.2.6).

See §2.2.7 for a delay comparison within CES depending on the enabled sub features, see also further on.

Table 5 Difference Between Protection and Hitless Switching

	64 kbps Protection Switching	64 kbps 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

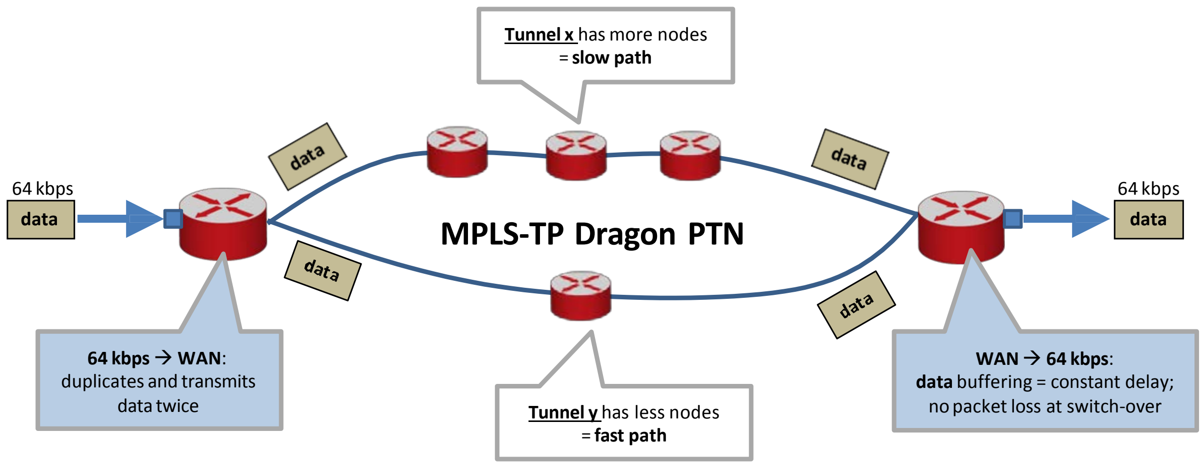

Figure 9 Hitless Switching

2.2.6 Single Path

The Single Path feature is a sub feature of Hitless Switching (see §2.2.5). 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; this setting results in bigger delays because of bigger buffers.
  - 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 §2.2.7 for a delay comparison within CES depending on the enabled sub features, see also further on.

