SDH

Basics, Pointers & Overheads

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Baseband signal in Digital Transmission?

Pulse Code Modulation

Telephony signals:

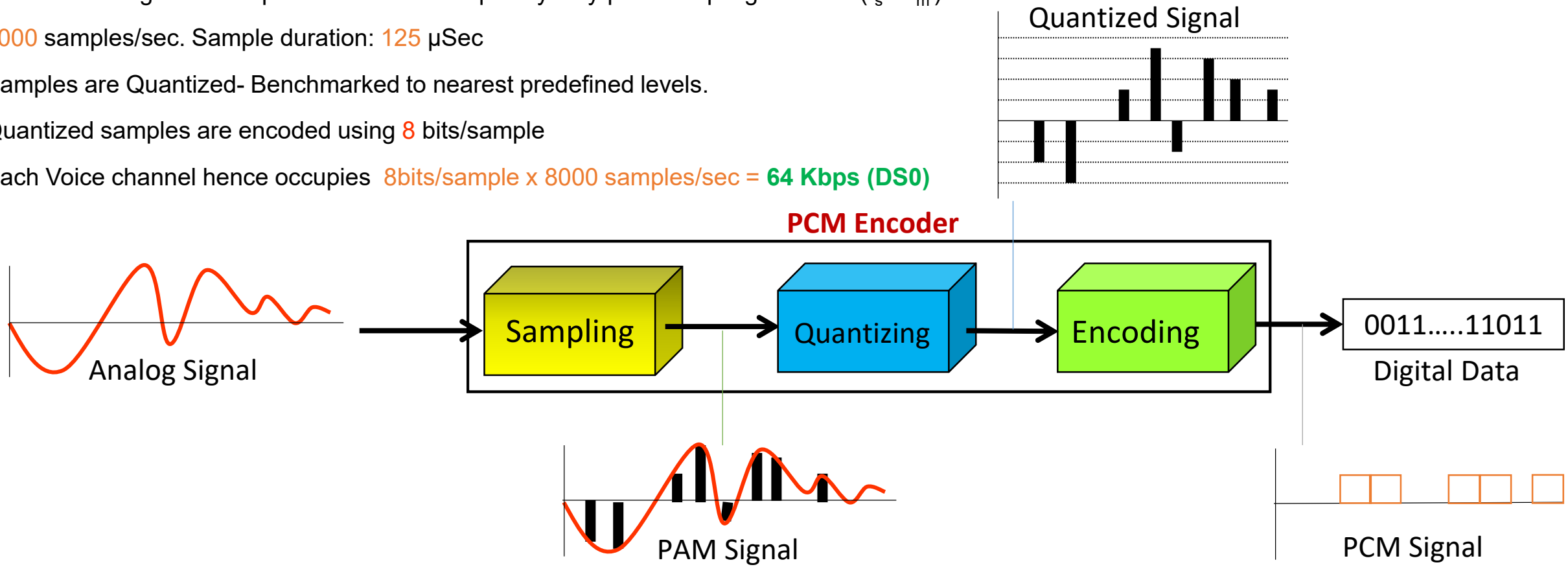
=> 4 KHz Voice signal is sampled at twice the frequency - Nyquist Sampling theorem ($f_s \geq 2f_m$)

=> 8000 samples/sec. Sample duration: 125 µSec

=> Samples are Quantized- Benchmarked to nearest predefined levels.

=> Quantized samples are encoded using 8 bits/sample

=> Each Voice channel hence occupies 8bits/sample x 8000 samples/sec = **64 Kbps (DS0)**



What is PDH?

Plesiochronous Digital Hierarchy: (Greek word)

Plesio ->Close : : Chronous-> Time

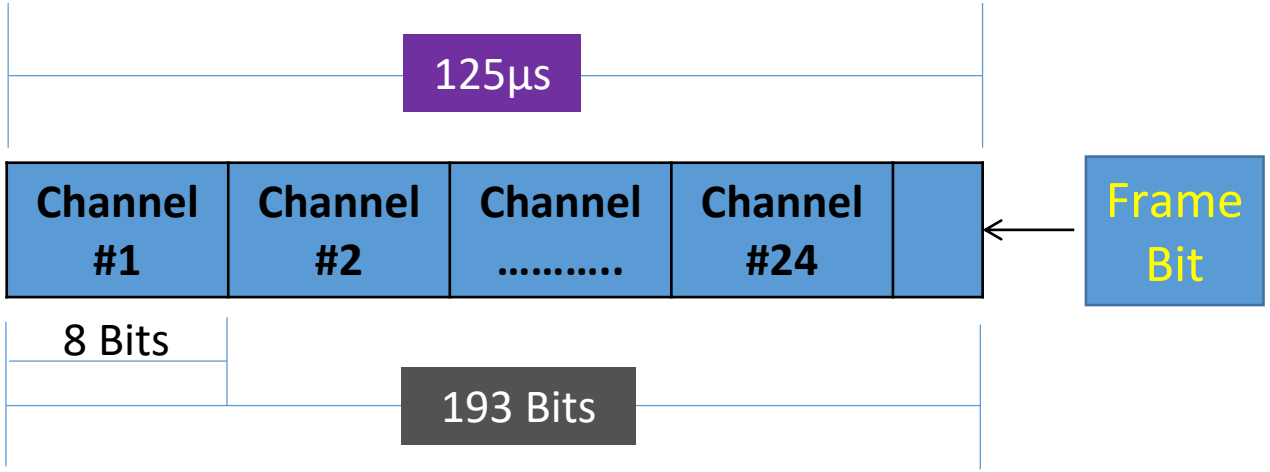
⇒ Almost synchronous but not completely synchronous

- PDH is a technology for transporting voice or data between multiple devices and which are working with clock sources with accepted tolerance levels for synchronization
- PDH was built for Digital transmission of signals
- Pulse Code Modulation (PCM) is the technique used in PDH networks which is based on Time Division Multiplexing (TDM)
- Main Mode of Transmission was Twisted Pair, Co-axial cables and Microwave

Multiplexing Hierarchy

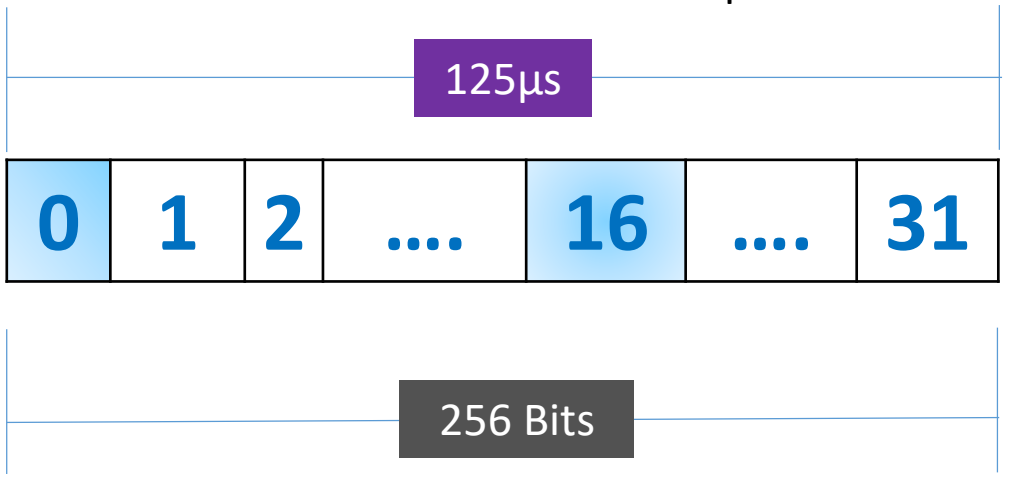
DS1 Frame in T1 and E1

T1 North America



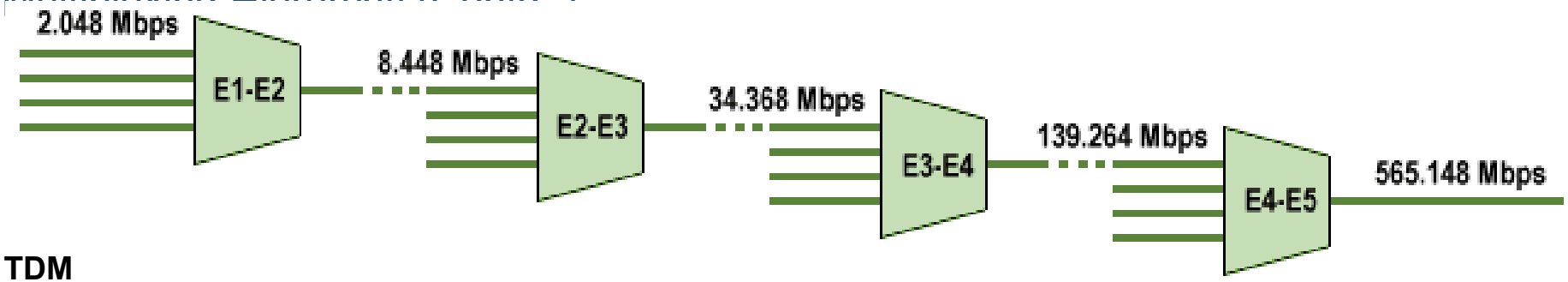
Data Rate = (24x8 +1 bit)/125 µs = 1.544 Mbps

E1 Europe



Data Rate = (32x8)/125 µs = 2.048 Mbps

- How PDH Works- Multiplexing Hierarchy (Contd..)



E0 Level: 64Kbps

E1 Level: Bit interleaved TDM

(32x64 KHz) = 2.048 Mbps [Capacity = 30 Base Channels]

E2 Level: Bit interleaved TDM

(4x2.048) + stuffing bits = 8.448 Mbps [Capacity = 120 Base Ch]

E3 Level: Bit interleaved TDM

(4x8.448) + stuffing bits = 34.368 Mbps [Capacity = 480 Base Ch]

E4 Level: Bit interleaved TDM

(4x 34.368) + stuffing bits = 139.264 Mbps [Capacity = 1920 Base Ch]

E5 Level: Bit interleaved TDM

(4x139) +stuffing bits = 564.992 Mbps [Capacity = 7680 Base Ch]

Plesiochronous Digital Hierarchy (PDH)

European Standard

Notation	Data Rate
E0	64 Kbps
E1	2048 Kbps
E2	8448 Kbps
E3	34368 Kbps
E4	139264 Kbps

- Used in South America, Europe, India etc

American Standard

Notation	Data Rate
T0/DS0	64 Kbps
T1/DS1	1544 Kbps
T2/DS2	6312 Kbps
T3/DS3	44736 Kbps
T4/DS4	139264 Kbps

- Used in USA, Canada Japan, Korea, Hong Kong etc

PDH Standards: Comparison

Digital MUX Level in North America, **Europe** and Japan

Digital MUX Level	No. of 64 Kbps channels	North America (T) Mbps	Europe (E) Mbps	Japan (J) Mbps
0	1	0.064	0.064	0.064
	24	1.544		
1	30		2.048	
	48	3.152		3.152
	96	6.312		6.312
2	120		8.448	
3	480		34.368	32.064
	672	44.376		
	1344	91.053		
	1440			97.728
4	1920		139.264	
	4032	274.176		
	5760			397.200

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Why SDH?

- **Need for extensive network management** capability within the hierarchy. Flexibility in OAM through Overhead provisioning
- **Standard interfaces between equipment and support multiplexing formats** for previous interfaces/ data rate supported by PDH network
- **Facilities to add or drop tributaries** directly from a high speed signal => should have ability to identify sub-streams in any high data rate frame
- Need for **inter-working** between North America and European systems (SDH with SONET and support for both E and T carrier)
- Provide **synchronization** between NE's and making all the NE's to take reference from PRC
- Should support both Electrical and Optical interfaces
- Should support self-healing mechanism –Ring Architecture? And Fast recovery
- Ability to support and transport **all the services of PDH**
- Ability to **provide better interleaving mechanism** compared to bit interleaving during multiplexing (Byte interleaving)
- **Decrease stuffing bits** during higher order multiplexing
- Switching Protection (K1,K2 Bytes)

Why SDH: Plesiochronous Vs. Synchronous

PLESIOCHRONOUS	SYNCHRONOUS
If two digital signals are Plesiochronous, then their transitions occur at “almost” the same rate, with any variation being constrained within tight limits	In a set of Synchronous signals, the digital transitions in the signal occur at exactly the same rate. There may be a phase difference between the transition of two signals –though this would lie in specified limits
Although this clocks are extremely accurate, there is a difference between one clock and the other (G.811)	All the clocks are traceable to one Primary Reference Clock (PRC). The accuracy of PRC is better than 1 in 10^{11} and is derived from cesium atomic standard

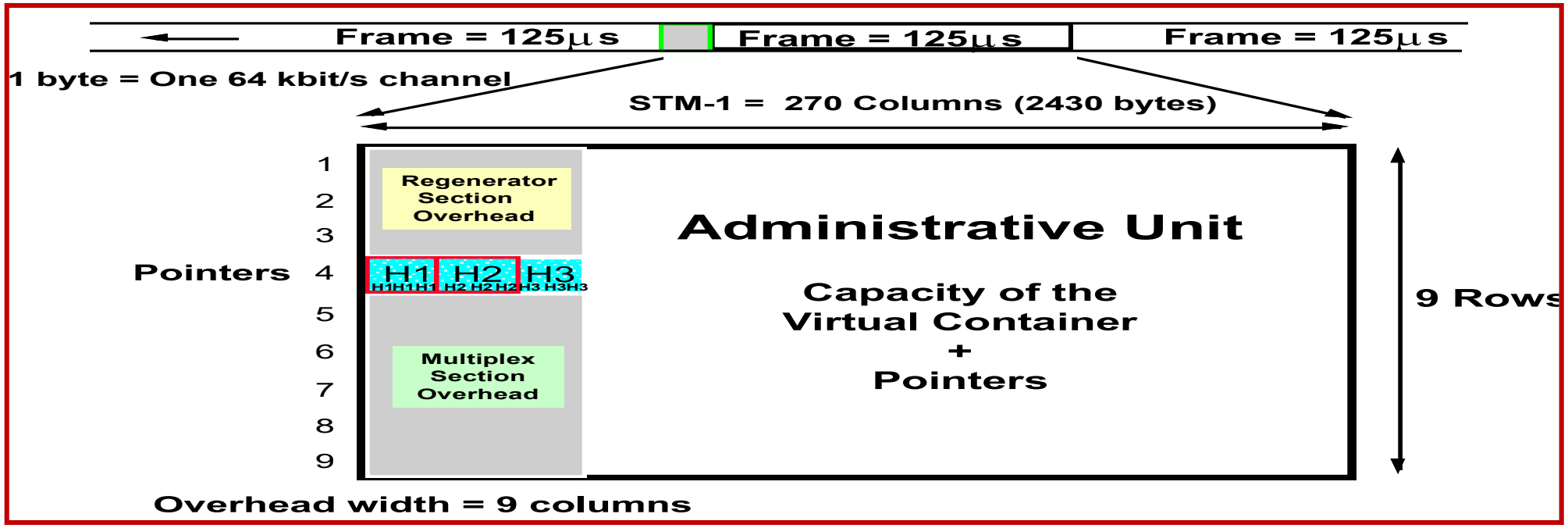
Standards in SDH

- **The hierarchy is as follows:**

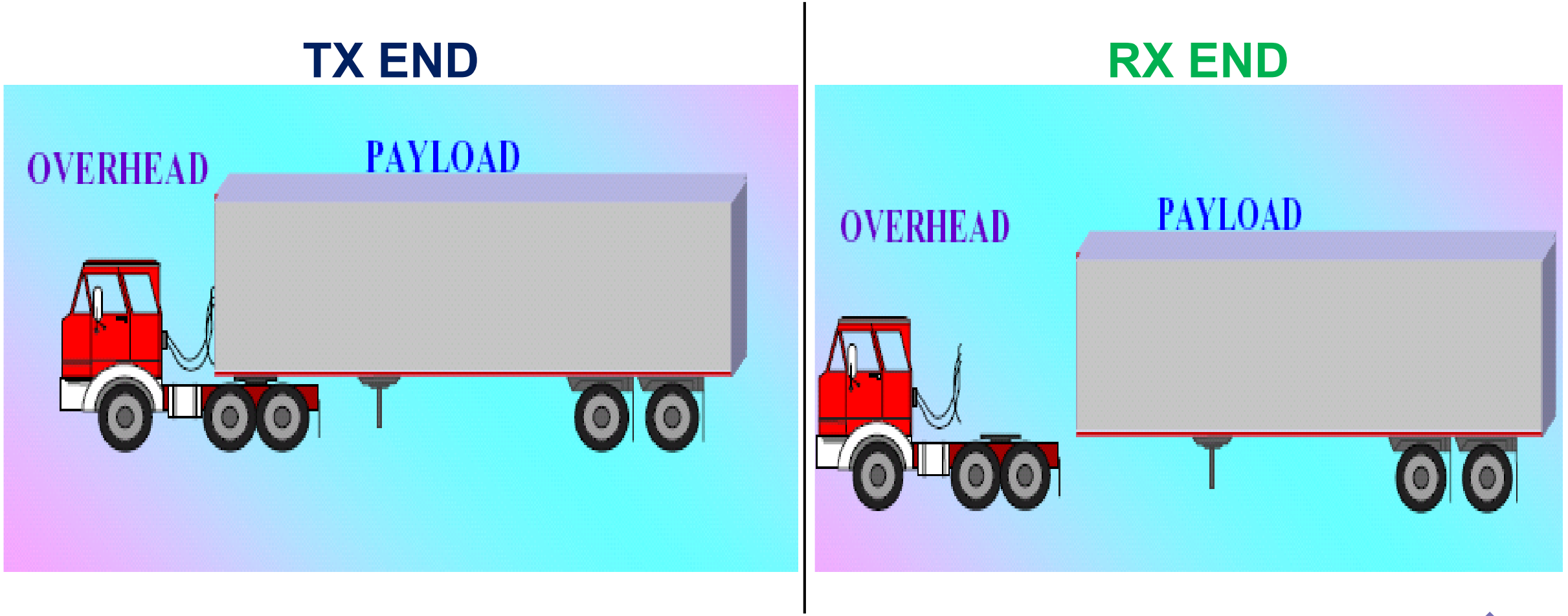
Optical Signal	Bit Rate	Abbreviated as
STM-1	155.52 Mbps	155 Mbps
STM- 4	622.080 Mbps	622 Mbps
STM-16	2488.320 Mbps	2.5 Gbps
STM-64	9953.280 Mbps	10 Gbps
STM-256	39813.12 Mbps	40 Gbps

STM-1 Frame Structure

- STM-1 (SYNCHRONOUS TRANSPORT MODULE) frame is the basic transmission format for SDH.
- Each frame lasts for 125 µsec. Therefore, there are 8000 frames per second.
- SDH signal is transported as a synchronous frame structure which comprises a set of bytes organized into a 2-Dimensional frame of 9 rows and 270 columns.
- STM-1 frame consists of two parts → Section Overhead (SOH) and Virtual Container (VC).

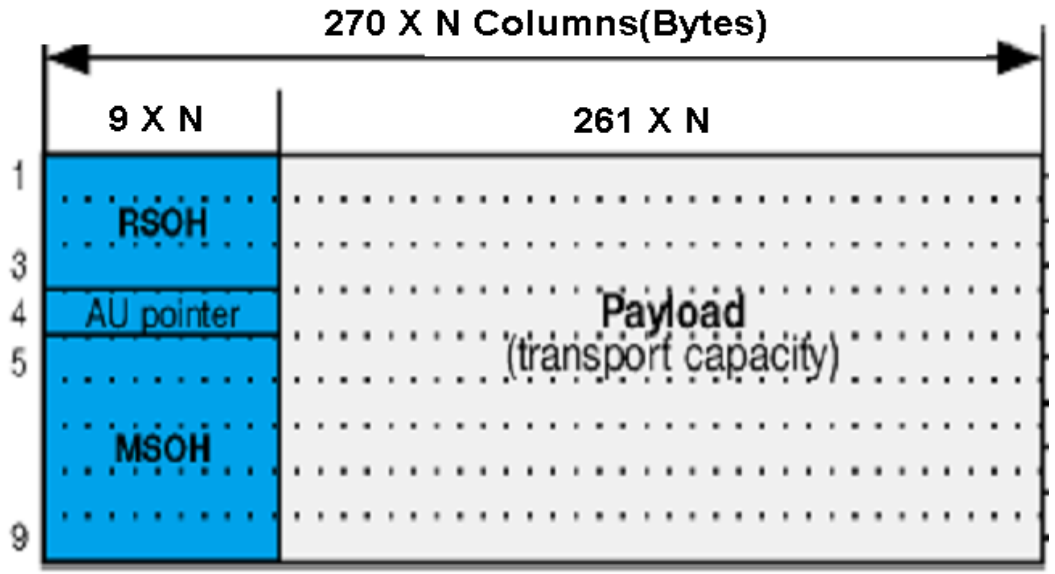


STM-1 Frame Structure: Overhead & Payload

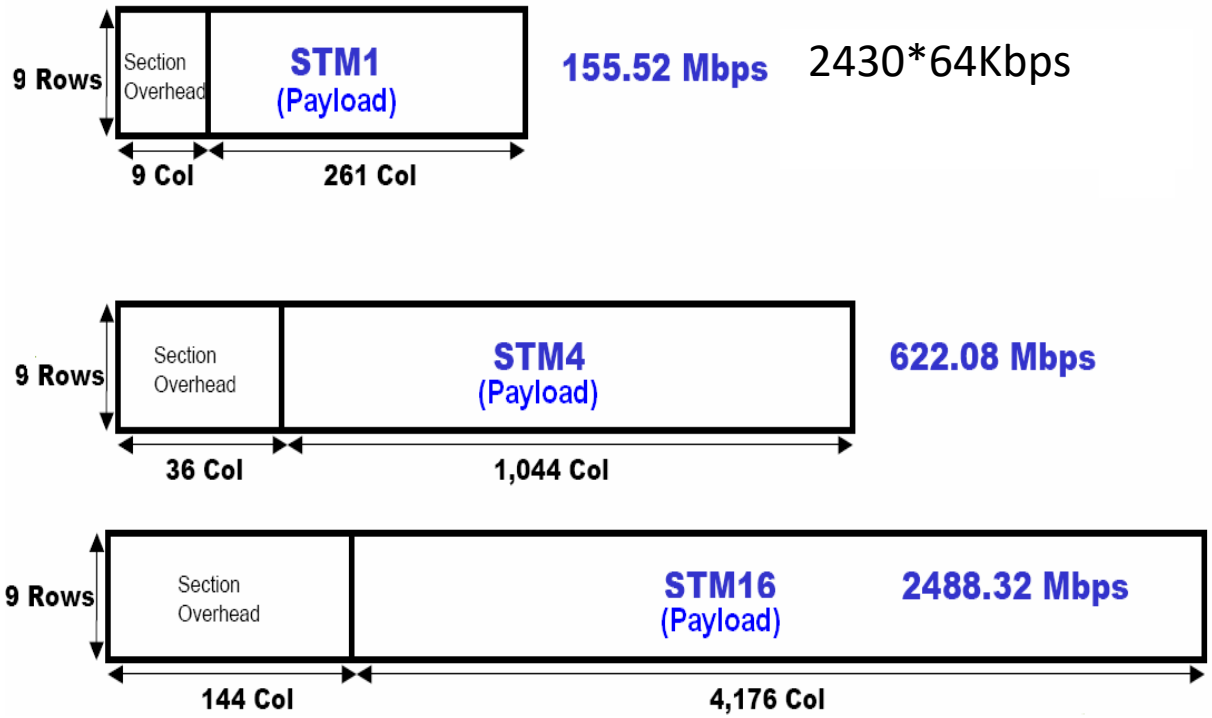


STM-N Frame Structure

- Similar to STM-1 frame, each STM-N frame also lasts for 125 µsec. with 8000 frames per second.
- STM-N frame is also organized as a 2-dimensional frame structure with 9 rows and (270 x N) columns.



STM-N Frame Structure

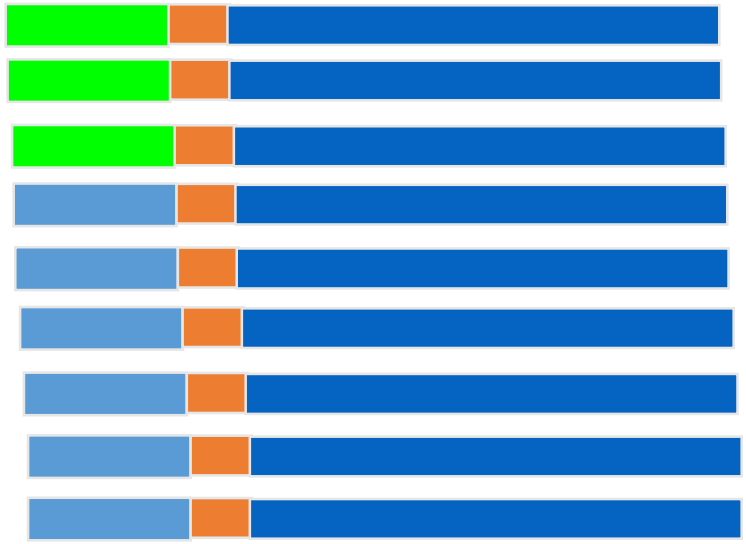


STM-N Frame Transmission

- STM-N frame is transmitted as serial stream of frames.
- Bytes in the STM-N frames are transmitted

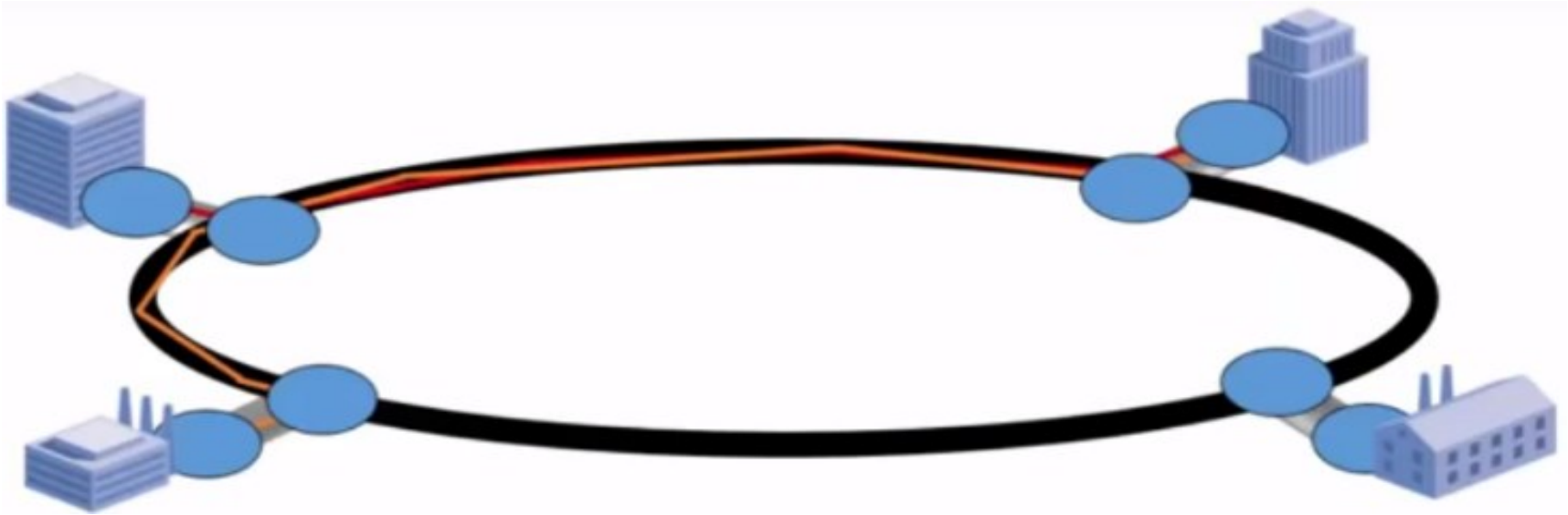
  Left …… Right

  Top …….... Bottom



STM-N Frame Transmission Format

Building Blocks in SDH Network



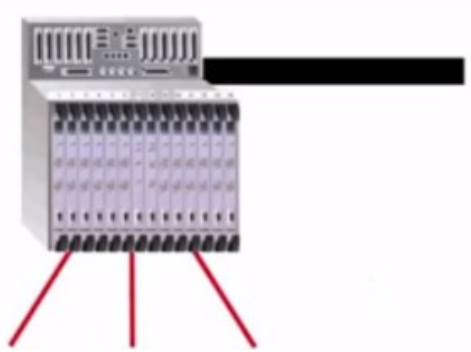
- At each point there is a network element (NE)
- Each NE moves signals between optical fibers
- Each NE has a number of high speed connectors (lines) and a number of low speed ones (Tributaries)
- The type of NE is based on the number and type of connections

Building Blocks in SDH Network (Contd..)

- Regenerator (Reg.)
- Terminal Multiplexer (TM)
- Add/Drop Multiplexer (ADM)
- Digital Cross Connect (DXC)

Building Blocks in SDH Network (Contd..)

- **Terminal Multiplexer (TM)**



- ✓ Combines Plesiochronous and Synchronous input signals into higher bit rate STM-N signal
- ✓ Inputs : One High Speed Line/ Many Lower Speed Tributaries
- ✓ Connections : Line to Tributaries

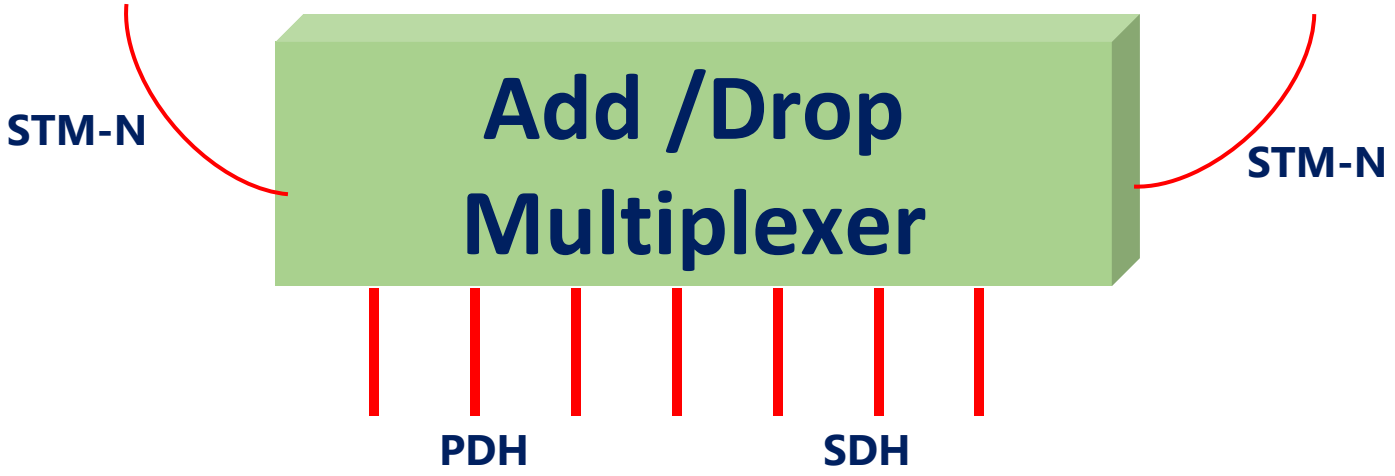
Building Blocks in SDH Network (Contd..)

- **Regenerator (Reg.)**

- ✓ Regenerates the clock and amplitude of incoming distorted and attenuated signal
- ✓ Derives the clock signal from incoming data stream
- ✓ Re-sends the data in required direction

Building Blocks in SDH Network (Contd..)

- **Add/Drop Multiplexer (ADM)**



- ✓ Extraction from and insertion into high speed SDH bit streams of Plesiochronous and lower bit rate synchronous signal
- ✓ Ring structure of network which provides automatic backup through path switching in the event of fault
- ✓ Inputs : Two High Speed Line/ Many Lower Speed Tributaries
- ✓ Connections : Line to Line/ Tributaries to Line
- ✓ Also called Ring/ Drop Insert RDI

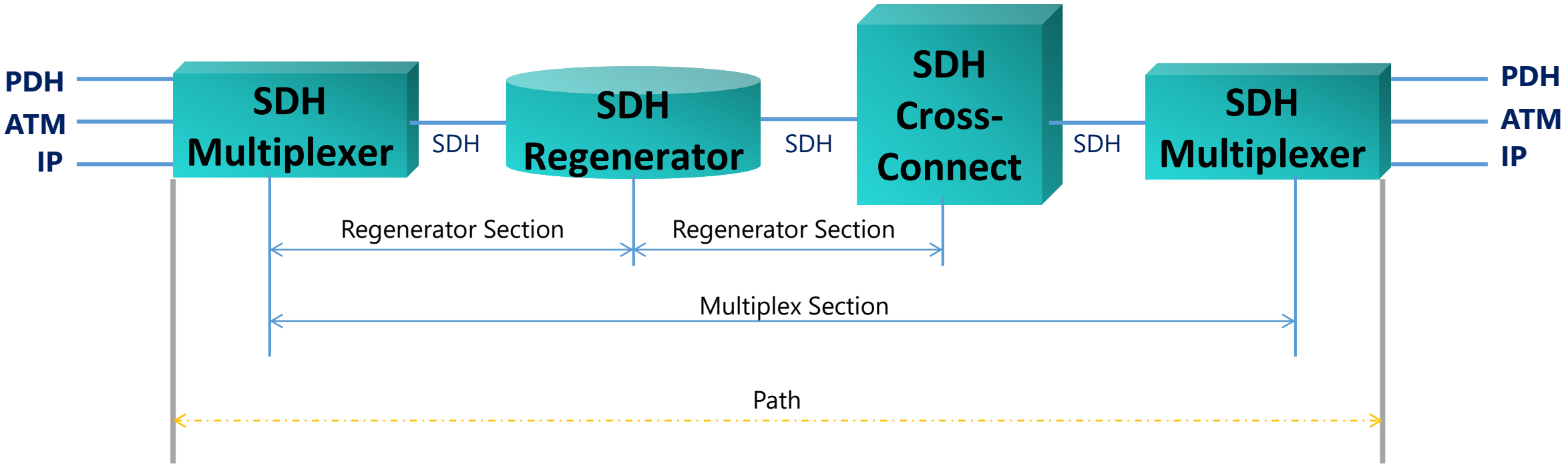
Building Blocks in SDH Network (Contd..)

- **Digital Cross Connect (DXC)**

- ✓ Ability to increase the aggregation
- ✓ Inputs : Any number of connectors
- ✓ Connections : Any to Any => Trib - Trib, Agg - Agg, Trib – Agg
- ✓ Also called LXC (Large Cross Connect) / DACS (Digital Access Cross Connect

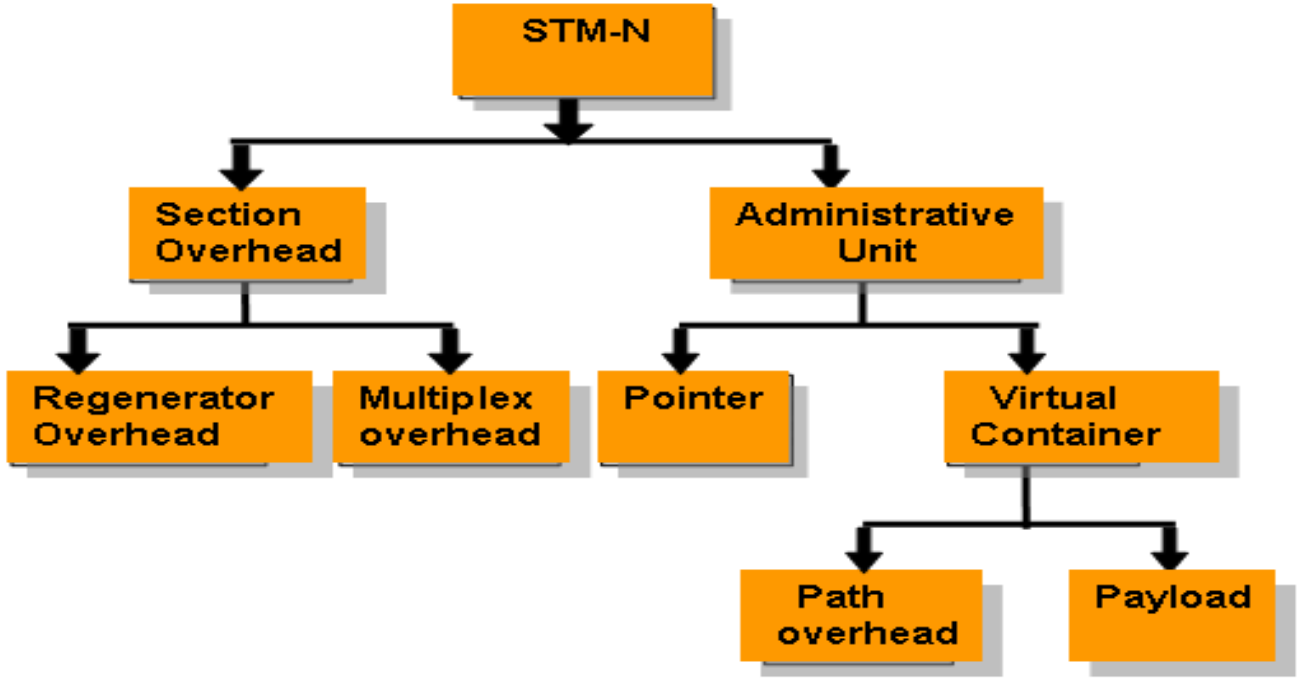
Building Blocks in SDH Network (Contd..)

Layered Architecture of SDH



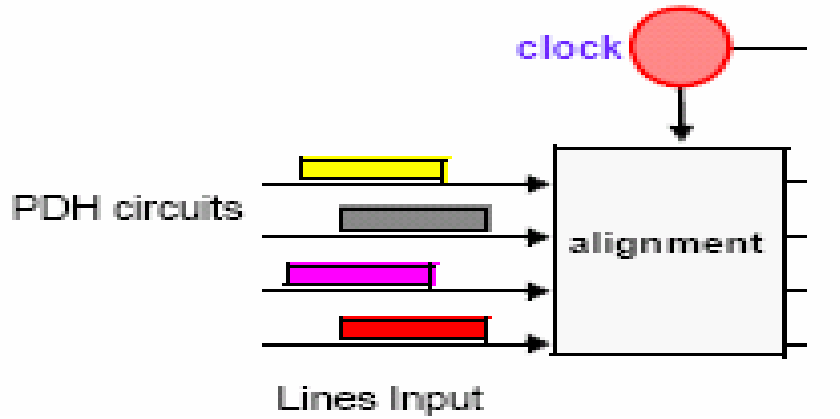
STM-N Frame Format

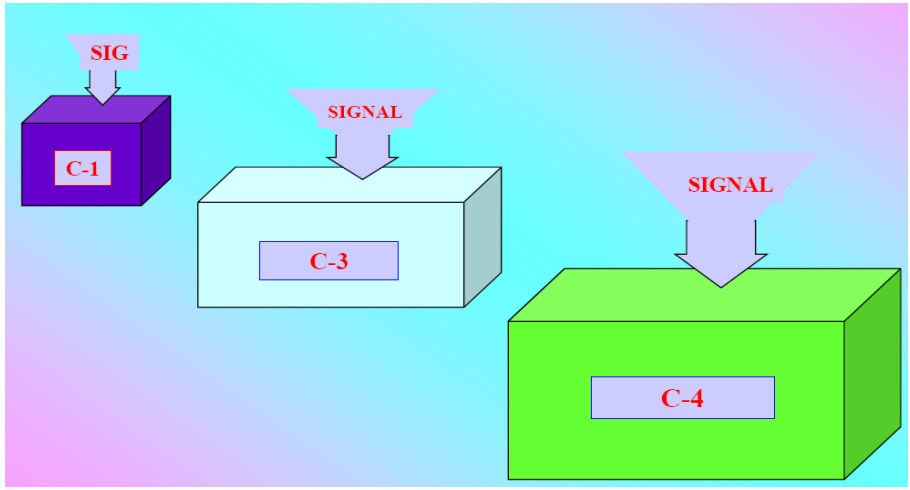
- STM-N → Section Overhead and Administrative Unit.
- Section Overhead → Regenerator Section Overhead and Multiplex Section Overhead.
- Administrative Unit → Virtual Container and Pointers.
- Virtual Container → Payload and Path Overhead information.
- 1 Byte = 8bits * 8000 frames/sec = 64 Kbps



Basic Mapping Elements (E1 into STM-1)

- The process of matching the signals to the network is called Mapping
- Container-n (C-n) => Basic packaging unit for tributary signals (PDH), special container is provided for individual traffic signal. Usually larger than the payload to be transported
- A container is the network synchronous information payload formed by adding justification (stuffing bits) in order to equalize out timing inaccuracies in PDH signals
- There are various containers to support different traffic. C-11 (for DS1 traffic-1.544 Mbps), C-12 (E1 tarfic-2.048 Mbps), C-2 (for DS2 traffic-6.312 Mbps), C-3 (for E3 traffic-34.368 Mbps or DS3 traffic-44.736 Mbps), C-4 (for E4/DS4 traffic-139.264 Mbps).



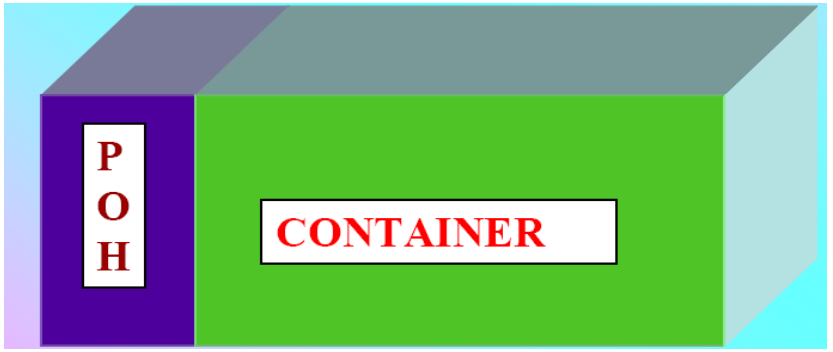


Container-n (C-n)

Basic Mapping Elements (Contd..)

Virtual Container (VC) :

- A Virtual Container (VC) is formed by adding Path Overhead (POH) to the Container.
- It is the information structure used to support path layer connections in SDH.
- There are two types of Virtual Containers. Lower order VC (VC-11, VC-12, VC-2) and Higher order VC (VC4, VC-3).



Virtual Container-n (VC-n)

Tributary Unit (TU-n) :

- By adding a pointer to the lower order VC (VC-11/ VC-12/ VC-2), a Tributary Unit is formed.
- Pointer allow the first byte of the Virtual container to be located.

Tributary Unit Group (TUG) : combines several Tributary Units to form a Tributary Unit Group (TUG) in turns to form a new VC (higher order VC).

Administrative Unit (AU) : is shaped if a pointer is allocated to the VC formed at last (i.e. a pointer is allocated to allow the 1st byte of higher order VC to be located.

Basic Mapping Elements (Contd..)

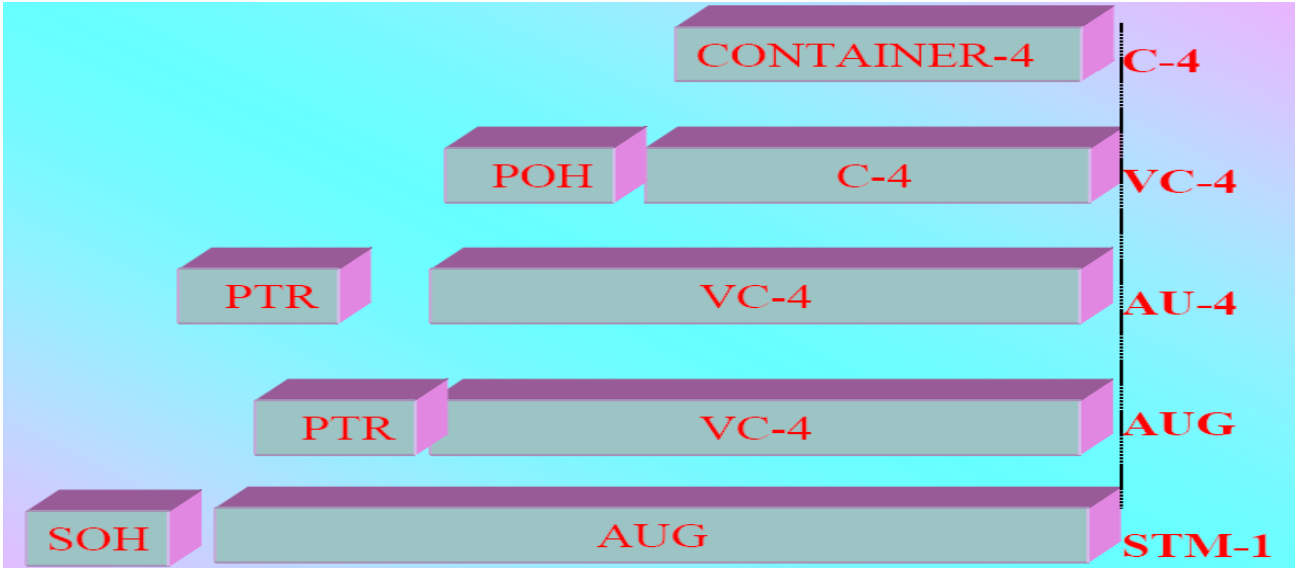
Administrative Unit Group (AUG) :

Combines several Administrative Units to form a Administrative Unit Group (AUG) to form a higher order STM signal.