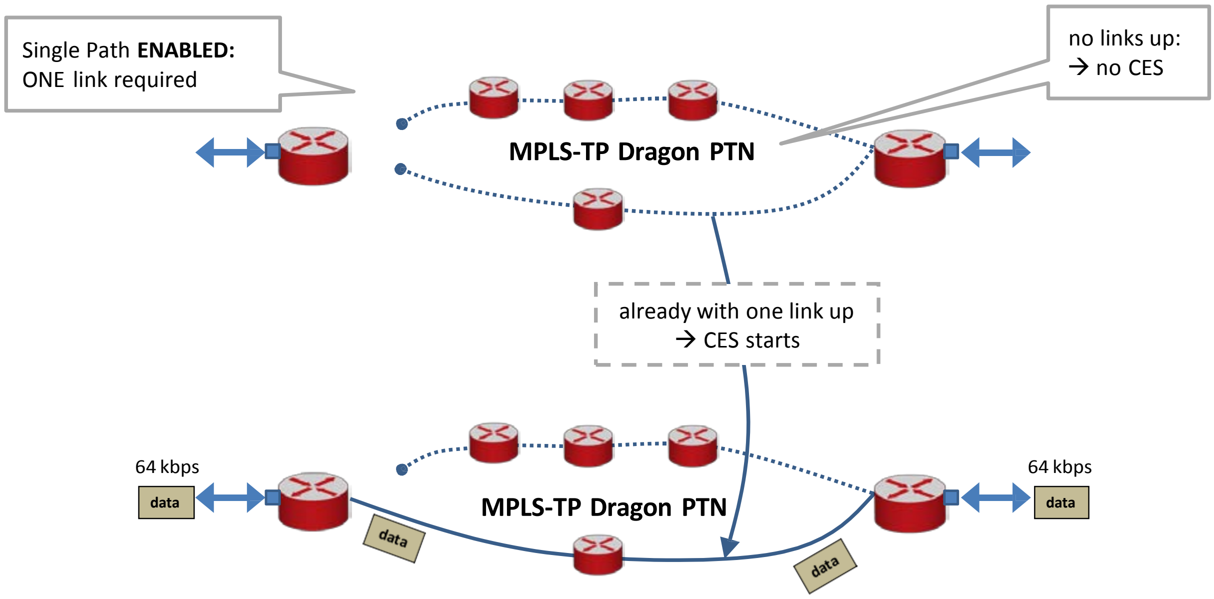

Figure 10 Single Path Enabled

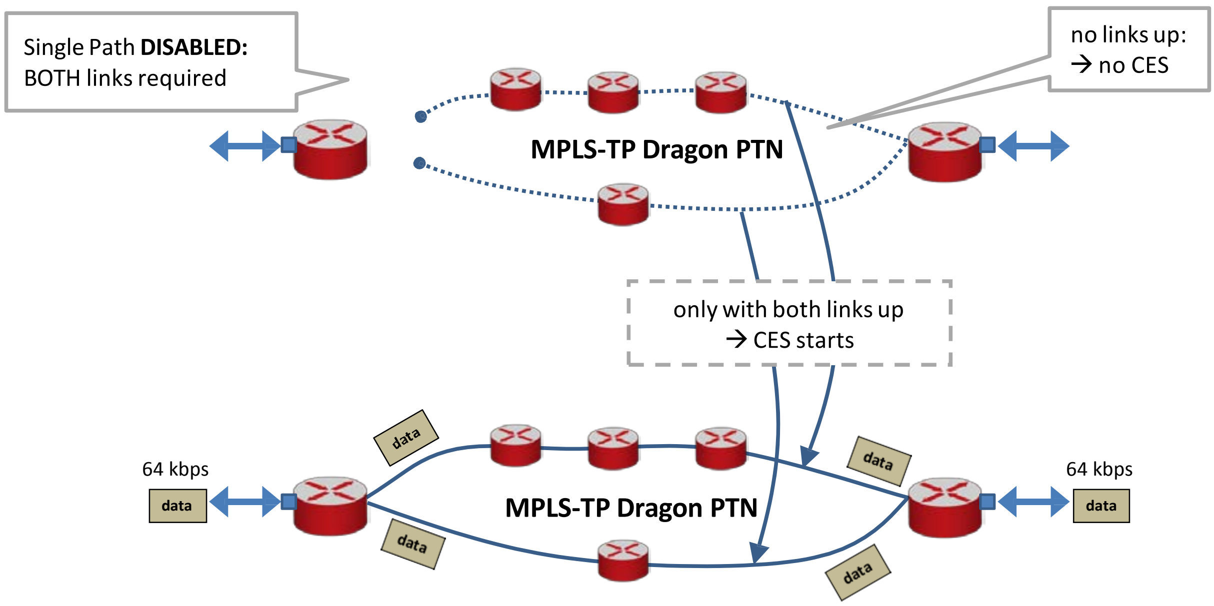

Figure 11 Single Path Disabled

2.2.7 Delay Comparison in CES (Features)

Table 6 Delay Comparison in CES (Features)

CES	Hitless Switching	Single Path	Resulting Delay
X	---	---	lowest
X	X	---	medium
X	X	X	highest
X = enabled; --- = disabled			

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

The 4-CODIR module receives 64 kbps 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 an Ethernet IFM (e.g. 4-GC-LW) onto the WAN. On the destination side, the same processing occurs in reverse order.