Administrative Unit

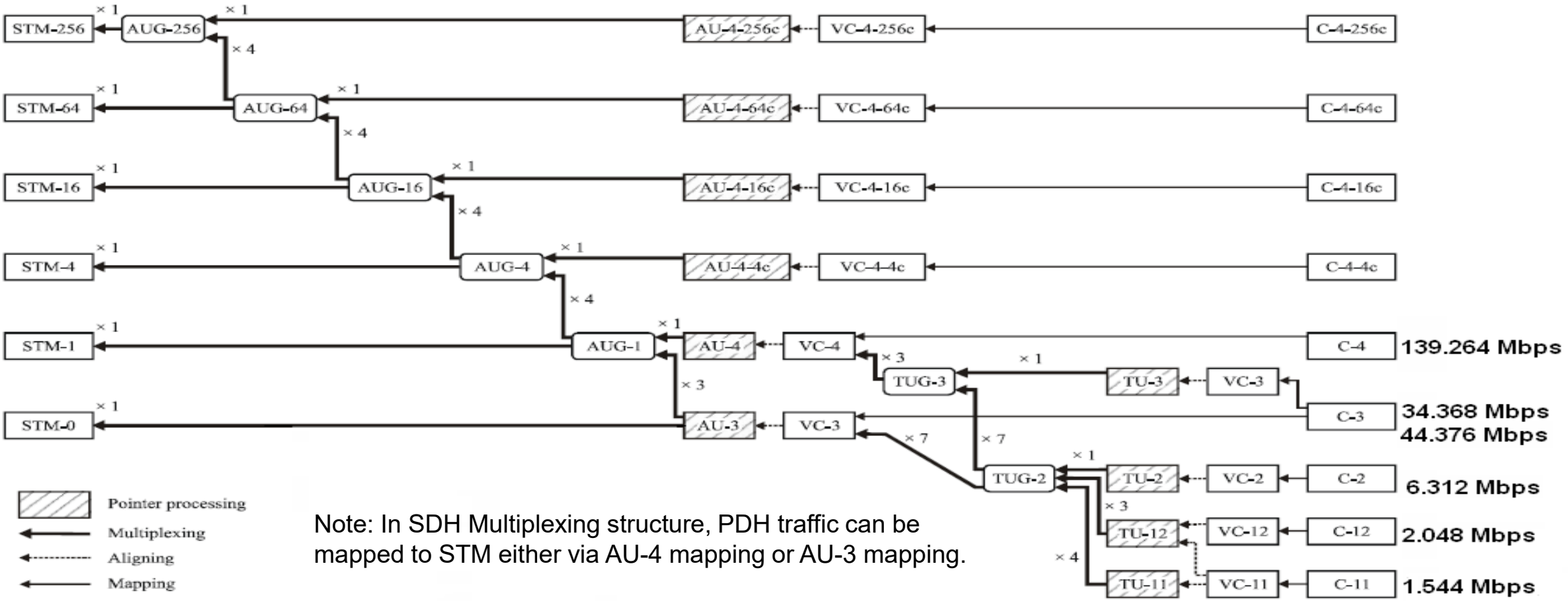
Synchronous Transport Module (STM):

Formed by adding section overhead (SOH) to AUG.



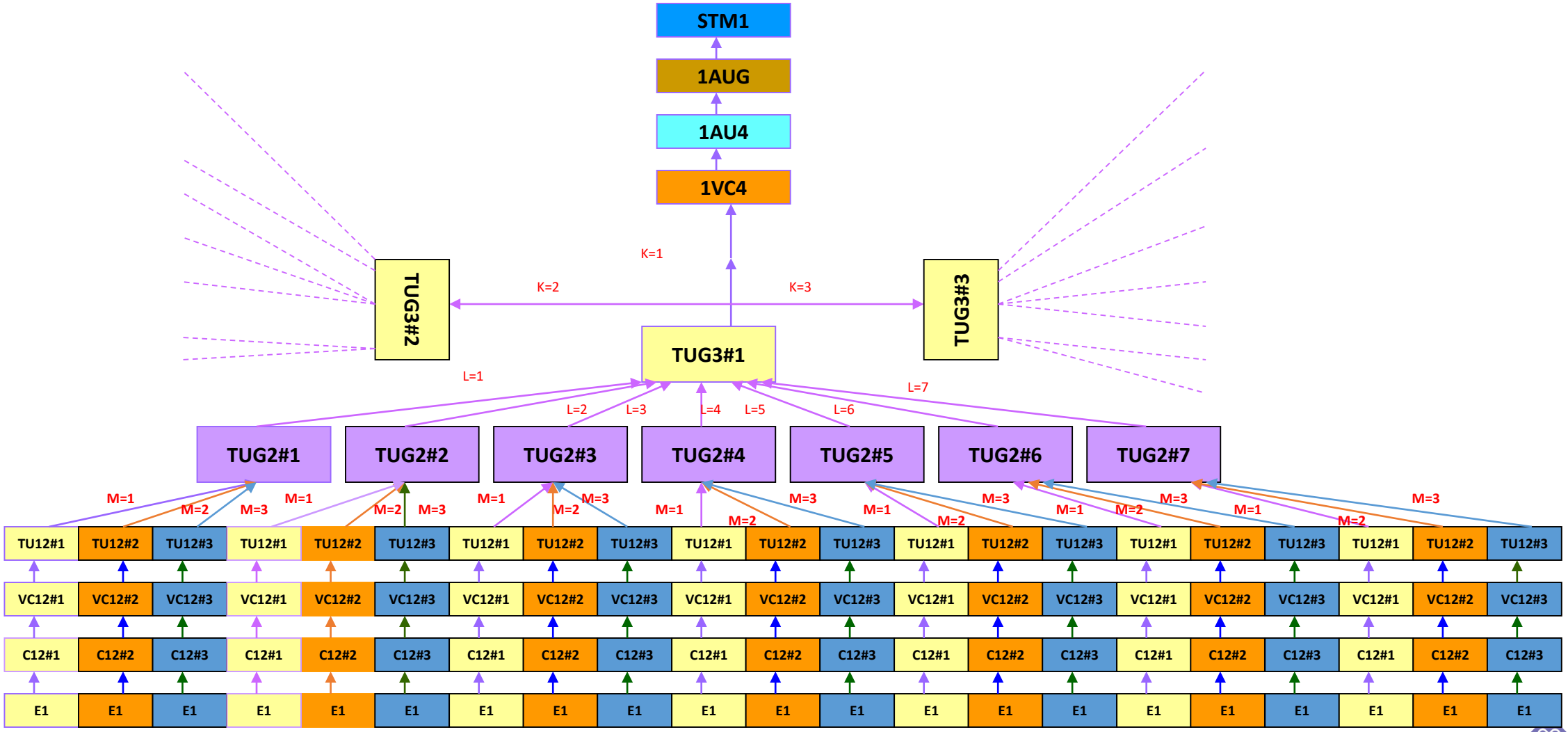
Mapping of C-4 to STM-1

SDH Multiplexing Structure



Note: In SDH Multiplexing structure, PDH traffic can be mapped to STM either via AU-4 mapping or AU-3 mapping.

SDH Multiplexing Structure (Contd..)



Objective : Pointer and Overheads

- Regenerator Section Overheads
- Multiplex Section Overheads
- Pointers
- Path Overheads

Why Overheads

- Monitoring and Alarm
- Framing
- Error management
- Data communication management
- Protection

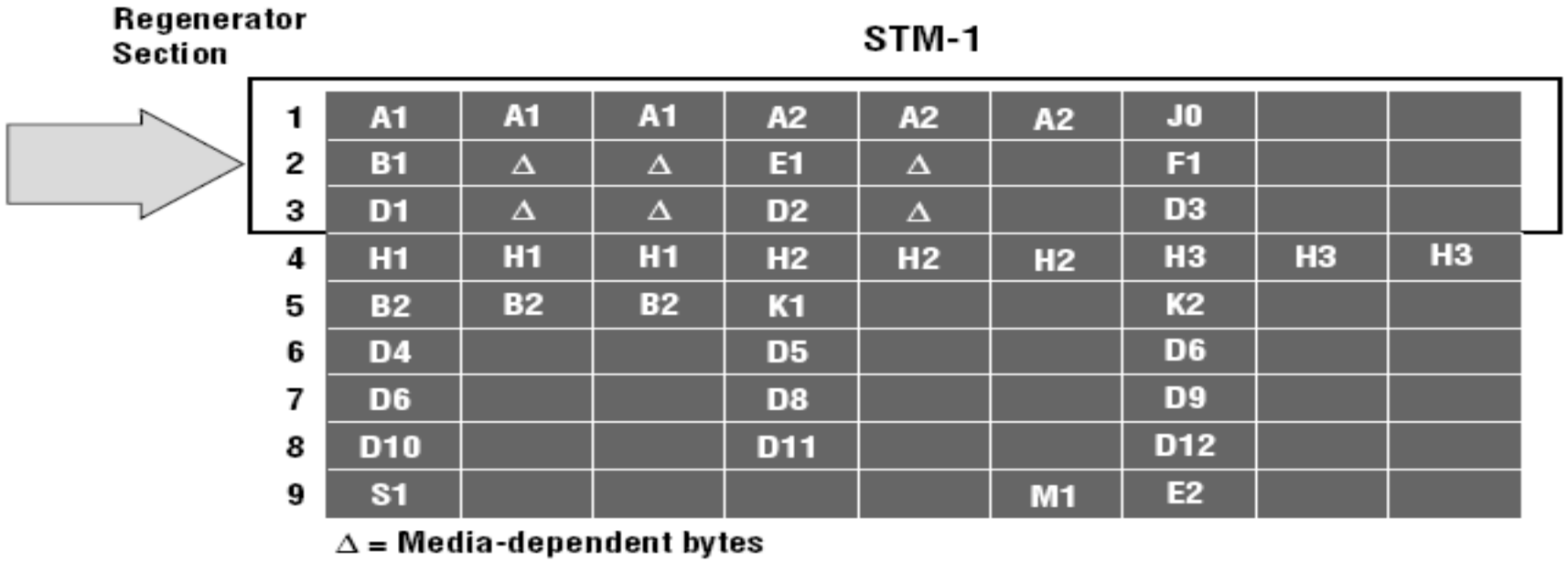
Section Overheads

- The SDH Section overheads are found in the first (9 x N) columns and 9 rows of the STM-N frame.
- The Section overheads of the STM-N frame can be divided into two parts.
  - Regenerator Section Overheads (RSOH)
  - Multiplex Section Overheads (MSOH)

Regenerator Section Overheads

- The Regenerator Section Overhead (RSOH) contains only the information required for elements located at both ends of the section.

- The RSOH is found in first 3 rows of columns 1 to 9 of the STM-1 frame.



Regenerator Section Overhead

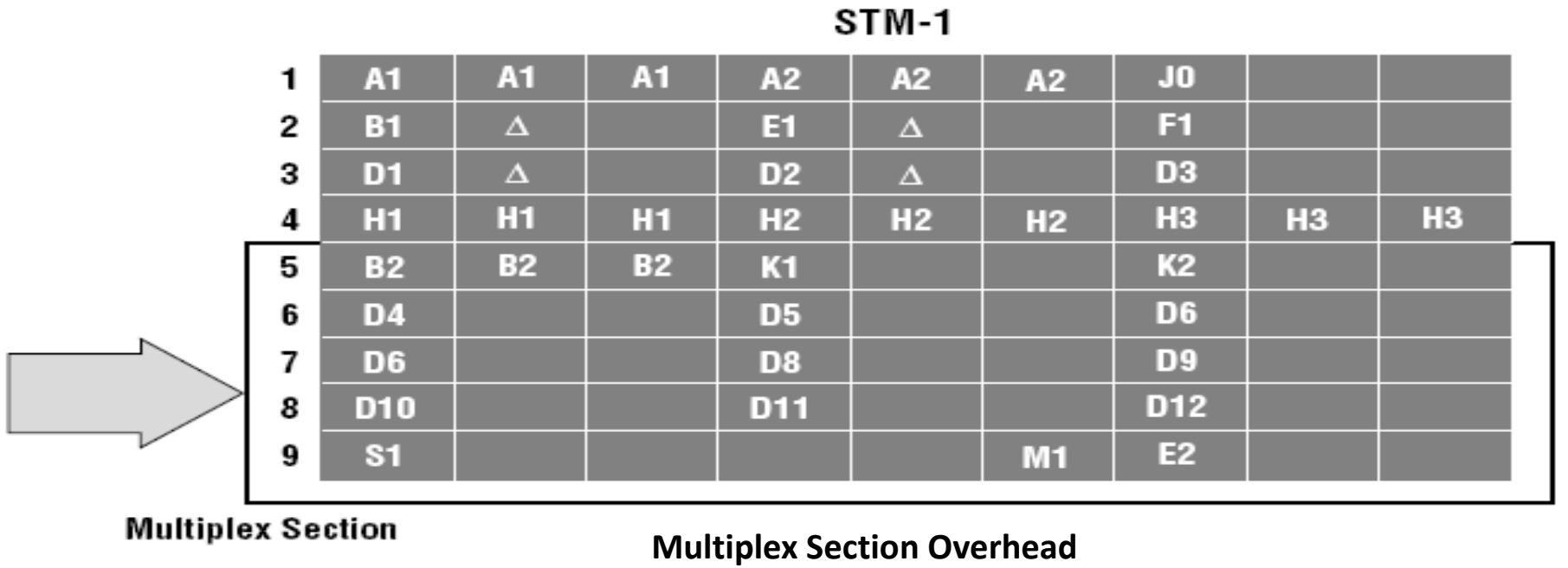
Regenerator Section Overheads (Contd..)

BYTE(S)	DESCRIPTION
A1, A2 (Framing Bytes – Frame Alignment Word)	▪ These two bytes indicate beginning of the STM N frame. ▪ A1 and A2 bytes have values F6 and 28 (in Hex) respectively. ▪ The frame alignment word of STM N frame is composed of (3xN) A1 bytes followed by (3 x N) A2 bytes.
J0 (Regenerator Section Trace Message)	▪ Used to transmit a 16 byte Section Access Point Identifier, so that a section receiver can verify its continued connection to the intended transmitter => Defined only for STM-1 number 1 of an STM N signal
B1 (RS Bit Interleaved Parity – BIP 8)	▪ An even parity code used to check transmission errors over a RS, calculated over all the bits of the previous STM-N frame and placed in B1 byte of current STM-1 frame => Defined only for STM-1 number 1 of STM-N signal.
E1 (RS Engineering Order wire)	▪ Provides a 64 Kbps order wire channel for voice communication (may be accessed at regenerators) => Defined for STM 1 of a STM N signal.
F1 (RS User Channel byte)	▪ This byte is set aside for user's purposes to provide temporary data communication channel for maintenance purposes => Defined for STM 1 of a STM N signal
D1, D2, D3 (RS Data Comm Channel – DCC bytes)	▪ These 3 bytes (DCC-R) form a 192 Kbps message channel for OAM purposes between pieces of section terminating equipment => Defined for STM 1 of STM N signal

Multiplex Section Overheads

- The Multiplex Section Overhead (MSOH) contains information required between the multiplex section termination equipment at each end of the multiplex section.

- MSOH is found in rows 5 to 9 of columns 1 through 9 of the STM 1 frame.



Multiplex Section Overheads (Contd..)

BYTE(S)	DESCRIPTION
B2 (MS Bit Interleaved Parity – BIP 24)	▪ This is calculated over all the bits of the previous STM N frame excluding RSOH and placed in the B2 bytes of the current STM N frame to determine transmission errors over MS. ▪ In a STM N signal there are (3 x N B2 bytes).
D4-D12 (MS Data Communication Channel Bytes)	▪ These 9 bytes (DCC-M) form a 576 Kbps message channel for OAM purposes between pieces of multiplex section terminating equipment => Defined for STM 1 of STM N signal.
M1 (MS Remote Error Indication)	▪ Bits 2-8 of the M1 byte are used to carry the error count of the interleaved bit blocks that the MS BIP-24 X N has detected to be in error at the far end of the section. ▪ For STM1, STM4, STM16 only M1 byte is provided. For STM64, STM256 => M0
E2 (MS order wire)	▪ Provides a 64 kbps channel for voice communication for maintenance purposes accessed at multiplex section terminations => Defined only for STM 1 of a STM N signal
S1 (Synchronization Status Message)	▪ Bits 5-8 of this byte carry synchronization messages. Following is the assignment of bit patterns to the four synchronization levels Bits 5-8 : 0000 => Quality unknown (existing sync. Network) 0010 => PRC || 0100 => SSU-A || 1000 => SSU-B || 1011 => SEC || 1111 => DNU => Defined for STM 1 of a STM-N signal.

Multiplex Section Overheads (Contd..)

K1 and K2 (APS bytes) →

- These bytes are used for MSP signaling between multiplex level entities for bi-directional protection switching. => Defined for STM 1 of STM N signal.
- Also used for communicating alarm indications MS-RDI or MS-AIS.

K1 Byte		
Bits	1-4	Type of request
	1111	Lock out of Protection
	1110	Forced Switch
	1101	Signal Fail – High Priority
	1100	Signal Fail – Low Priority
	1011	Signal Degrade – High Priority
	1010	Signal Degrade – Low Priority
	1001	(not used)
	1000	Manual Switch
	0111	(not used)
	0110	Wait-to-Restore
	0101	(not used)
	0100	Exercise
	0011	(not used)
	0010	Reverse Request
	0001	Do Not Revert
	0000	No Request
Bits	5-8	Indicate the number of the channel requested

K2 Byte		
Bits	1-4	Selects channel number
Bit	5	Indication of architecture
	0	1+1
	1	1:n
Bits	6-8	Indicate mode of operation
	111	MS-AIS
	110	MS-RDI
	101	Provisioned mode is bi-directional
	100	Provisioned mode is unidirectional
	011	Future use
	010	Future use
	001	Future use
	000	Future use

Advantages

- High speed standards.
- Efficient Multiplexing /De multiplexing.
- Enhanced Operation, administration, Provisioning, Maintenance capabilities (OAM & P).
- A reduction in the amount of equipment.
- The provision for overhead and payload bytes.
- Synchronous multiplexing format for carrying lower-level digital signals is justified.
- The availability of a set of generic standards, which enable multi-vendor interoperability.

Tejas Supports Next Generation SDH

- Supports data(Ethernet) as well as voice.
- No need for separate data infrastructure.
- Use of GFP, VCAT, LCAS, Auto Negotiation.

Acronyms

- SDH- Synchronous Digital Hierarchy
- STM- Synchronous Transport Module
- RSOH- Regenerator Section Overheads
- MSOH- Multiplex Section Overheads
- STM- Synchronous Transport Module
- BIP- Bit Interleaved Parity
- EOW- Engineering Order Wire
- DCC- Digital Communication Channel
- OAM- Operation, Administration & Management
- REI- Remote Error Indication
- RFI- Remote Failure Indication
- RDI- Remote Defect Indication
- SSM- Synchronous Status Machine
- PRC- Primary Reference Clock
- SSU- Synchronization Supply Unit
- SEC- System Equipment Clock
- DNU- Do Not Use
- APS- Automatic Protection Switching
- VC- Virtual Container
- AU- Administrative Unit
- PPJ- Positive Pointer Justification
- NPJ- Negative Pointer Justification
- HPOH- Higher Order Path Overheads
- LPOH- Lower Order Path Overheads
- AIS- Alarm Indication Signal

SDH

Protection Switching Schemes

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Table of content

Network Topologies

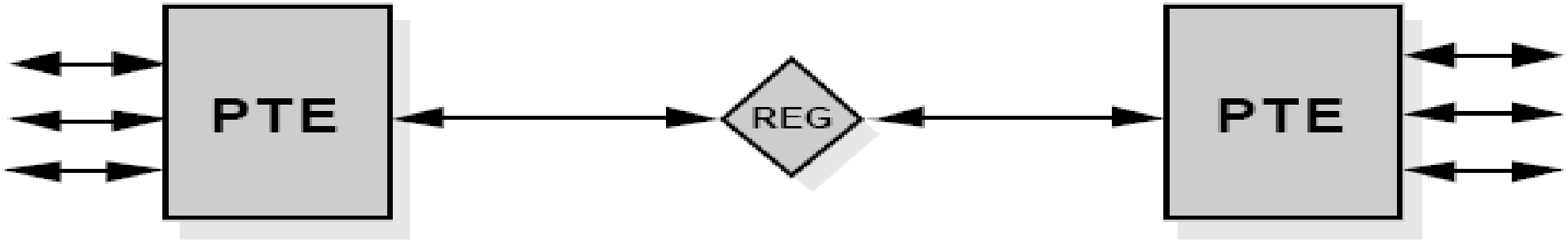
In PDH, natural configuration of the network was point to point. In SDH, various network topologies are possible.

- Point-to-Point
- Point-to-Multipoint
- Ring topology
- Mesh topology

Network Topologies (Contd..)

Point-to-Point

- This is the simplest network configuration involving two terminal multiplexers linked by a fiber with or without a regenerator in the link.
- It is the first approximation easier by directly substituting PDH installations that use this topology.

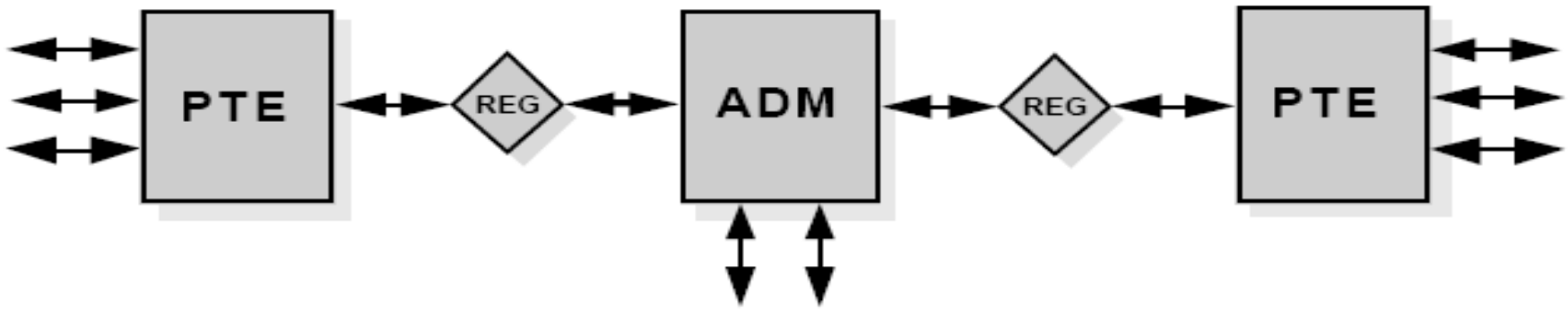


Point-to-Point Network Topology

Network Topologies (Contd..)

Point-to-Multipoint (Linear Add/Drop)

- This architecture includes adding or dropping circuits along the way. SDH ADM is used for this task.
- The ADM is typically placed in a SDH link to facilitate adding and dropping tributary channels at intermediate points in the network.

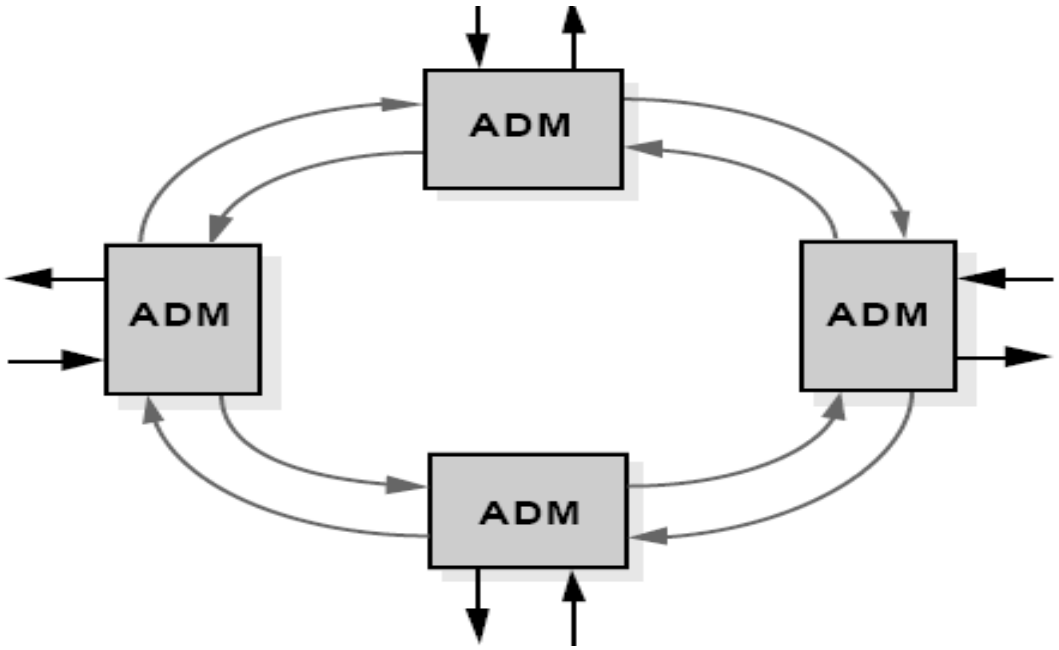


Point-to-Multipoint Topology

Network Topologies (Contd..)

Ring Topology

- The SDH building block for a ring architecture is ADM.
- Multiple ADMs can be put into a ring configuration for either Bi-directional or Uni-directional traffic.
- This setup also lets tributaries to be added and dropped in each node of the network.
- The main advantage of ring topology is its survivability or protection feature.

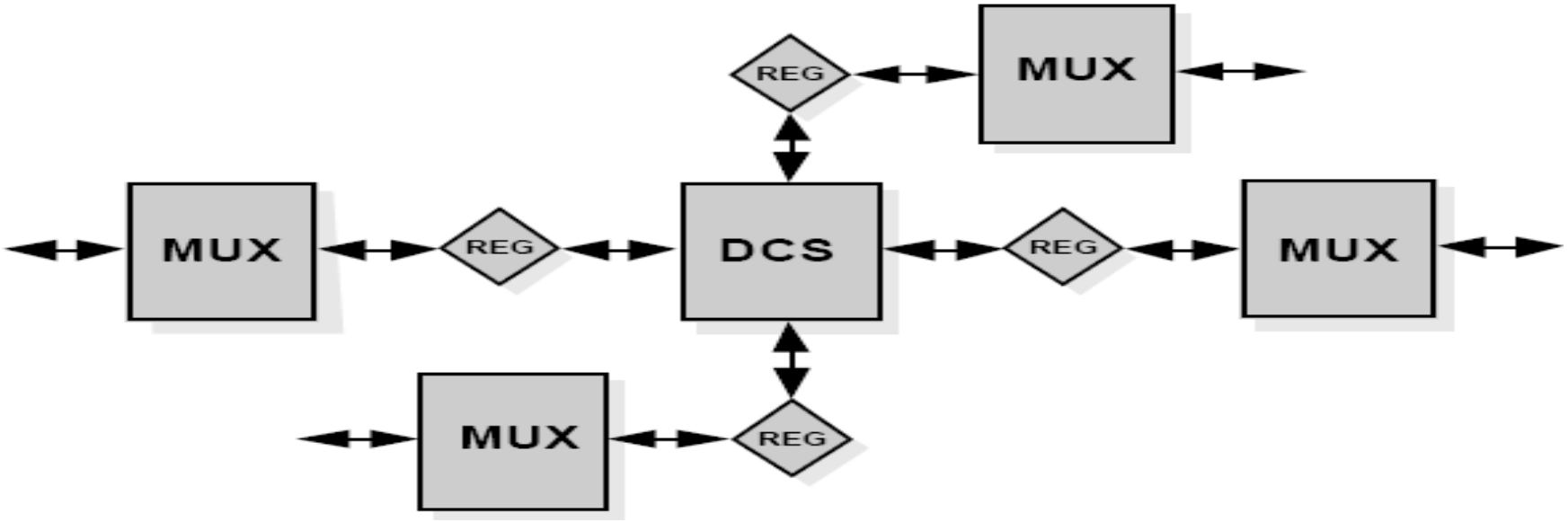


Ring Topology

Network Topologies (Contd..)

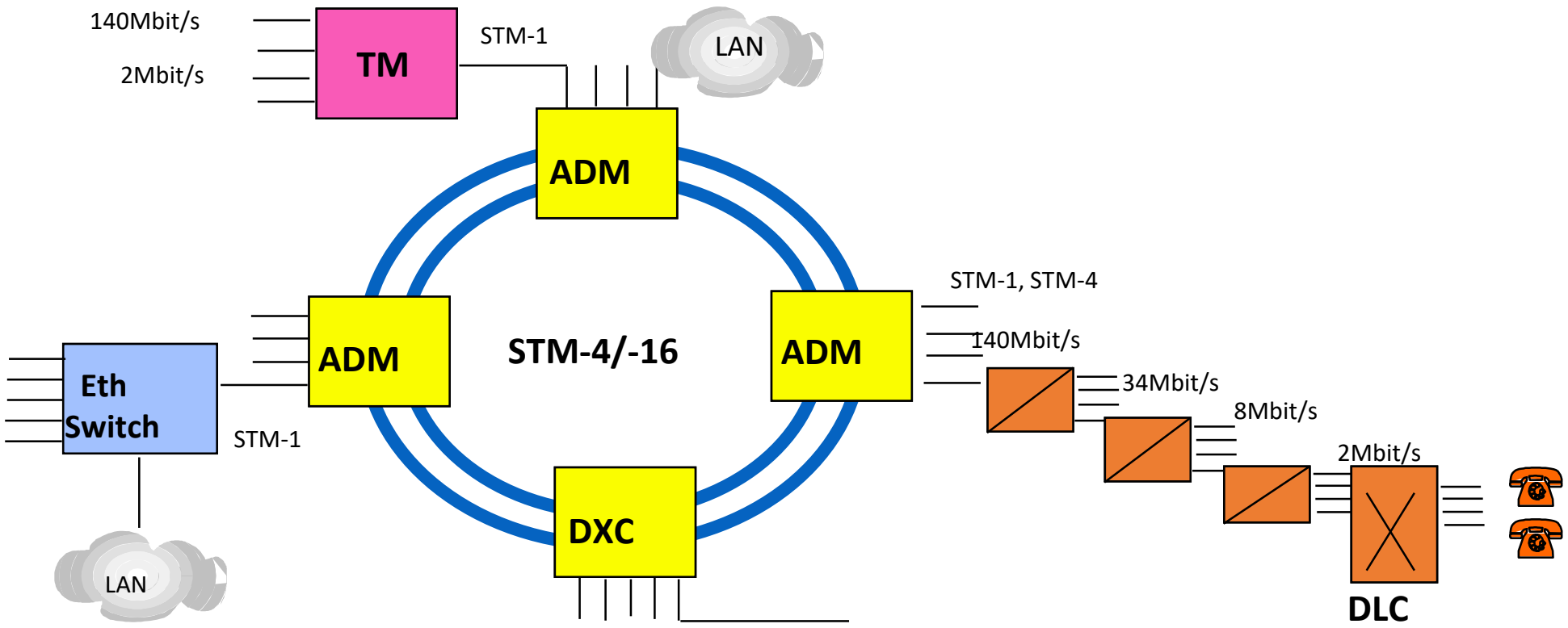
Mesh Topology

- The meshed network architecture accommodates unexpected growth and change more easily than simple point-to-point networks.
- A DXC is used to concentrate the traffic at a central site and allows easy re-provisioning of the circuit



Mesh Topology

Synchronous Network Structure



ADM : Add Drop Multiplexer
DXC : Digital Cross Connect
TM : Terminal Multiplexer
DSC: Digital Switching Center
LAN: Local Area Network

2Mbit/s
34Mbit/s
140Mbit/s
STM-1
STM-4

STM-1 Gateway to another **SDH** ring

Why protection is required?

- A common requirement in any service-level agreement is that the connection be available 99.9999% (**Six 9s**) of up-time. That is a connection down time of < 5 minutes per year.
- Only practical way to achieve this is, to make the network survivable.
- Survivability of a network can be defined as its ability to continue providing service in the presence of failure(s).

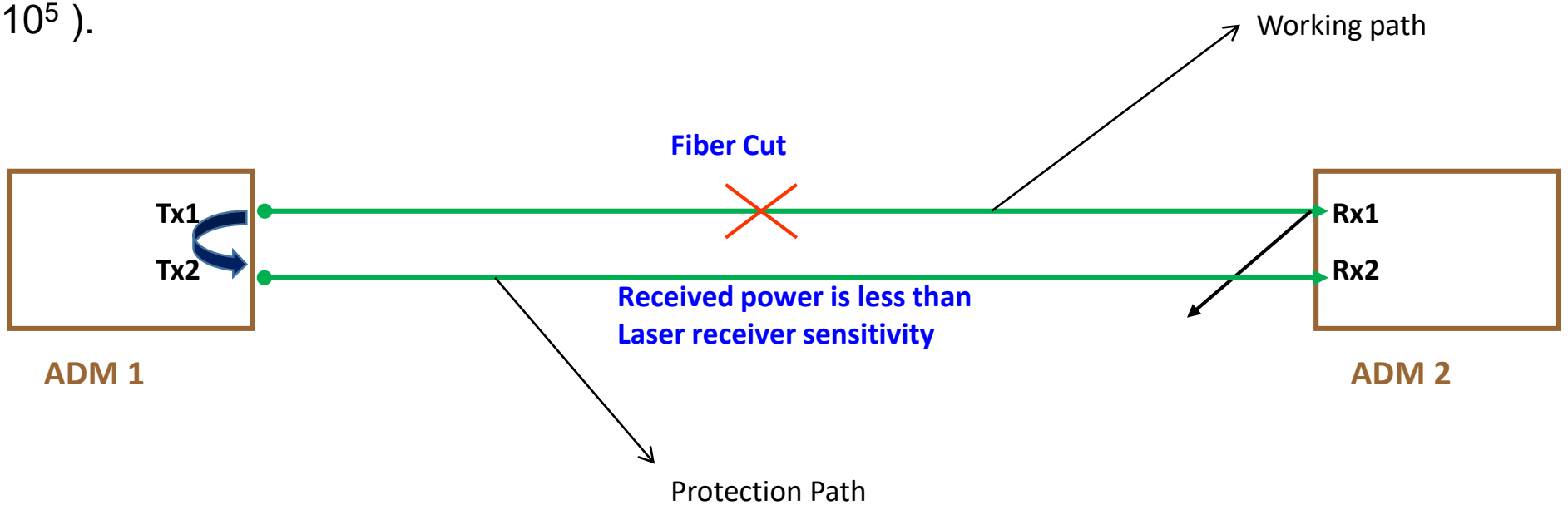
  => A network is survivable if it has a certain degree of survivability.
- Protection is the key technique used to ensure survivability.
- Protection is to provide some redundant capacity (Always??) within a network & automatically reroute traffic around the failure using this redundant capacity.

During Signal degrade(SD) ,Signal Fail(SF) and Fiber Cut

Signal Degrade: This alarm is generated when equivalent BER exceeds alarm generation threshold (1 in 10^6 / 1 in 10^7 /1 in 10^8).

Signal Fail: This alarm is generated when equivalent BER exceeds alarm generation threshold (1 in 10^3 / 1 in 10^4 / 1 in 10^5).

Fiber Cut:



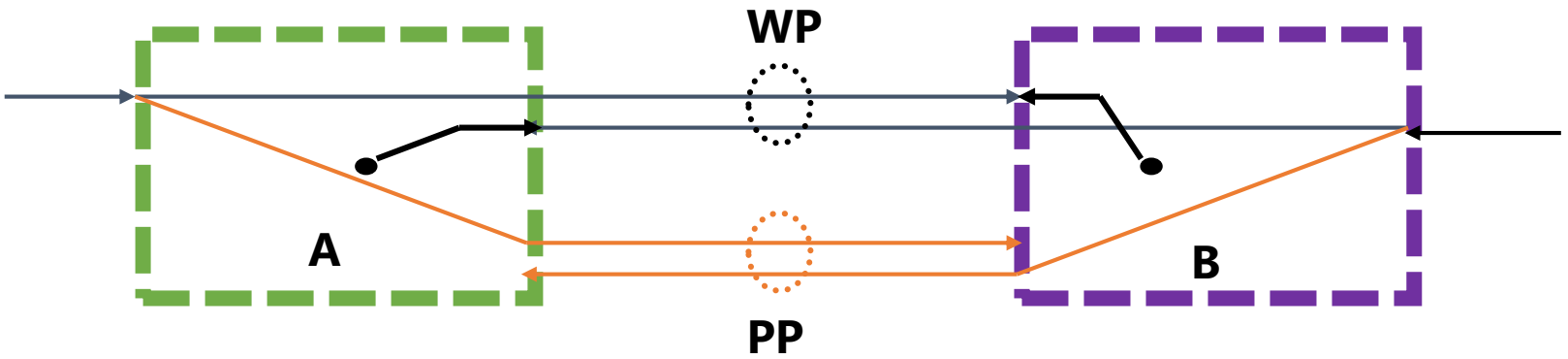
Classifications

- LINEAR
  - 1+1
  - 1:1
  - 1:N
  - 1+1 MSP

- RING
  - SNCP
  - MSSP

Protection Schemes -Linear (1+1)

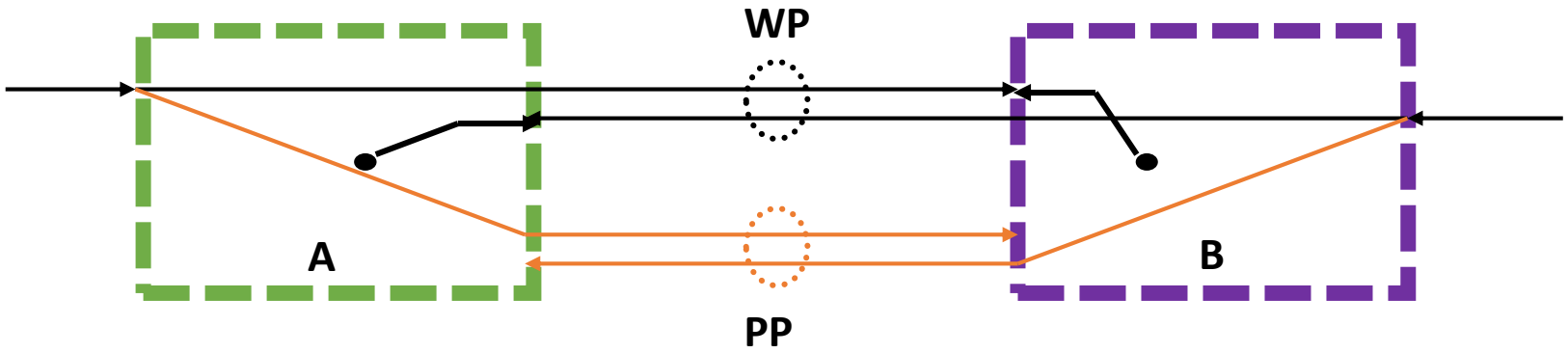
- 1+1 Protection is dedicated type of protection.



- Working Path (WP) → Carry traffic under normal operation.
- 1+1 Protection is based on the principle of Bridging at the sending site and Selection at the receiving site.
- Protection Path (PP)→ Provides alternate paths to carry the traffic in case of failure on WP.
- Working & Protection paths are usually diversely routed (link-disjoint) so that both path are not lost in case of single failure.
- 1+1 protection is fast but requires high bandwidth redundancy (Why ??).

Protection Schemes –Linear (1:1)

➢ 1:1 Protection



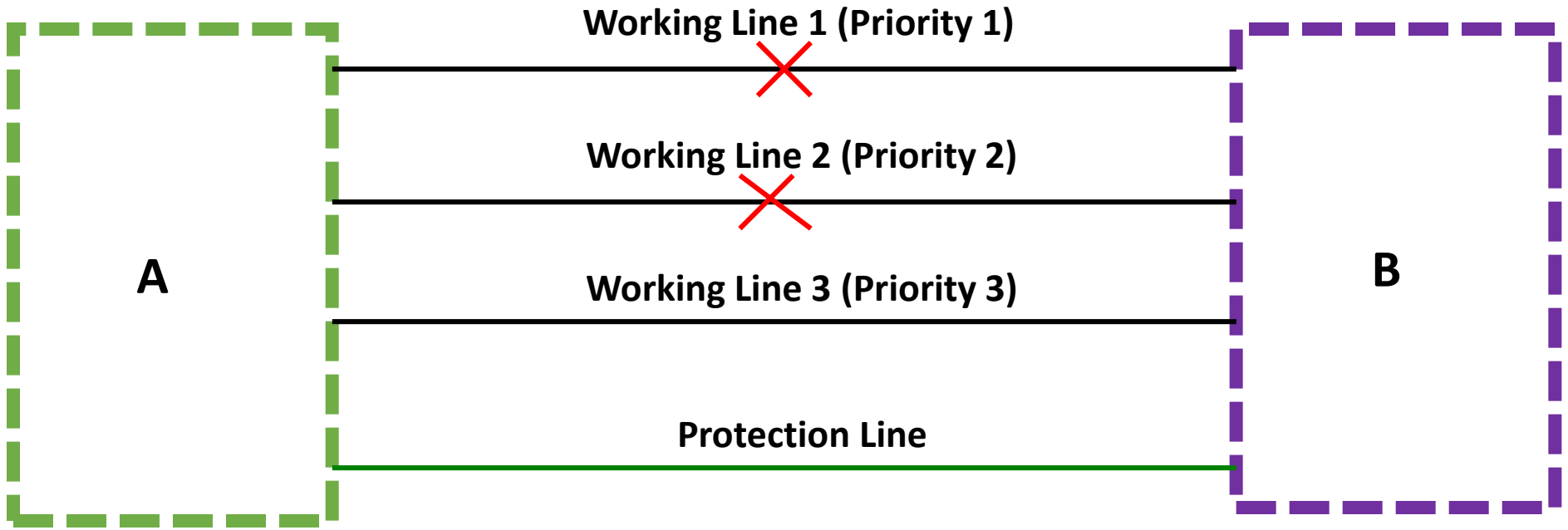
❑ In 1:1 Protection, traffic is carried on the Work Path. If there is a failure on the Work path through APS protocol the traffic is switched to Protect Path.

❑ In the event of fiber cut, the source & the destination both switch over to the other protection fiber.

❑ 1:1 protection is not as quick as 1+1 protection in restoring traffic, but results in a better band width utilization.

Protection Schemes –Linear (1:N)

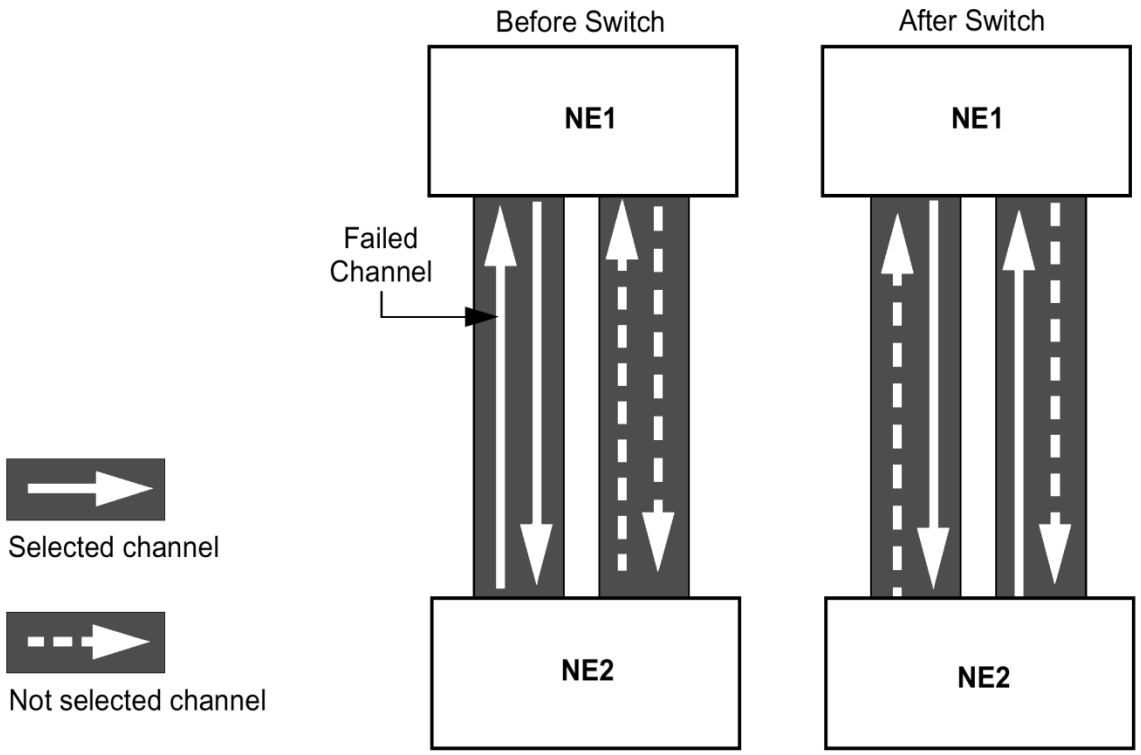
- 1:N protection is a generalization of 1:1 protection in which N working fibers share a single protection fiber.
- Very efficient in terms of bandwidth utilization as some low priority traffic can be sent in normal scenario over protect fiber.



- Now, fault at Working Line 1 causes Protection Line stop servicing Working Line 2 & service Working Line 1, which has a higher priority.

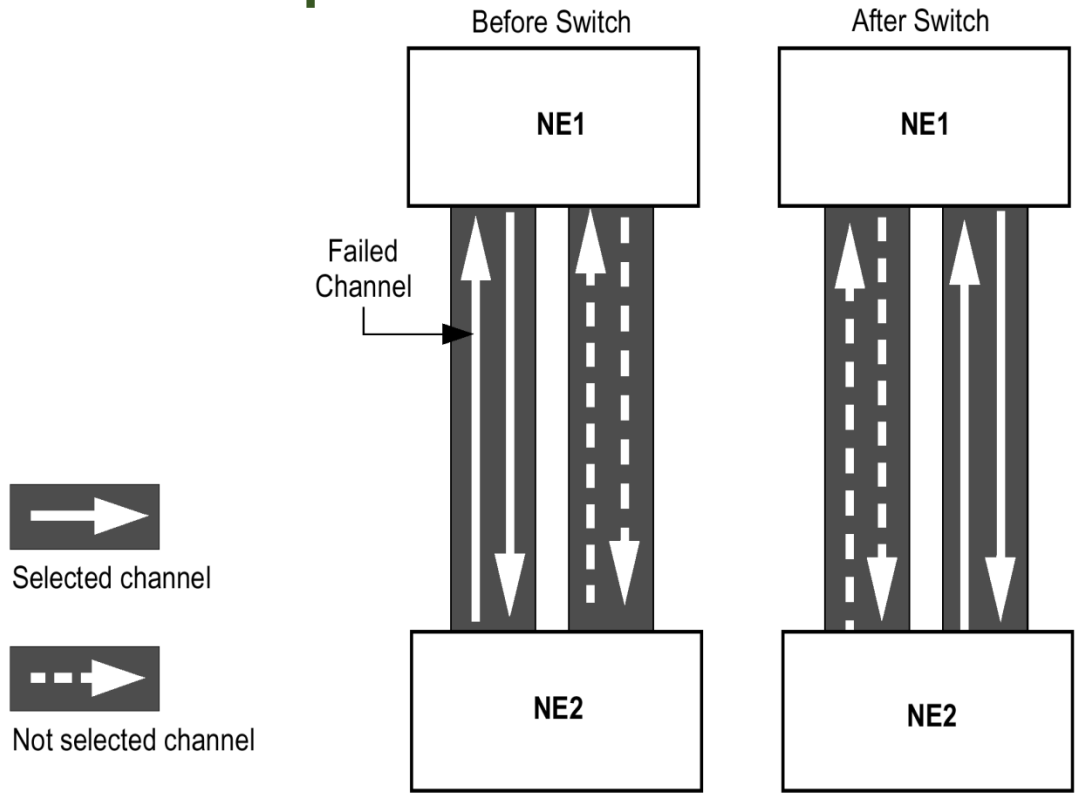
Protection Schemes –Uni/Bidirectional Operation

Unidirectional Operation



In the event of a single fiber cut, only one direction of traffic is switched over to the protection fiber and the other direction remains on the original working fiber. Suitable for dedicated protection schemes.