2.2.9 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: CODIR' service can communicate in a synchronized way. Which method can be used depends on:

- the ‘Clock source’ port setting of the two endpoints;
- the 'Differential Clocking' setting in this service;
- 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;

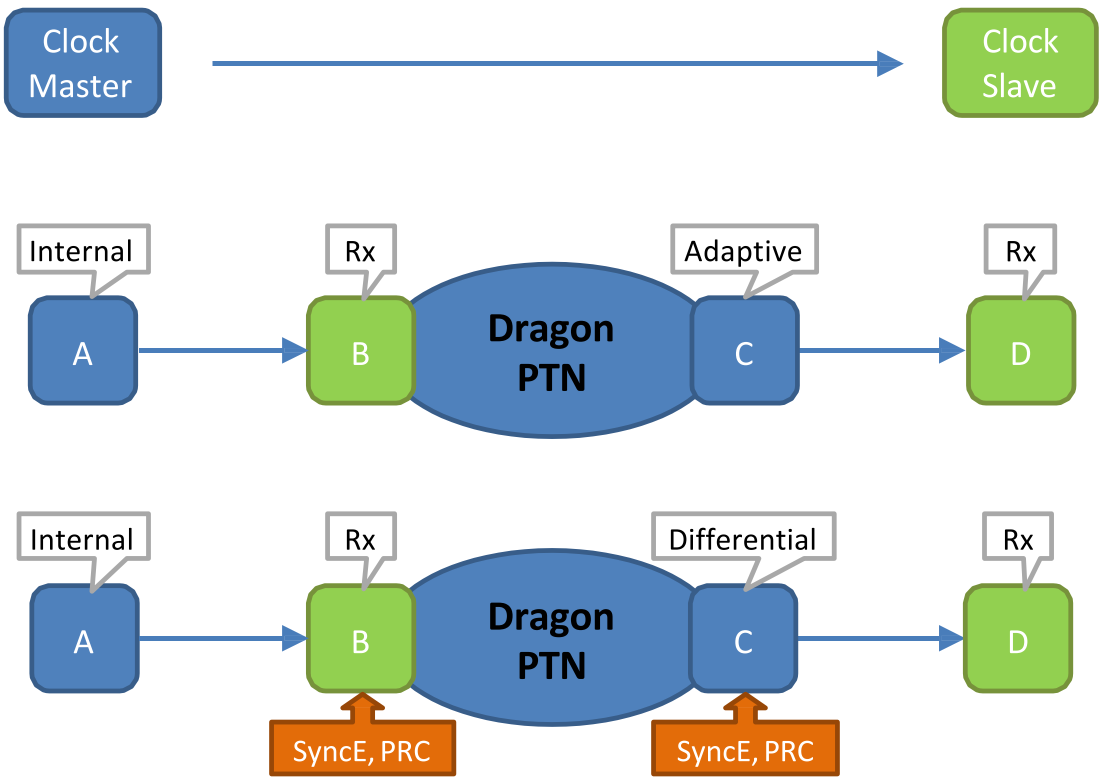

Figure 12 Clocking: Application D Slaves to Application A via Dragon PTN

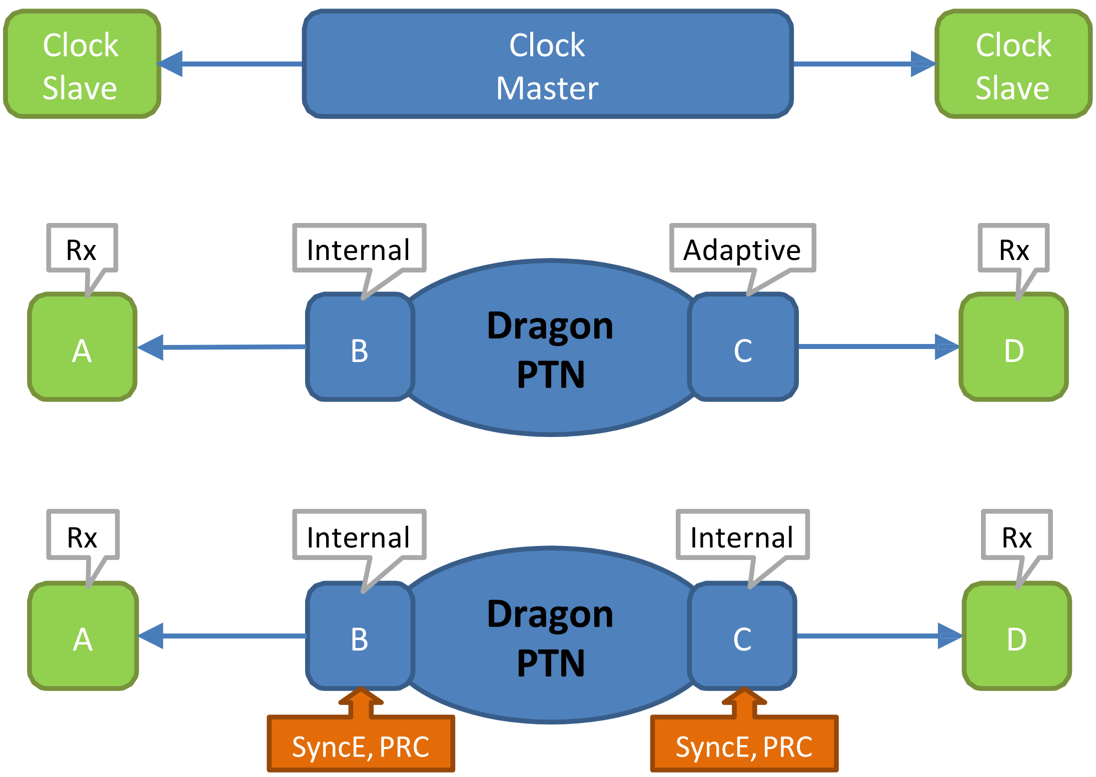

Figure 13 Clocking: Both Application A and D Slave to Dragon PTN Clock Master

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'	Node (B) recovers the clock from the incoming data stream from Application (A) and uses it to decode/encode the packet stream. 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.
'Internal Clock'	'Rx Clock' + SyncE	Checked	'Adaptive/ Differential' + SyncE	'Rx Clock'	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. Node (C) generates the clock based on the PRC and the embedded RTP timing information in the incoming packet stream. The generated clock is used to encode/decode the data stream. Application (D) slaves its clock to this stream.
Both Applications A and D slave to Dragon PTN Clock Master					
'Rx Clock'	'Internal Clock'	Unchecked	'Adaptive/ Differential'	'Rx Clock'	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. Both applications (A) and (D) slave their clock to the data streams delivered by node (B) and (C).
'Rx Clock'	'Internal Clock' + SyncE	Unchecked	'Internal Clock' + SyncE	'Rx Clock'	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 to the node. Both applications (A) and (D) slave their clock to the data streams delivered by node (B) and (C).

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

2.2.10 Test and Loopback Selftests

Test and Loopback selftests 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 selftests 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