Bidirectional Operation



In the event of a single fiber cut, both directions of traffic are switched over to the protection fibers. Suitable for shared protection schemes.

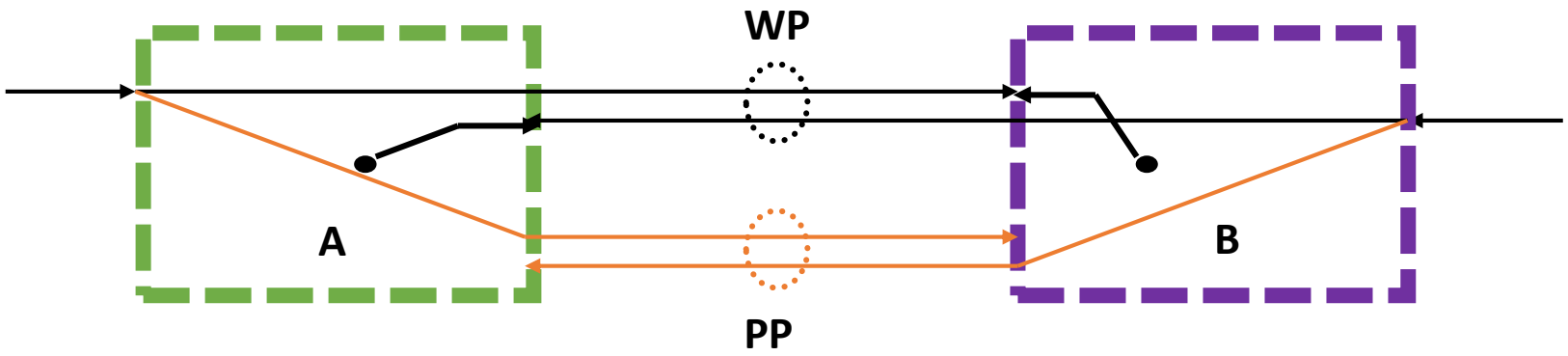
Protection Schemes –Linear (1+1 MSP)

- 1+1 MSP (Multiplex Section Protection) is a port level protection supported on the STM interfaces.
- This is so called “bridging at the sending site, selection at receiving site” function.
- 1+1 MSP works on the principle that multiplexed optical signal is split into two channels of identical signal that are transmitted on work & protected fiber line simultaneously, thus forming a redundant route.
- At the receiving end, an optical switch selects one of the two channels as received signal.
- The protection switching mode can be configured either as revertive & non-revertive mode.
- Non-revertive protection allows the traffic to remain on the protect path even after the working path is repaired.
- Revertive systems restore working traffic on the original path after the Wait To Restore time (WTR).

Protection Schemes –Linear (1+1 MSP) (Contd..)

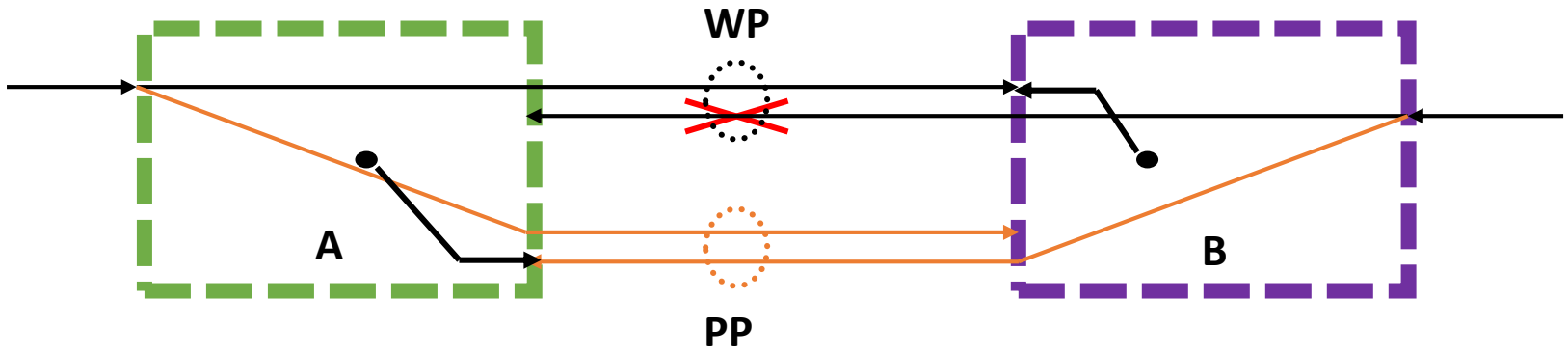
- The MSP groups can be configured as uni-directional or bi-directional.

Normal Operation:



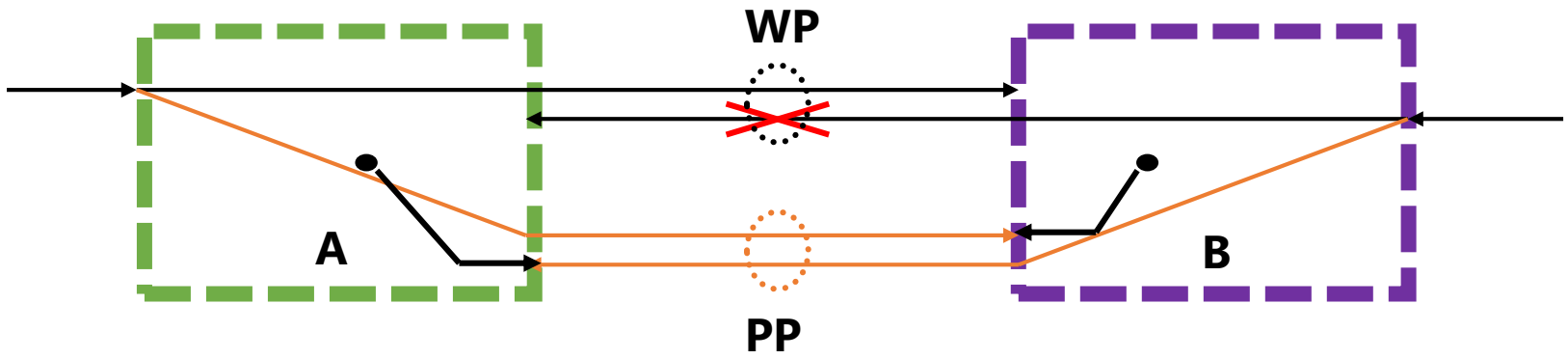
Protection Schemes –Linear (1+1 MSP) (Contd..)

- Switching in case of uni-directional configuration

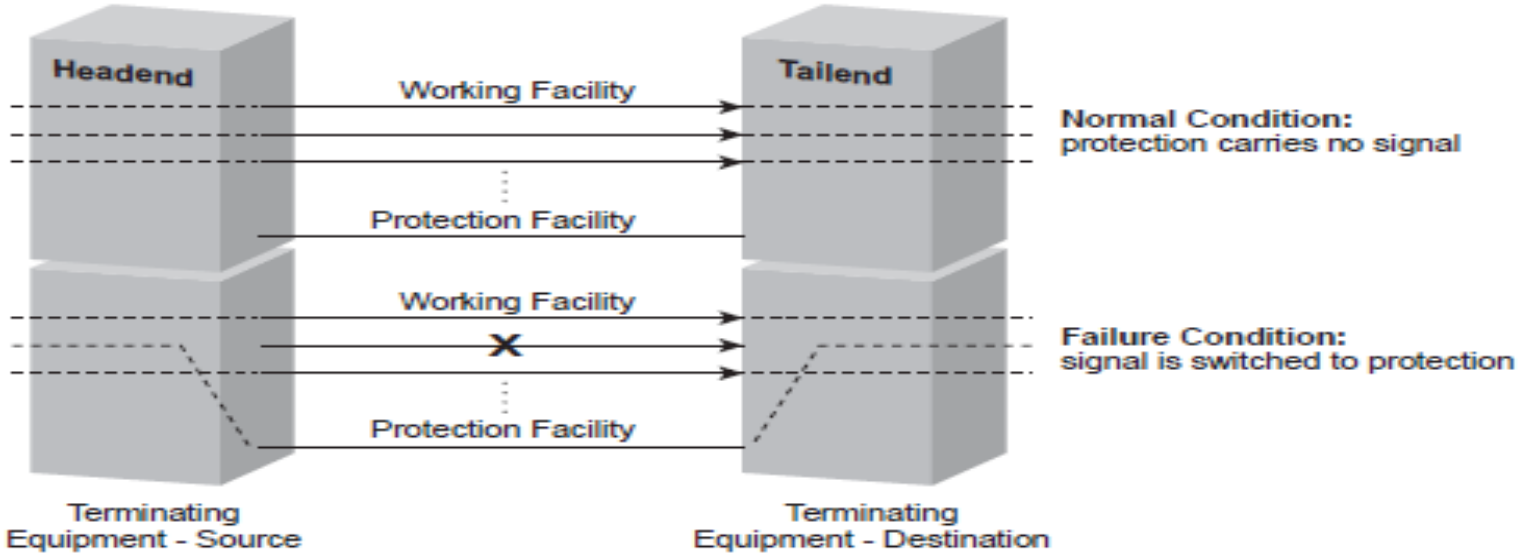


Protection Schemes –Linear (1+1 MSP) (Contd..)

- Switching in case of bi-directional configuration



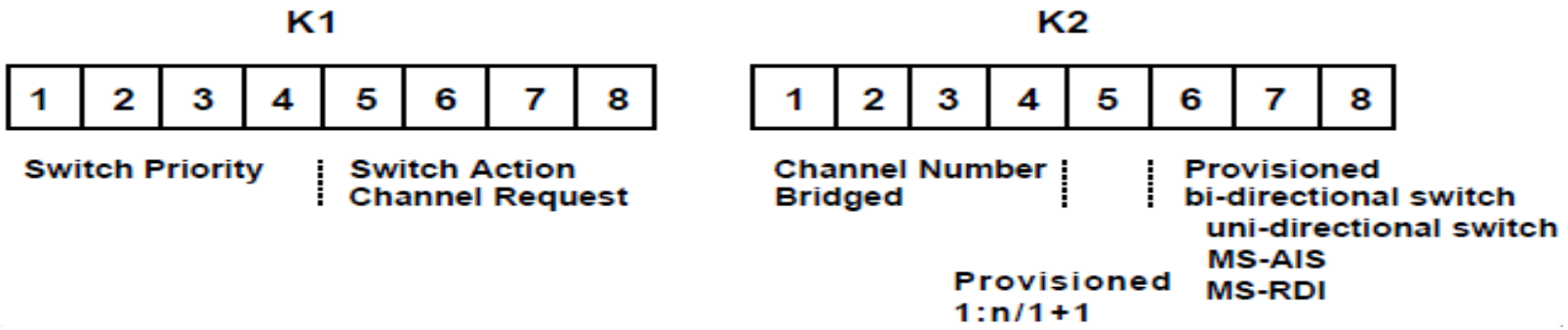
Protection Schemes –Linear (1:N MSP)



- In 1:N MSP protection switching, there is one protection facility for several working facilities (Range : 1 to 14).
- 1:N MSP is always revertive as it is a shared protection scheme.
- All communications from source to destination and vice versa are carried out over the APS channel via K1 and K2 bytes.
- Compared to 1+1 MSP, 1:N MSP has a higher switching time, as APS protocol messages are to be exchanged between source and destination to switch the traffic to the protect path. 1:N MSP is more bandwidth efficient.

K1 and K2 Bytes

- K1 and K2 bytes co-ordinate APS switching between Multiplex sections.



K1 and K2 Bytes

Bits 1234	Condition (state or external request)	Order
1111	Lockout of protection	Highest
1110	Forced switch	
1101	Signal fail high priority	
1100	Signal fail low priority	
1011	Signal degrade high priority	
1010	Signal degrade low priority	
1001	Unused	
1000	Manual switch	
0111	Unused	
0110	Wait to restore	
0101	Unused	
0100	Exercise	
0011	Unused	
0010	Reverse request	
0001	Do not revert	
0000	No request	Lowest

K1 Byte Bits 1-4

Bits 5678	Channel number	Requesting switch action
0000	0	*Null channel* (no working channel or extra traffic channel). Conditions and associated priority (fixed high) apply to the protection section.
0001 ⋮ 1110	1-14	*Working channel* Conditions and associated high priority (high or low) apply to the corresponding working sections. For 1+1, only working channel 1 is applicable, with fixed high priority.
1111	15	*Extra traffic channel* Conditions are not applicable. Exists only when provisioned in a 1:n architecture.

K1 Byte Bits 5-8

K1 and K2 Bytes

Bits 1234	Channel number	Indication
0000	0	*Null channel*
0001 ⋮ 1110	1-14	*Working channel* For 1+1, only working channel 1 is applicable.
1111	15	*Extra traffic channel* Exists only when provisioned in a 1:n architecture.

K2 Byte Bits 1-4

Bit (5)	Architecture	Bits (678)	
0	1+1	111	MS-AIS
1	1:n	110	MS-RDI
		101	Reserved for future use
		⋮	
		000	

K2 Byte Bits 5-8

Protection Schemes –Ring (SNCP)

- SNCP (Sub Network Connection Protection) is essentially a 1+1 protection. It is Uni-Directional and Dedicated type of protection. It is also called as UPSR.

- SNCP is Path Protection Switching.

- Traffic in the source network element is bridged on both work & protection paths, while the destination network element select the best of the signals from the work or protection path

- The protection is performed at TU11, TU12, TU3 level.

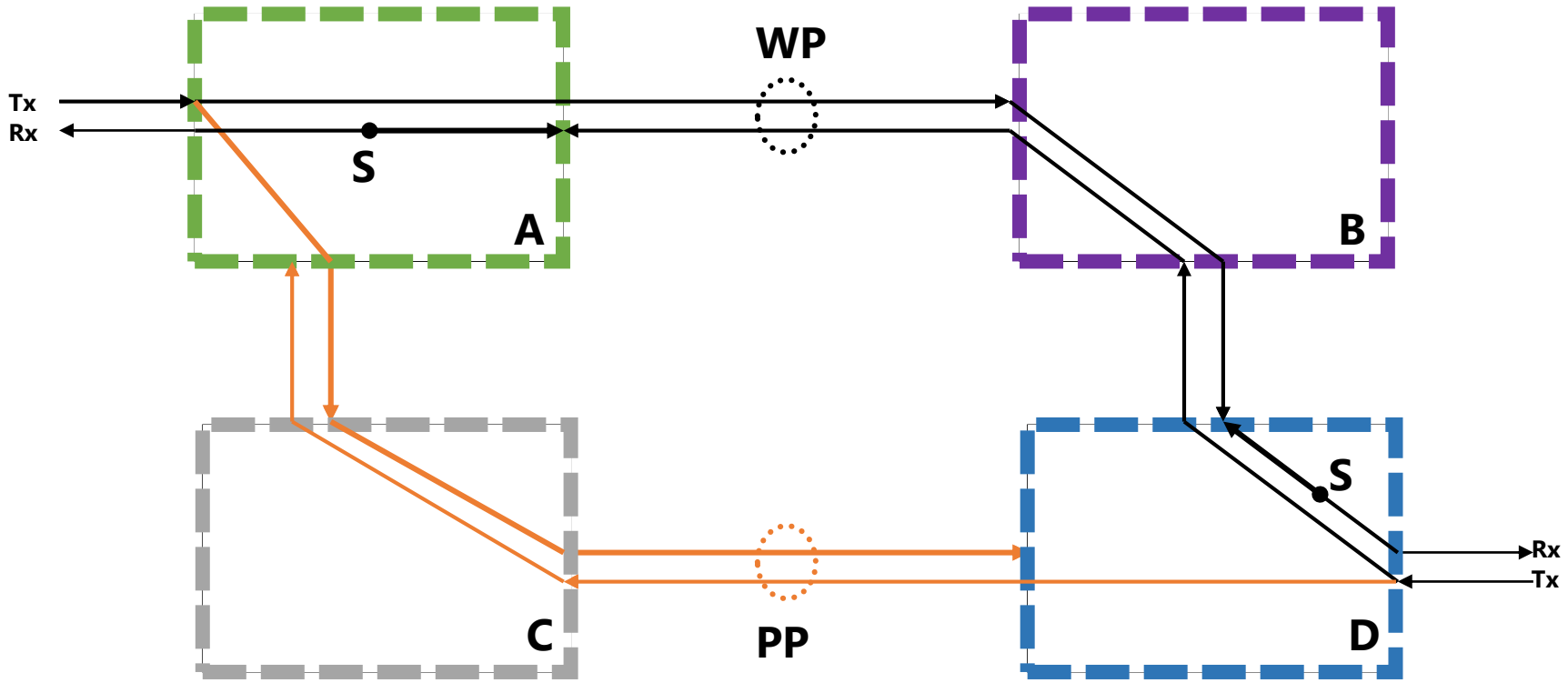
- The protection switching mode can be configured either as revertive & non-revertive mode

- Non-revertive protection allows the traffic to remain on the protect path even after the working path is repaired.

- Revertive systems restore working traffic on the original path after the Wait To Restore time (WTR).

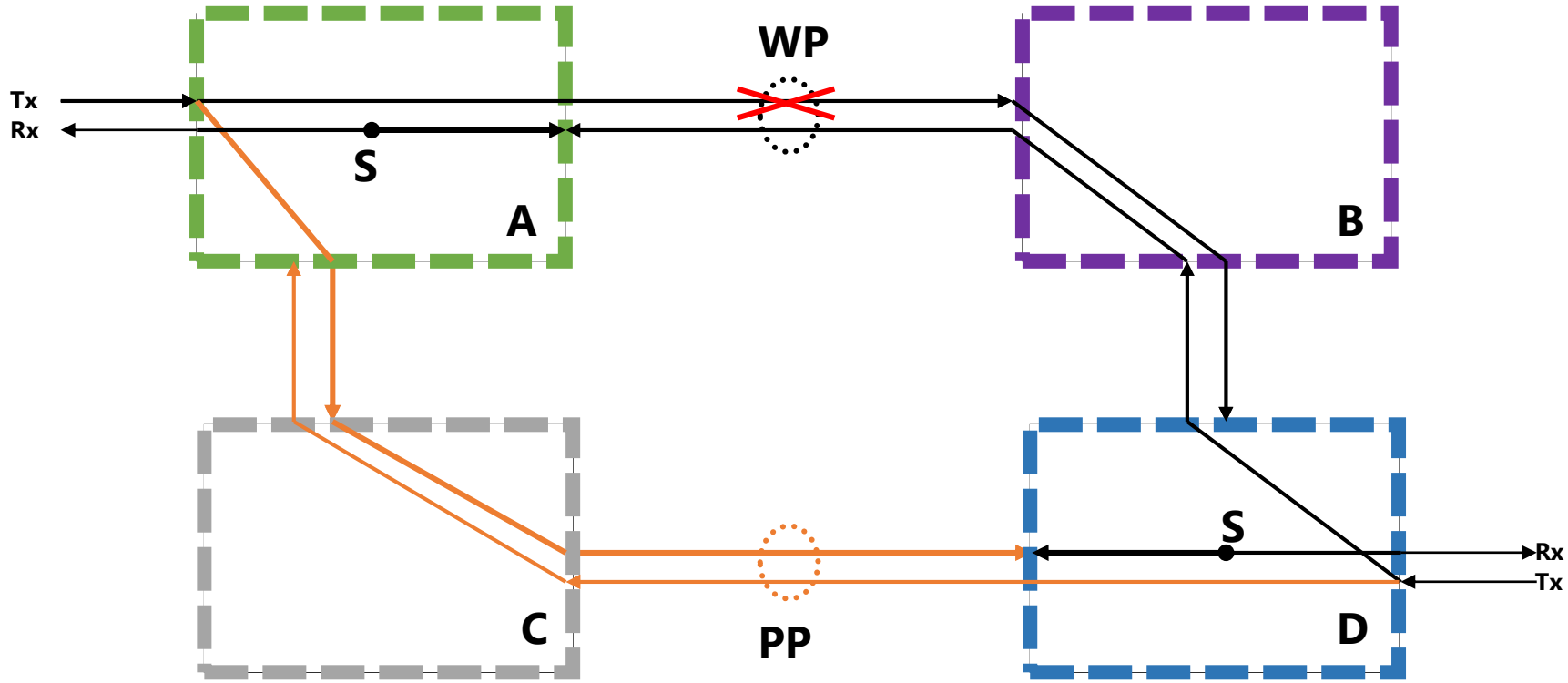
Protection Schemes –Ring (SNCP) (Contd..)

➢ **Normal Operation :**



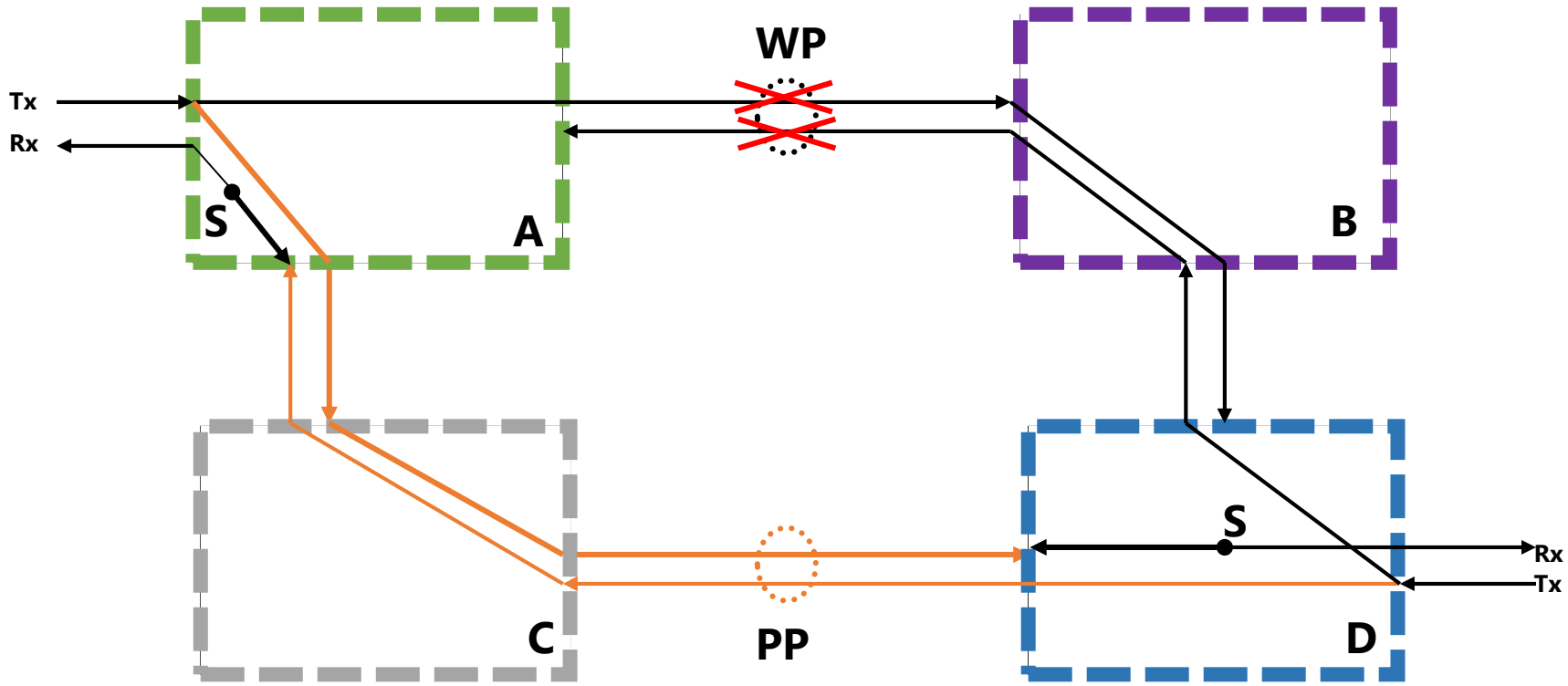
Protection Schemes –Ring (SNCP) (Contd..)

- Switching in case of single fiber cut



Protection Schemes –Ring (SNCP) (Contd..)

- Switching in case of dual fiber cut



External Commands

- **Forced Switch to Protection**

  - Traffic from work path will be switched to protect path even though protect path is not healthy (has SF and SD).
  - This command is issued if a maintenance work is to be carried on the work path.
  - (SF>FS>MS)

- **Forced Switch to Work**

  - Traffic from protect path will be switched to work path even though work path is not healthy (has SF and SD).
  - This command is issued if a maintenance work is to be carried on the protect path.
  - (FS>SF>MS)

External Commands

➢ **Manual switch to Protect**

- Traffic from work path will be switched to protect path only if protect path is healthy (has no SF and SD).
- This command is issued if a maintenance work is to be carried on the work path.

➢ **Manual switch to Work**

- Traffic from protect path will be switched to work path only if work path is healthy (has no SF and SD).
- This command is issued if a maintenance work is to be carried on the protect path.

Forced Switch has a higher priority than Manual Switch.

External Commands

➢ Lockout of Protection

- This command locks protection switching mechanism so that switching to the protection path is not possible.
- This command is issued when long term maintenance work is carried on protect path.
- This command has the highest priority.

➢ Clear

- This command is used to clear any of the previously issued commands.

Comparison of Protection Schemes

Parameters / Protection Schemes	Topology	Uni-Directional / Bi-Directional	Revertive /Non-Revertive	Shared / Dedicated	Switching Time
1+1 MSP	Linear	Uni /Bi-Directional	Revertive /Non-Revertive	Dedicated	Low
1+1 SNCP	Ring	Unidirectional (UPSR)	Revertive /Non-Revertive	Dedicated	Low
1:N	Linear	Uni /Bi-directional	Revertive	Shared	More Switching Time
MSSP2F	Ring	Bidirectional (BLSR)	Revertive	Shared	More Switching Time

Ethernet over SDH (EoS) was developed primarily to provide a simple, flexible and cost-effective solution to customers offering Ethernet based services.

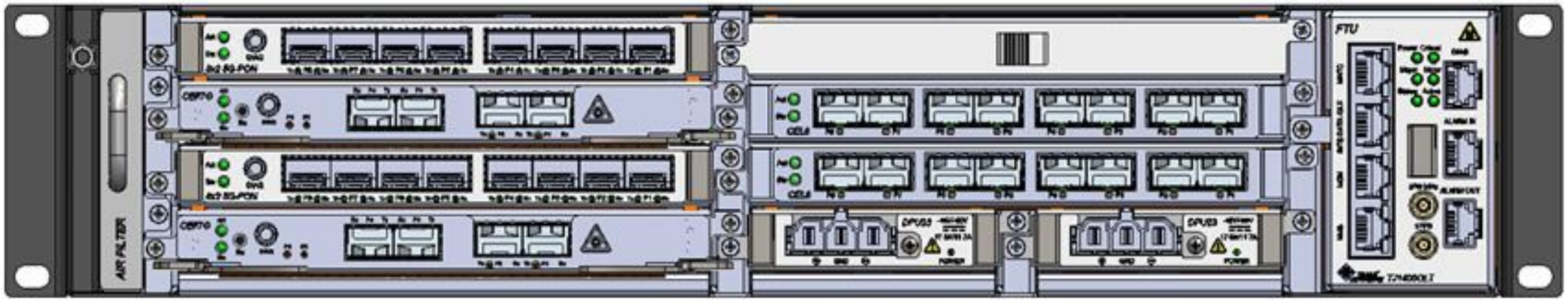
An EoS transport solution fundamentally addresses the following key issues :

- ✓ **Auto Negotiation (AN):** to negotiate and select a common speed and mode of communication between two link partners
- ✓ **Generic Framing Procedure (GFP):** Framing protocol to encapsulate Ethernet frames to generate an SDH payload
- ✓ **Virtual Concatenation (VCAT):** Bandwidth provisioning scheme. Bandwidth mapping of the SDH payload to SDH channels, which are either high-order or low-order virtual containers (VCs)
- ✓ **Link Capacity Adjustment Scheme (LCAS):** a scheme for hitless adjustment (addition & deletion) of link capacity (BW)
- ✓ **Link Integrity (LI):** for point to point communication, alive feature checks end to end (client to client) integrity of the link and if there is a breach of integrity anywhere in the link, then forcefully the health client side(s) are made down
- ✓ **Flow Control:** Rate shaping mechanism to avoid packet drops

TJ1400 7-SR [TJ1420]

TEJAS® NETWORKS

TJ-1400-7

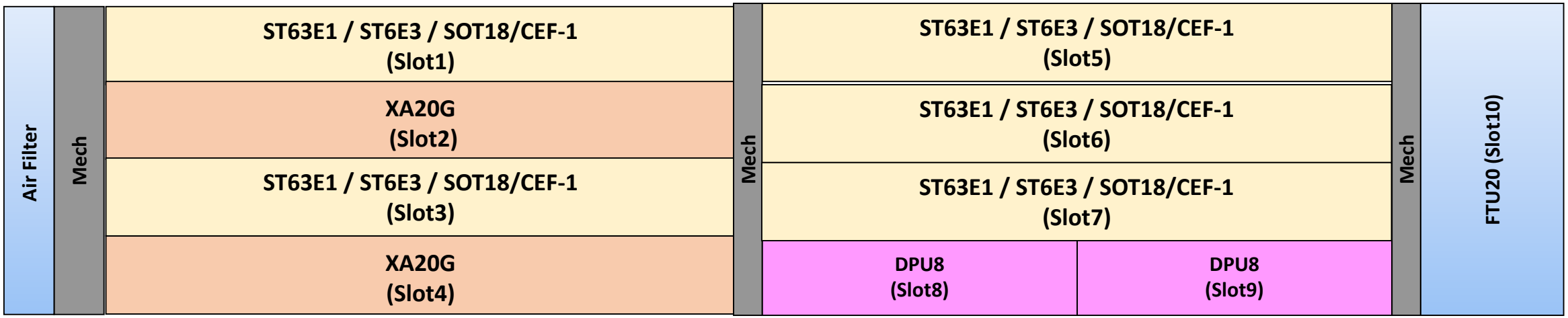


2 Rack unit chassis

Physical Dimensions

Height-88.5mm
Width-444mm(without mount angles)
Depth-237mm(without air filter handle)

Slot View



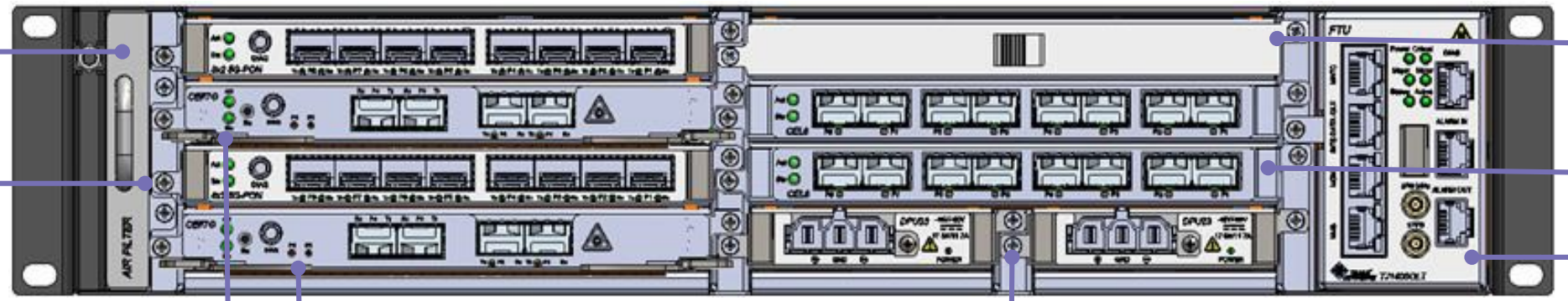
- **Universal Tributary cards – Slot1, Slot3, Slot5, Slot6 & Slot7.**
- **2 Cross connect cards - Slot 2 & Slot4.**
- **2 DC Power Supply Units – Slot8 & Slot9.**
- **FTU20_OAM – Slot10.**

Physical Dimension

- Dimensions (H x W x D): 88 mm x 444 mm x 204 mm
- Rack unit: 2U, Half-Depth.
- Output power delivered in fully loaded condition 250W*.

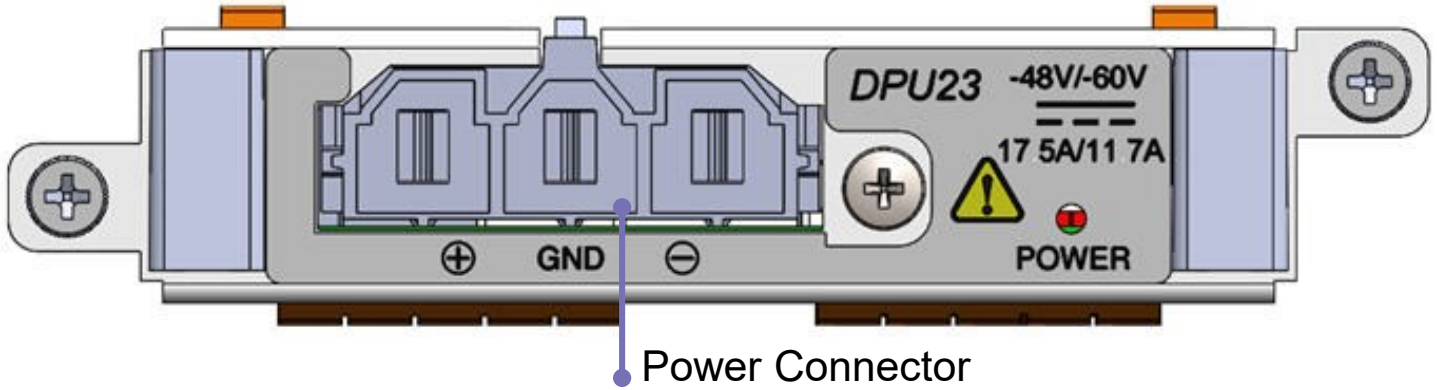
NOTE :* Fully loaded power varies from Config to Config.

Slot ID and Card population



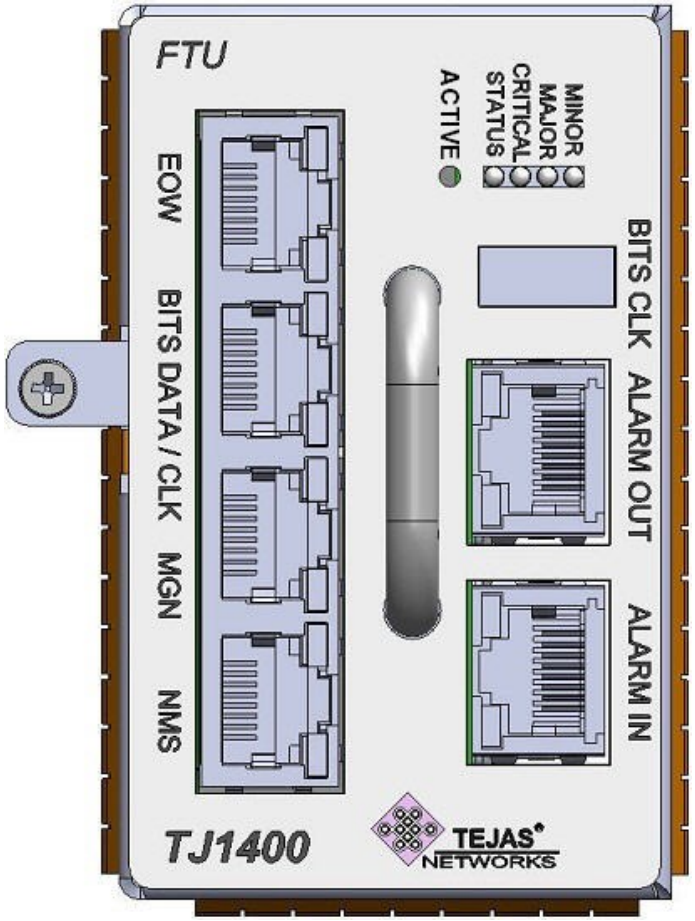
Air Filter Unit			
	Slot 1 - Tributary card	Slot 5 - Tributary card	Slot 10 FTU
	Slot 2 – Controller card	Slot 6 - Tributary card	
	Slot 3 - Tributary card	Slot 7 - Tributary card	
	Slot 4 - Controller card	Slot 8 – Power Supply Unit	Slot 9 – Power Supply Unit

Power Supply Unit-DPU23



Parameter	Specification
Input Voltage	-40V to -72V DC
Output Voltage	12.45V ± 0.6V
Output Power	500W maximum
Fuse	20A Fast Acting Fuse
Redundancy Support and Reverse Polarity Protection	Yes
Operating temperature range	0°C to 40°C full power Up to 65°C with derating

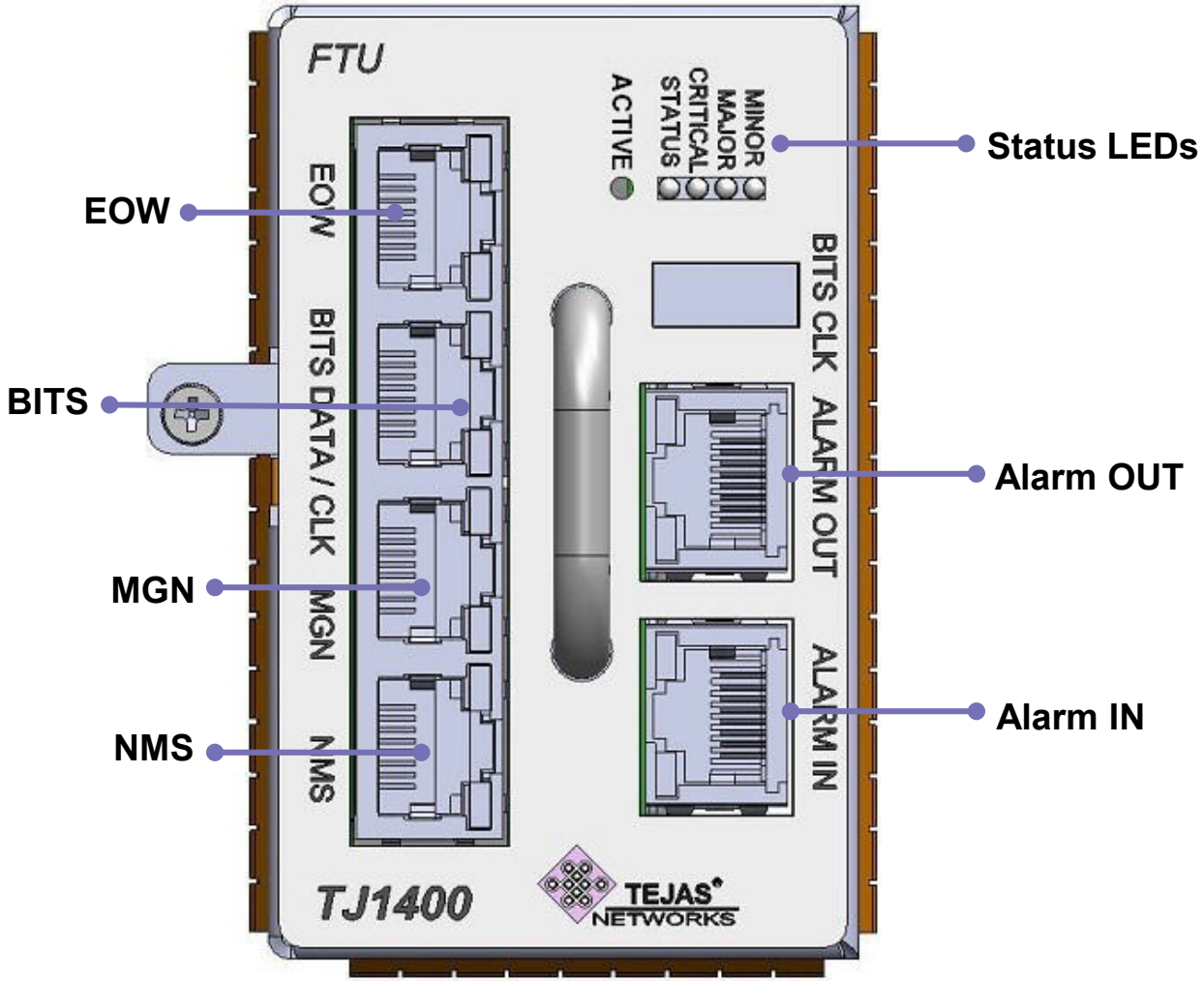
Fan Tray Unit



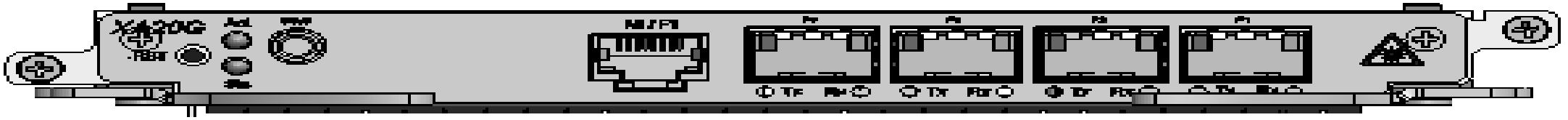
- FTU supports six fans.
- Fuse on each fan power supply to isolate any failed fan from other fans.
- Fan speed monitoring and control through software, based on the temperature sensed.
- Temperature monitoring on the airflow path.
- Field replaceable.

Specification	Range
Input Voltage	12 V
Power Consumption	54W Maximum

FTU-OAM Interface



- **EOW:** 64Kbps voice channel
- **Status LEDs**
- **BITS:** Data and Clock synchronization
- **Alarm OUT:** To extend alarms to external devices like LED panels, buzzers etc.
- **MGN:** Local access using default IP (192.168.1.254)
- **Alarm IN:** To report external alarms like door open, AC fail etc in NE.
- **NMS:** Local access using Ethernet IP

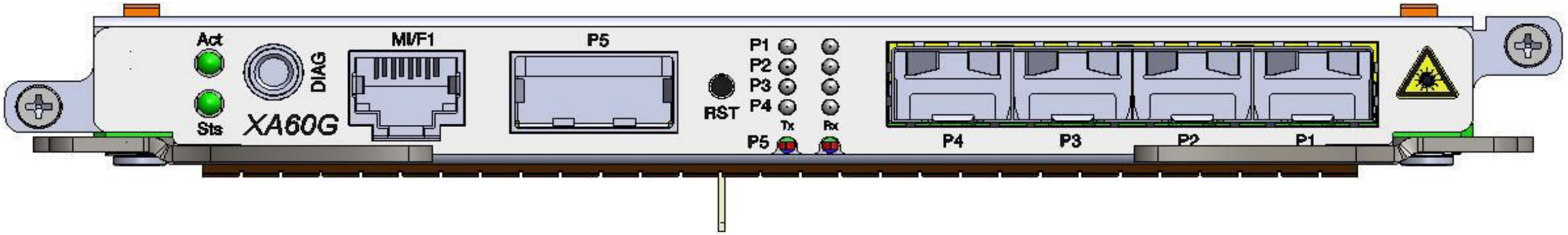


- Supports 1xSTM 4/16 (P4)+1xSTM4(P3) + 1xSTM1(P1 & P2).
- Granularity supported VC4-16c, VC4-4c, VC4, VC3,VC12,VC11 in SDH mode.
- Redundancy & UI switch over supported.
- DIAG interface: Local console login (tejas personnel only) .
- M1/F1: 1 F1 user data channel/MODEM interface, baud rate: user configurable for M1(9600,19200,38400, 57600), applications: terminal server, login, ppp, udc - RJ 45connector.

Cross Connect Card – XA20G

- Need to use Y cable with Terminal cable
- Baud rate for UDC is 57600 which is not user configurable.
- Two types of RESET present. One for Jack out another for soft reboot.
- Total uplink capacity of this card is 16G.
- Maximum power consumption : 30W.
- Note: Supported in R1 backplane with R1.6 and not in R2.

XA60 G

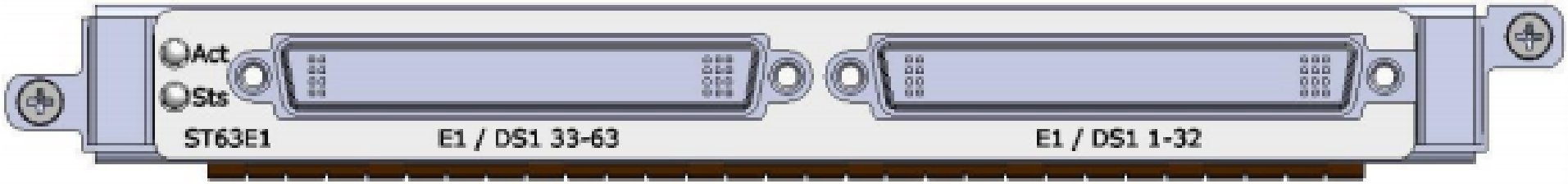


- The ports can be configured as:
  - 2xSTM-1/4/OC-3/12 (P1 and P2) + 2xSTM-1/4/16/OC-3/12/48 (P3 and P4) 4xSTM-16 (P1 to P4)

- The functional features:

  - Redundant and non-redundant configurations.
  - Supports diag-audio jack.

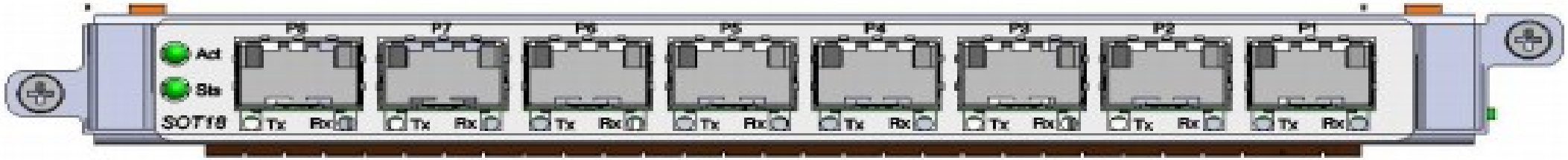
E1/DS1 Tributary Card – ST63E1



- The ST63E1 card provides line interface to sixty three E1/DS1 channels in both add and drop directions. The E1/DS1 interface is provided through LFH connector.