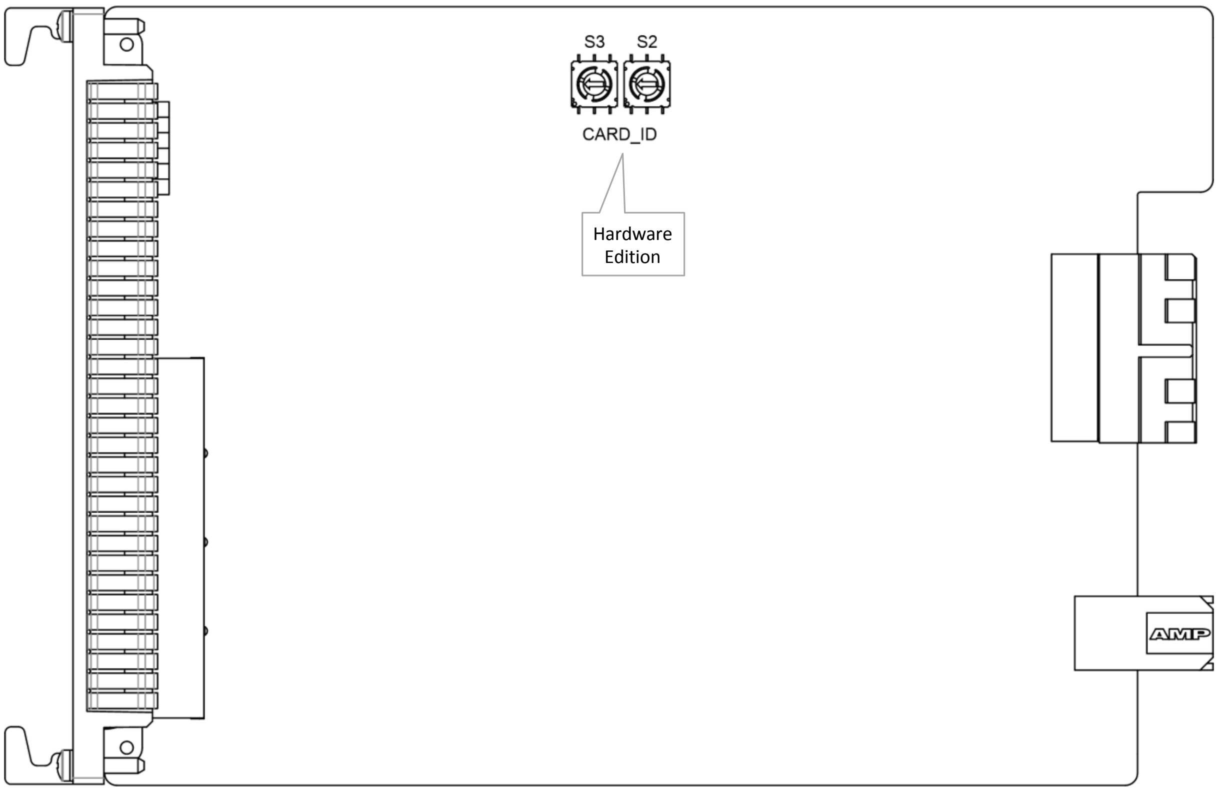

Figure 14 4-CODIR: Side View

2.3.1 Straps

No user relevant straps.

2.3.2 DIP Switches

a. Hardware Edition

The Hardware Edition (Figure 14) 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).

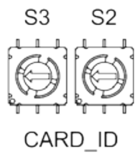

Figure 15 Hardware Edition

3. TDM FRAMES/PACKET

3.1 General

In a CES service, 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.

- Default TDM Frames/Packet = 4;
- Maximum TDM Frames/Packet, no Hitless Switching: 24;
- Maximum TDM Frames/Packet, Hitless Switching: 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.

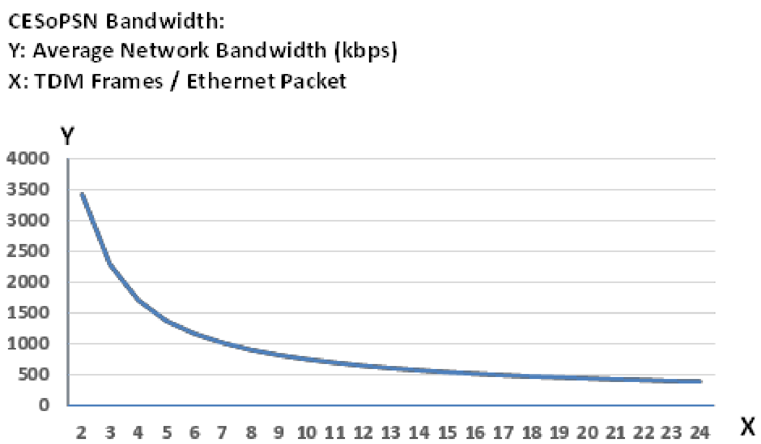

Figure 16 CESoPSN Bandwidth

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 64 kbps input into MPLS-TP packets;

- **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) + 5µs/km + 10µs/node;
- **DP** (=Depacketization Delay): Delay to decode MPLS-TP packets into 64 kbps output;
- **DPh**: Extra Depacketizing Delay due to hitless switching;
- **Total Delay** = Total Network delay between two 64 kbps applications;
- **Total Delay** = (Packetization + Path + Depacketization + Hitless Switching) Delay;