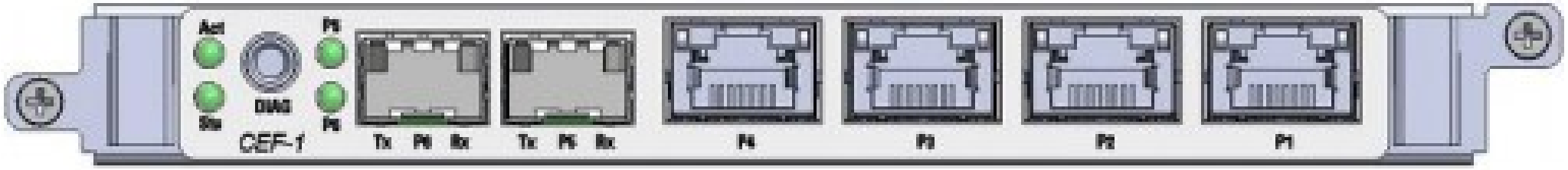
- The ST63E1 provides the following functional features:
  - Transporting both framed and unframed E1/DS1 traffic
  - E1/DS1 interface can be nominated as a timing source
  - Performance monitoring for errors and alarm conditions
  - Software configurable E1/DS1 mode

Optical Tributary Card - SOT18



- SOT18 card can be field configured by using different SFP plug-ins to operate as either
  - 8xSTM-1/OC-3 or 2xSTM4/OC-12 or 1xSTM-16/OC-48 or 8xSTM-1/OC-3/ 4xSTM-1/OC-3+1xSTM-4/OC-12/ 1xSTM-4/OC-12+4xSTM-1/OC-3/ 2xSTM-4/OC-12. In STM-4/OC-12 mode, SFPs of STM-4/OC-12 capacity is plugged in at ports 1 and 5.
- STM-1/OC-3 Optical Interface: SOT18 has eight LC connectors operating at STM-1/OC-3 line rate.
- STM-4/OC-12 Optical Interface: SOT18 has ports 1 and 5 with LC connectors operating in STM-4/OC-12 line rate.
- STM-16/OC-48 Optical Interface: SOT18 has port 1 with LC connectors operating in STM-16/OC-48 line rate.

Ethernet Switching Card - CEF-1



- The CEF-1 consists of 4 FE Electrical (10/100Base-Tx) and 2 GE Optical (1000Base-X) ports.
- CEF-1 card supports a switching capacity of 5G.
- The card supports STM-4/16/OC-12/48 uplink bandwidth.
- Signal connections uses High Speed connector. For power connections, a 12-pin power connector is used which receives 12V input from the backplane.

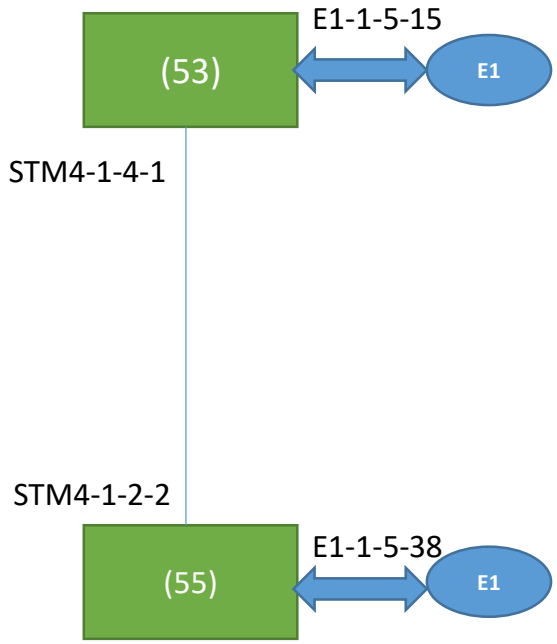
Supports following port configurations

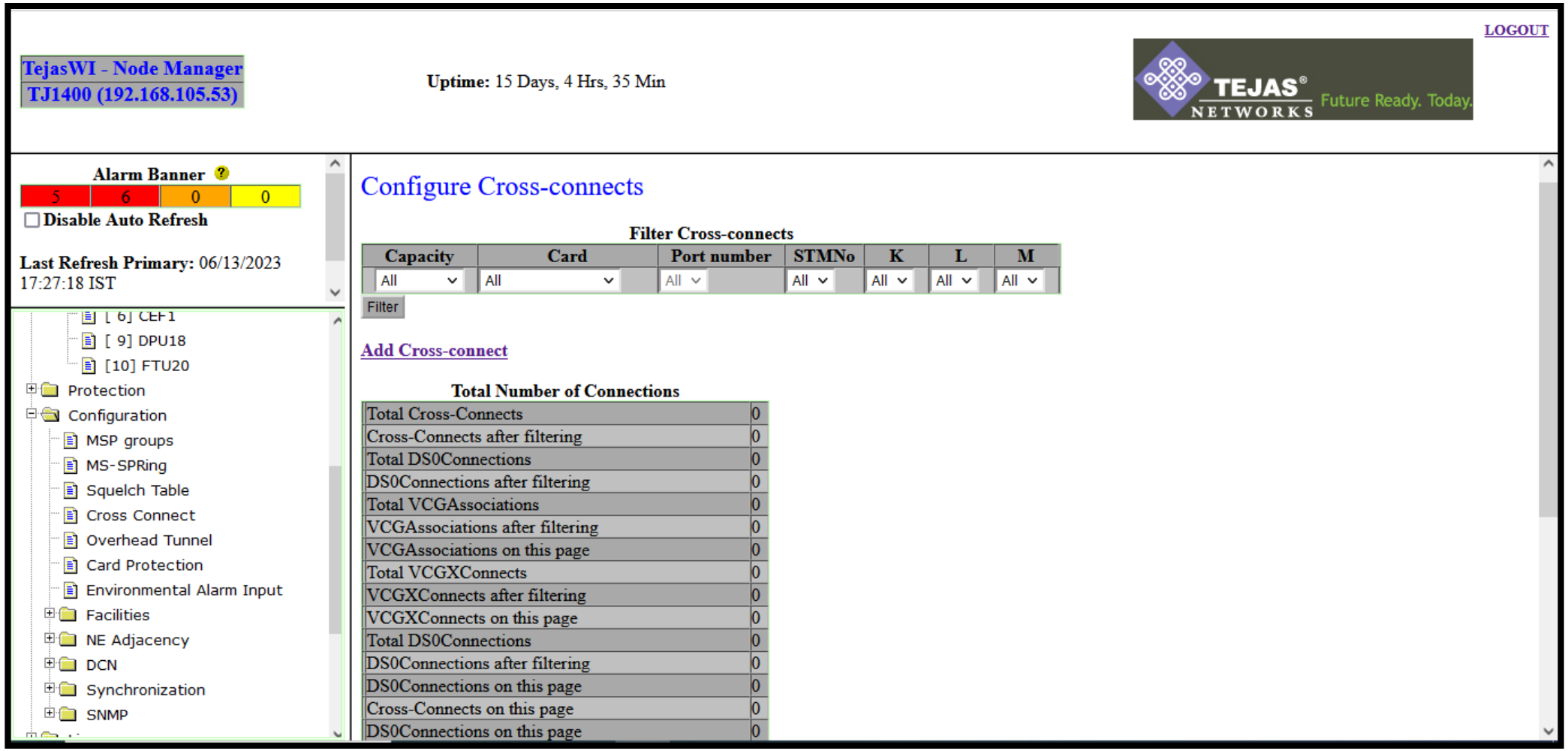
- 4x100Mbps Cu-Ports + 2x1Gbps Optical-Ports + 1x1Gbps Mate-Link + 16 CEM
- 3x100Mbps Cu-Ports + 1x1Gbps Cu-Ports + 2x1Gbps Optical-Ports + 16 CEM
- 2x100Mbps Cu-Ports + 2x1Gbps Cu-Ports + 2x1Gbps Optical-Ports + 1x1Gbps Mate-Link + 16 CEM

SDH- LAB SETUP

TEJAS® NETWORKS

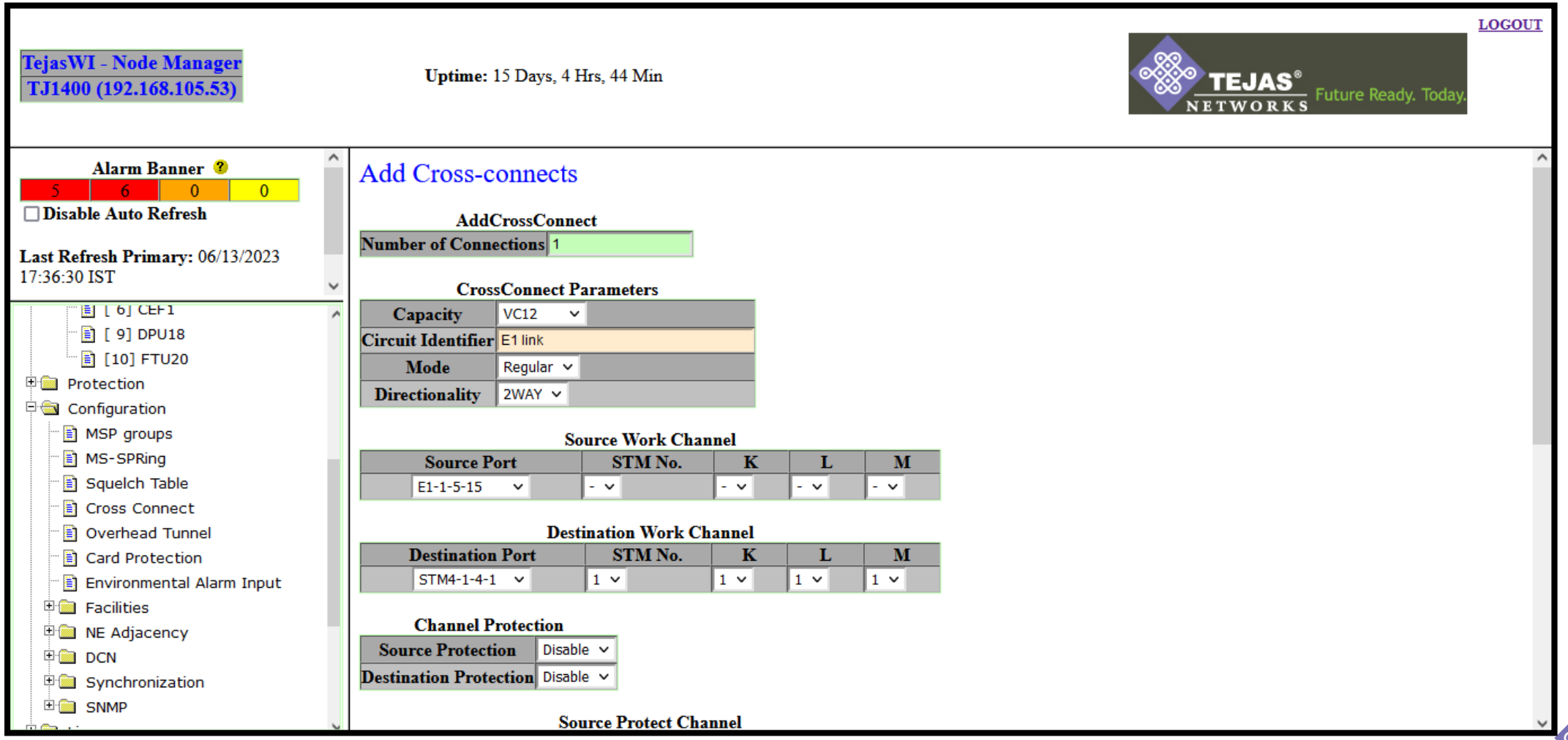
- Create a XC between 53 to 55 and bring it up. Use K-L-M (1-1-1) at both the ends.





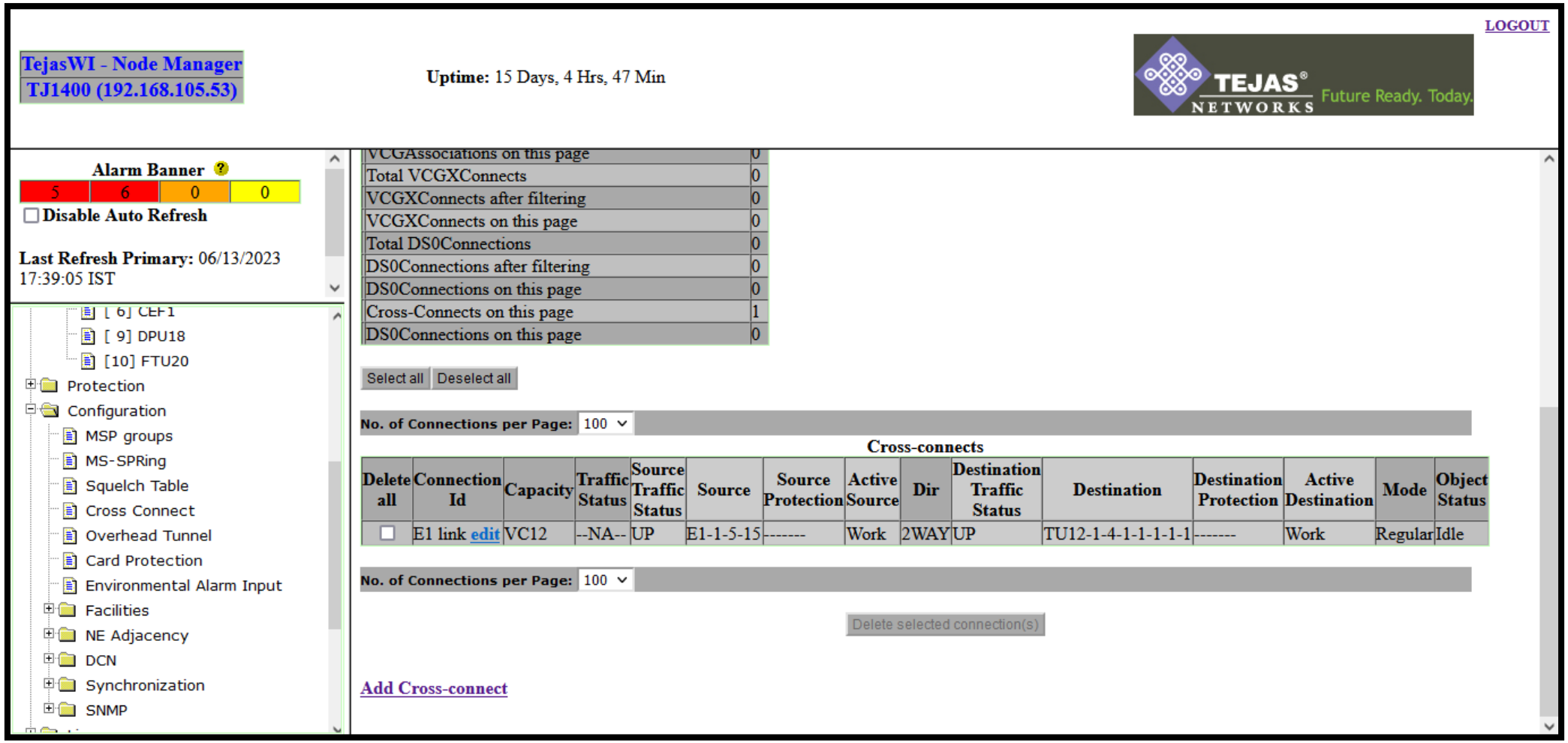
E1 Link Creation - 192.168.105.53

STEP 2: Go to Add Cross connects -> Select Source port -> Select Destination port, STM no. and KLM value



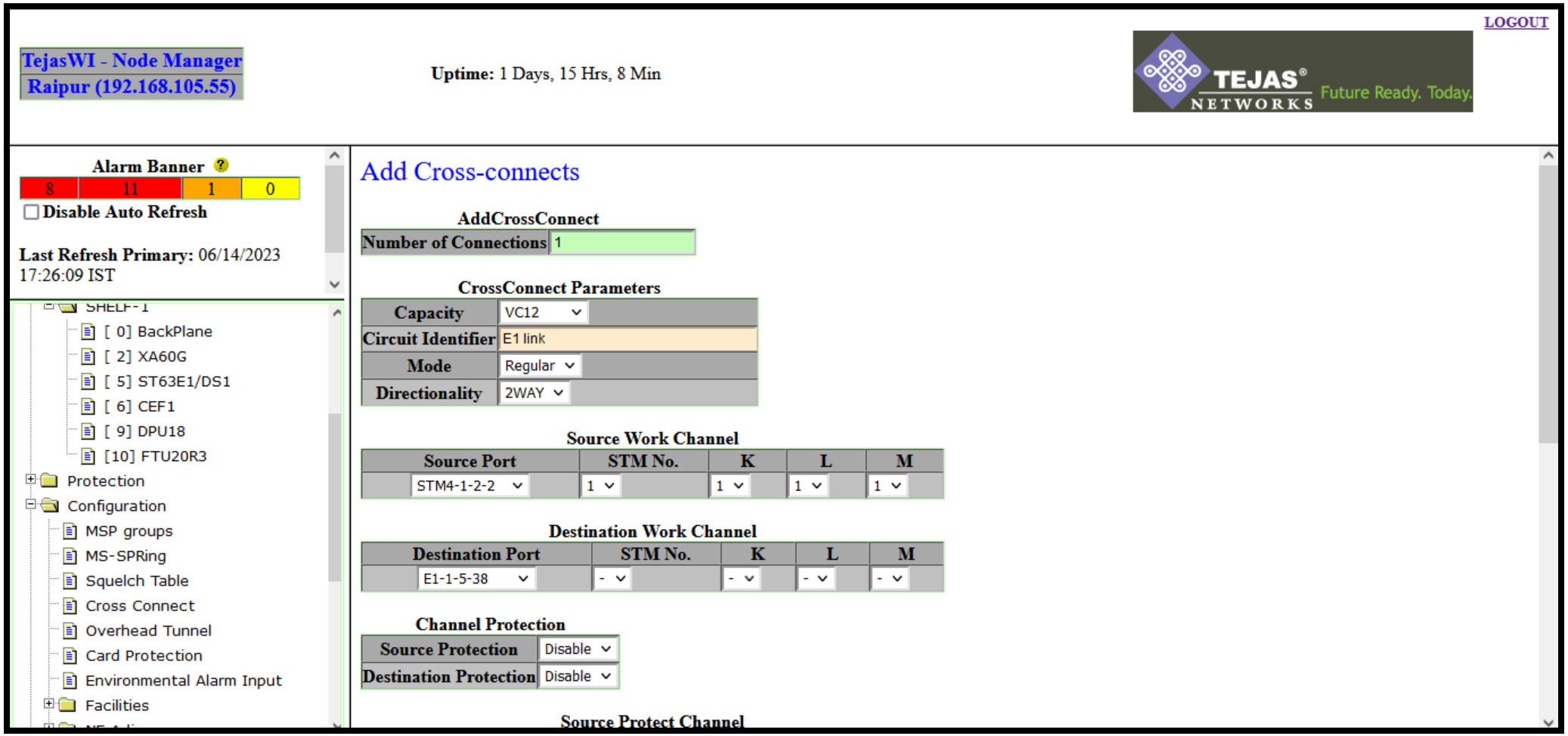
E1 Link Creation - 192.168.105.53

STEP 3: Click on View Cross connects -> Check Source and Destination Traffic status – to be UP



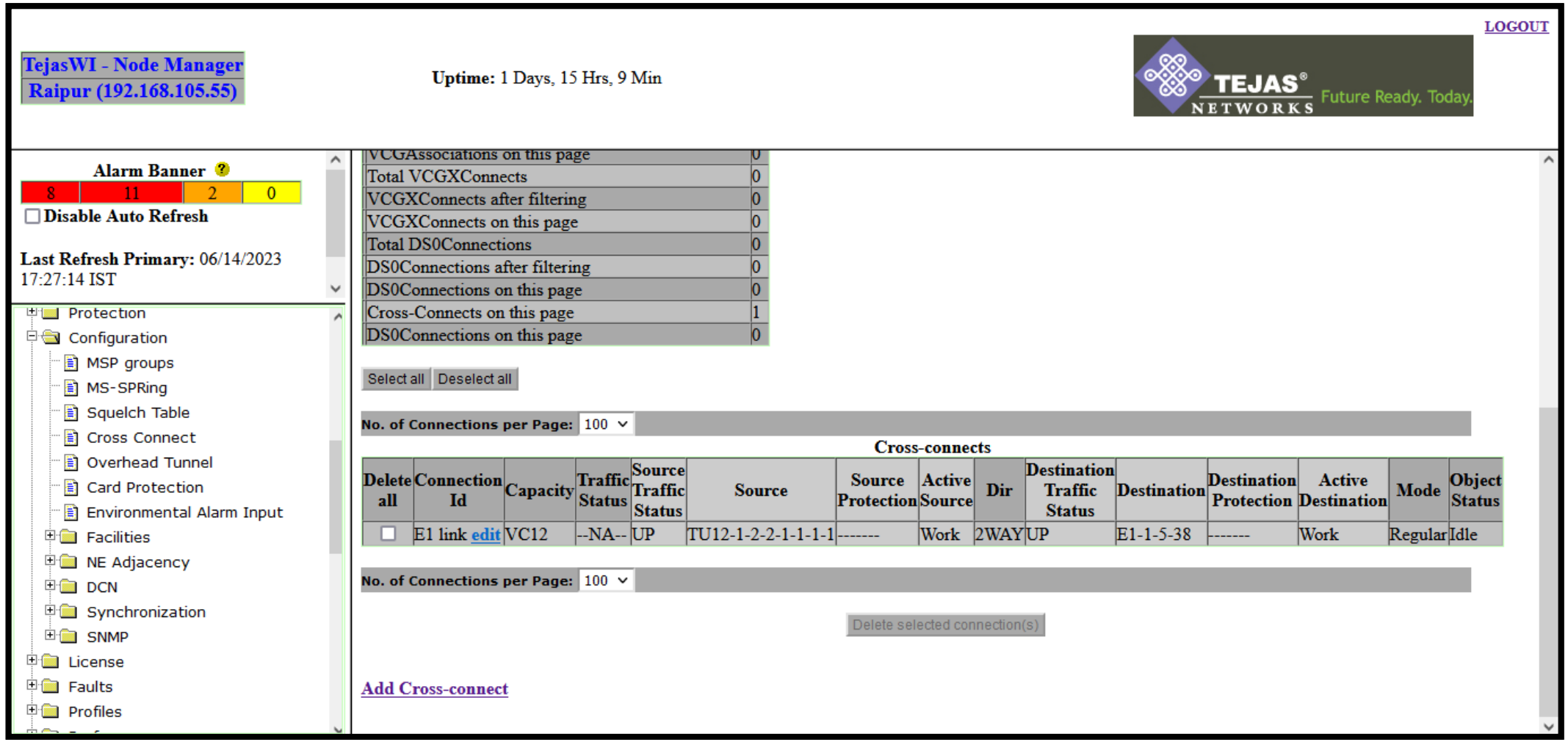
E1 Link Creation - 192.168.105.55

STEP 4: Go to Add Cross connects -> Select Source port , STM no. and KLM value -> Select Destination port