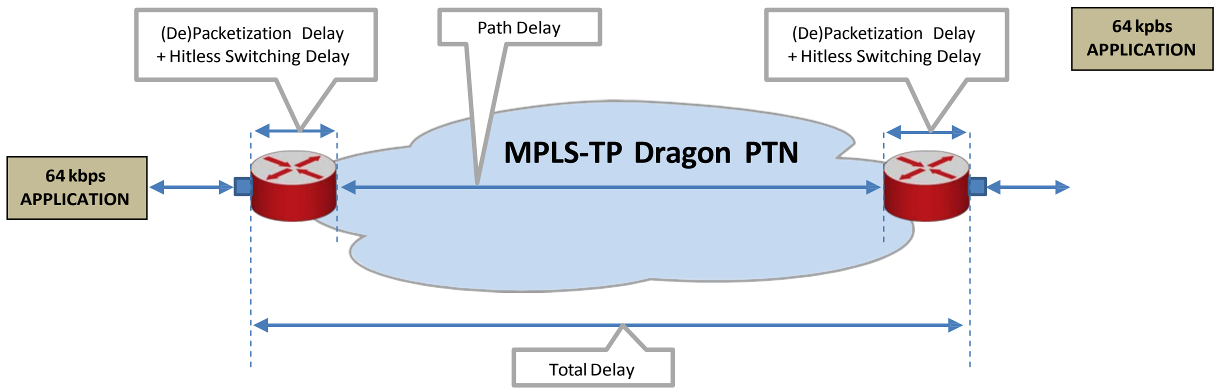

Figure 17 Delays

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 µs; The expected peak-to-peak jitter (µs) must be measured in the network. If the packetizing delay 'P' <2000 µs, set the buffer size to at least 2000 µs. If the packetizing delay 'P' > 2000 µs (e.g. 2500 µs), set the buffer size to at least e.g. 2500 µs.

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): advise: 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 MaxNetwPathDelayDiff = 9*10 + 250 = 340 µs;

3.3.3 Estimated Delay Calculation and Formulas

Table 8 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 8 Estimated Delay Formulas

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

3.3.4 Estimated Delay Examples

Find some example values below. Fill them out in the formulas to find the estimated total delay:

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

Table 9 Estimated Delay (µs) Examples

Delay	No Hitless Switching	Hitless Switching
P	10 * 125 = 1250	
Path Delay	500	
DP	(4000 – 1250) / 2 = 1375	
DPh	0	2*1250 + 340 + 1087 = 3927
Total	1250 + 500 + 1375 + 0 = **3125 µs**	1250 + 500 + 1375 + 3927 = **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.

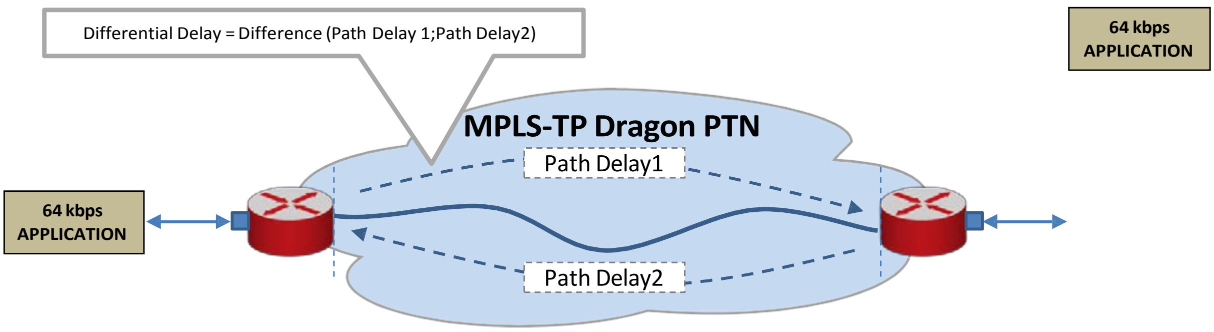

Figure 18 Differential Delay

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

- Not use Hitless Switching with Single Path (§2.2.6), all the other modes are OK;
- Use SAToP (=future) (§2.2.3) 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 → 1-6 TDM frames/packet;
- if less bandwidth is required and delay is not important → at least 8 TDM frames/packet;
- if less bandwidth and a small delay are wanted → 8 .. 10 TDM frames/packet.

4. MODULE SPECIFICATIONS

4.1 General Specifications

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

4.2 Other Specifications

Table 10 Other Specifications

Description	Value
Weight	0.27 kg / 0.6 lb
MTBF	96 years at 25°C/77°F
Power Consumption	6 W (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

4.3 Ordering Information

- PTN-4-CODIR: future support.

5. ABBREVIATIONS

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