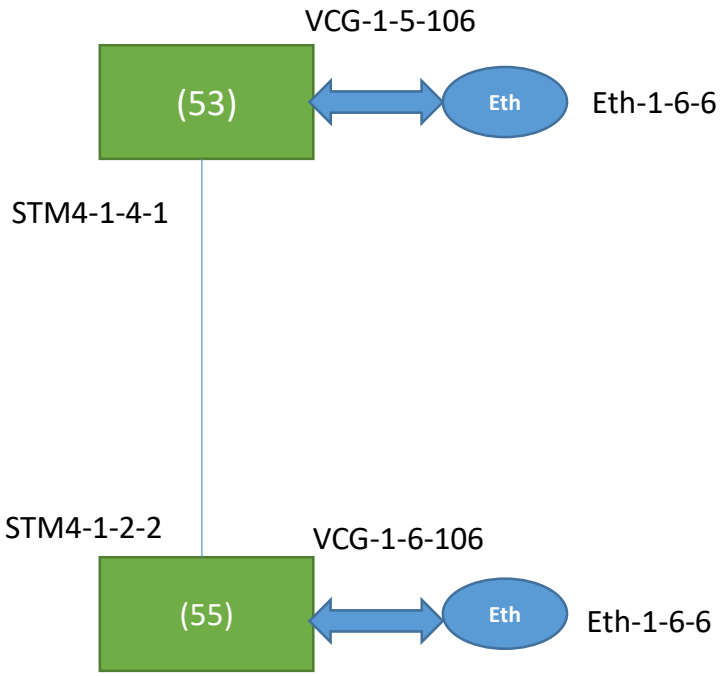


E1 Link Creation - 192.168.105.55

STEP 5: Click on View Cross connects -> Check Source and Destination Traffic status – to be UP



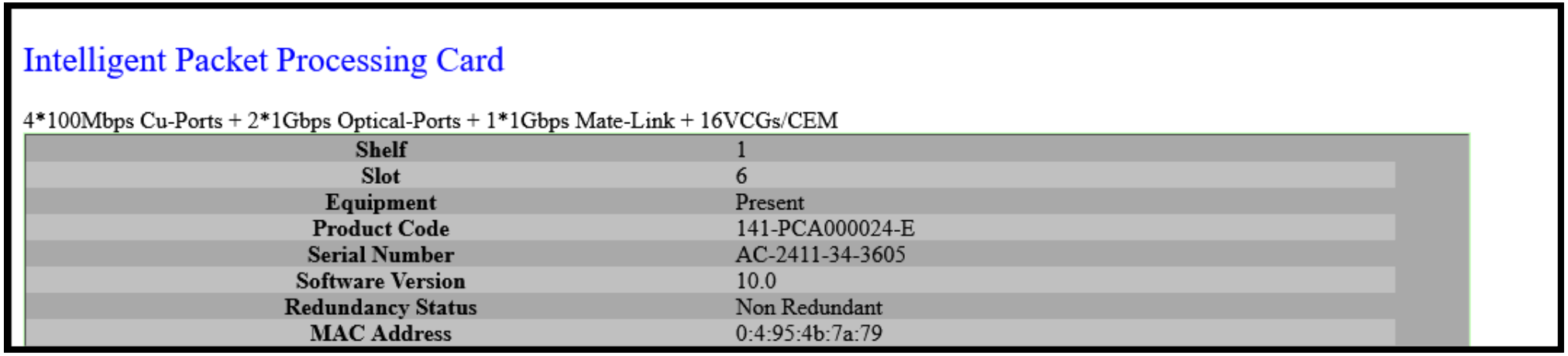
- Provision 10 Mbps between 53 to 55 and bring it up. Use contiguous K-L-M (1-1-1 onwards) at both the ends.
- Create an transparent ELINE service between Eth <> VCG ports of respective nodes (53 and 55).



Step 1: CEF1->Configure CEF1 ports

Card Configuration: EOS

Add VCG(multiple VCGs as required) CEF 1 supports 16 VCGs



Intelligent Packet Processing Card

4*100Mbps Cu-Ports + 2*1Gbps Optical-Ports + 1*1Gbps Mate-Link + 16VCGs/CEM

Shelf	1
Slot	6
Equipment	Present
Product Code	141-PCA000024-E
Serial Number	AC-2411-34-3605
Software Version	10.0
Redundancy Status	Non Redundant
MAC Address	0:4:95:4b:7a:79

Step 2: Admin enable ETH and STM ports

Ports on Card Shelf : 1 Slot: 6

Ports

Port name	Admin status	Operational status	Protect status
ETH-1-6-1	DOWN	DOWN	unprotected
ETH-1-6-2	DOWN	DOWN	unprotected
ETH-1-6-3	DOWN	DOWN	unprotected
ETH-1-6-4	DOWN	DOWN	unprotected
ETH-1-6-5	DOWN	DOWN	unprotected
ETH-1-6-6	DOWN		
INT-ETH-1-6-7	UP	DOWN	unprotected
VCG-1-6-101	UP	DOWN	unprotected
VCG-1-6-102	DOWN	DOWN	
VCG-1-6-103	DOWN	DOWN	unprotected
VCG-1-6-104	DOWN	DOWN	unprotected
VCG-1-6-105	DOWN	DOWN	unprotected
VCG-1-6-106	DOWN	DOWN	unprotected
VCG-1-6-107	DOWN	DOWN	unprotected
VCG-1-6-108	DOWN	DOWN	unprotected

Admin up the Eth and VCG Ports

Select the Operating granularity

Provisioning Ethernet Interface Port - ETH-1-6-6

Admin Status	Up
Alarm Reporting Status	Report
Link Status	Up
MTU	9216
Laser	PFEFX-1-6-6
Auto-Negotiation	Disable
Flow Control	Manual Tx-Rx
SyncE Transmit Capability	Enable
Speed and Duplex	100Mbps, Full Duplex
Link Integrity Status	Off
Threshold Enable for 15min/1-Day Interval	Disable
Medium	1000 BaseLX 10km 1310nm
LAN Circuit Identifier	

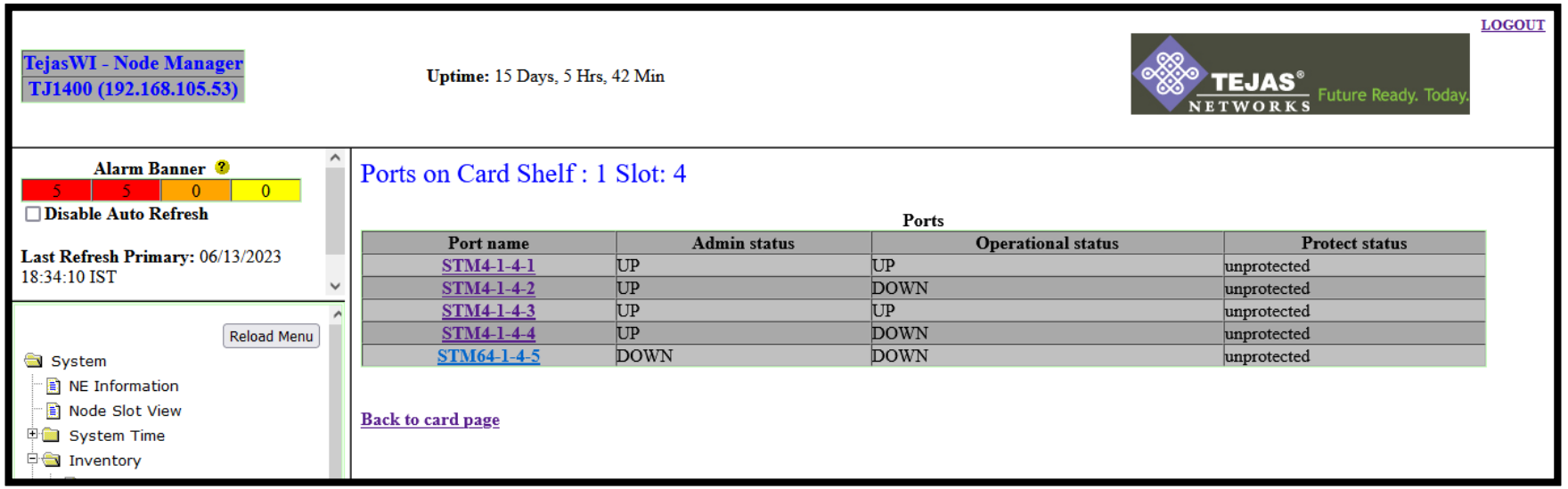
Reset Submit

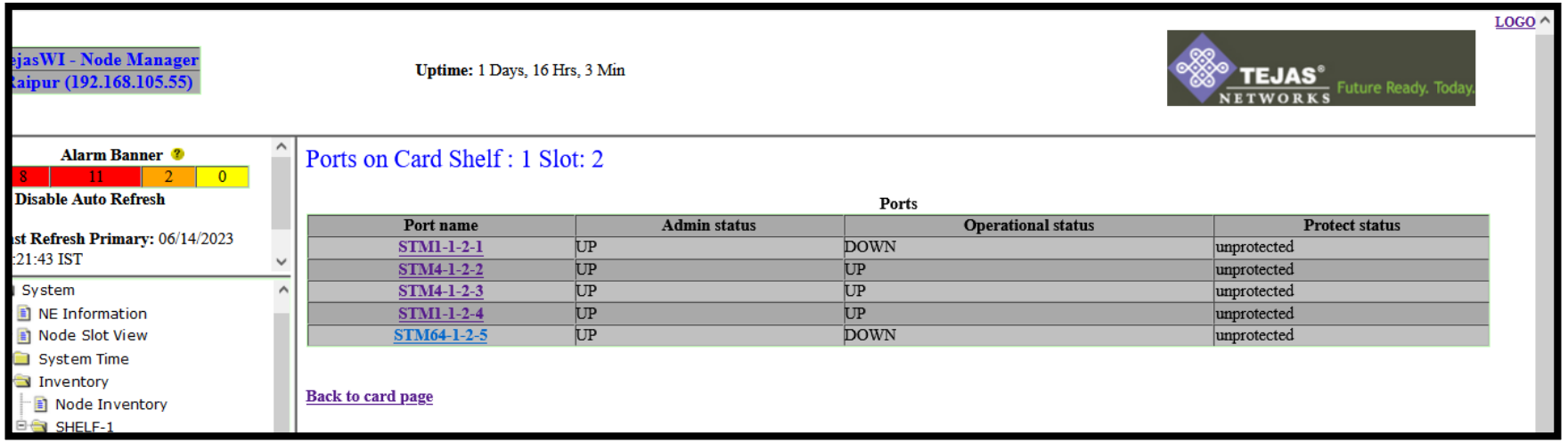
Provisioning VCG Interface - VCG-1-6-106

Admin Status	Up
Alarm Reporting Status	Report
LCAS Support	Enable
Remove Channels with MND	Enable
Framing Type	GFP-F
Maximum Differential Delay (ms)	63 ms
CRC Type	CRC-32
VCAT	Enable
Operating Granularity	VC12
Payload FCS	Enable
IgnoreRDI in LFE	Disable
Remove Channels with SD	Disable
Threshold Enable for 15min/1-Day Interval	Disable
VCG Circuit Identifier	Tejas Networks.
Number Of Channels	0 (0 Mbps)

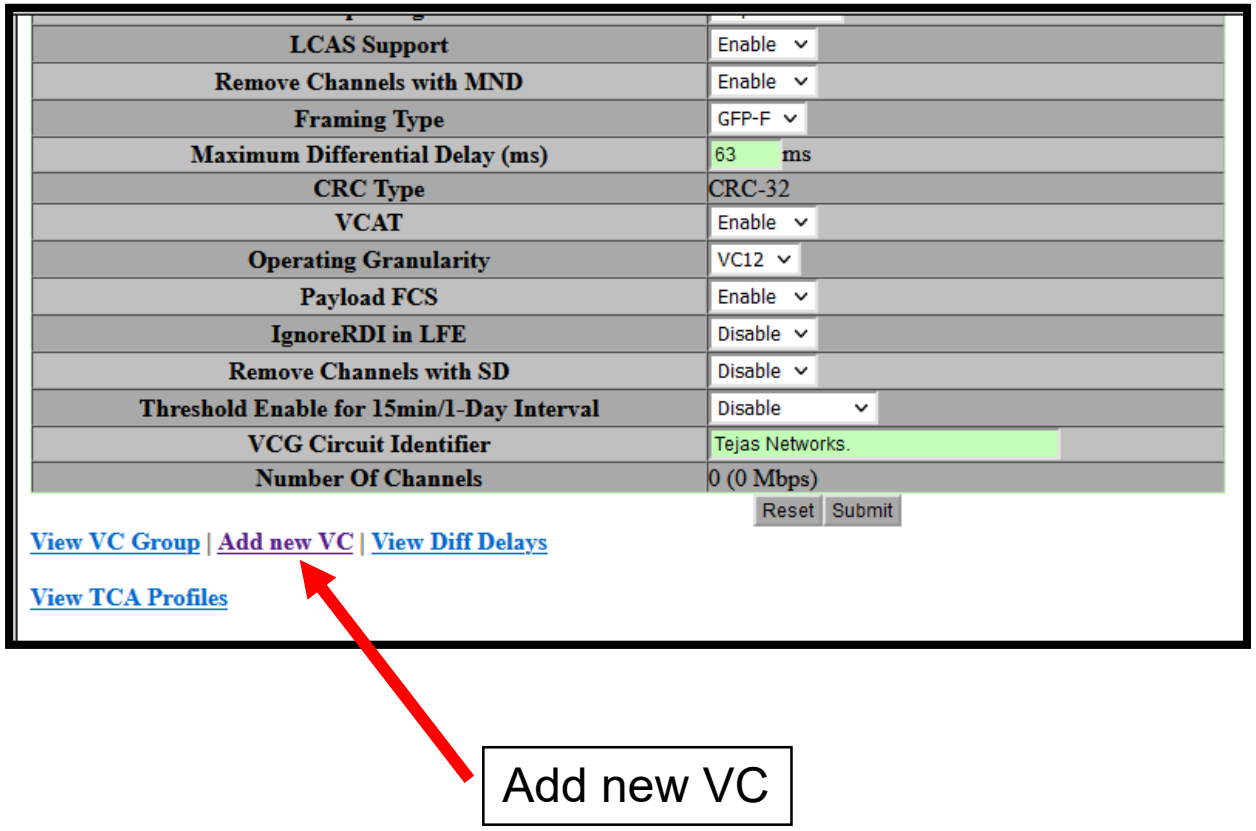
Reset Submit

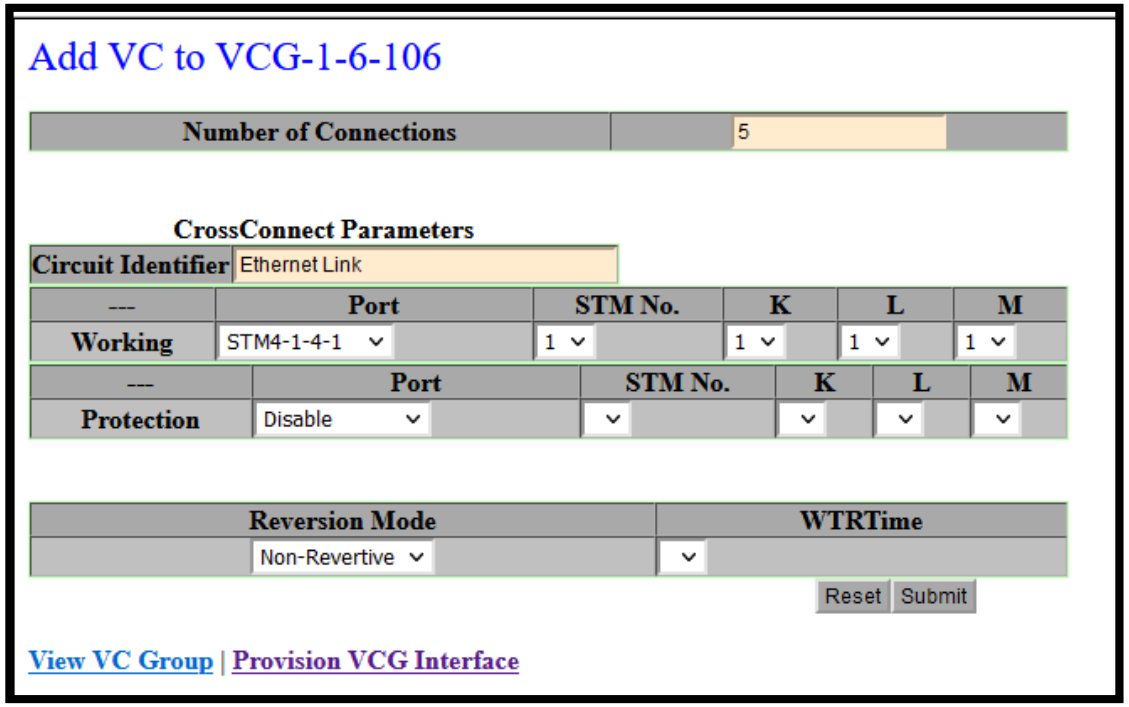
Step 2: Admin enable ETH and STM ports (STM4-1-4-1 and STM4-1-2-2)

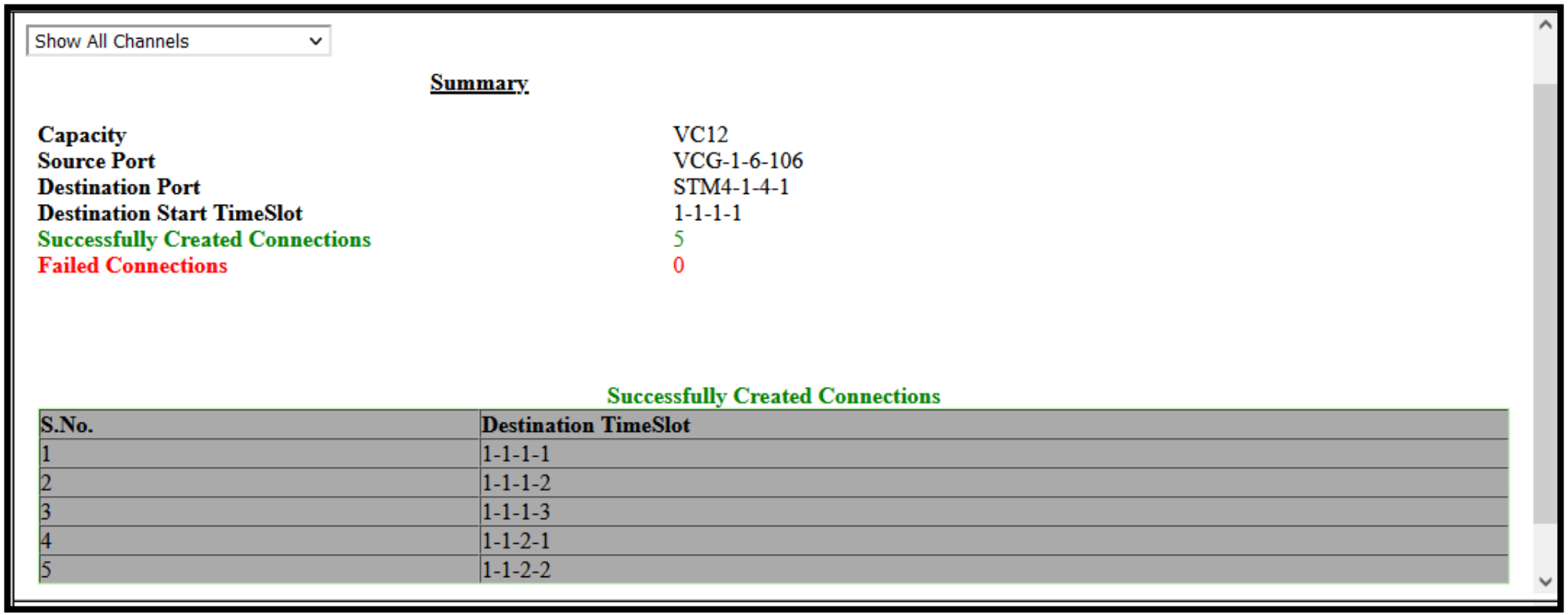




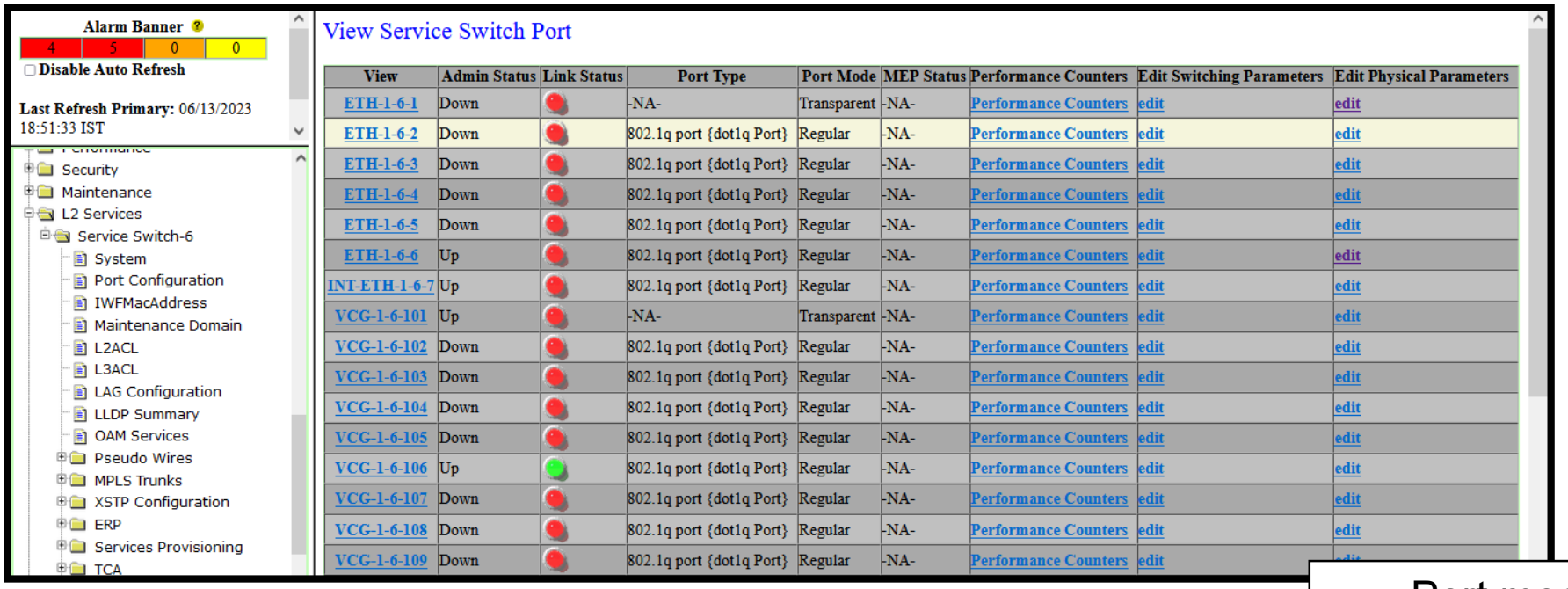
Step 3: Choose VCG, add new VC, define no of connections, select the working port (Add VC or Cross-connect) in both the nodes 53 and 55





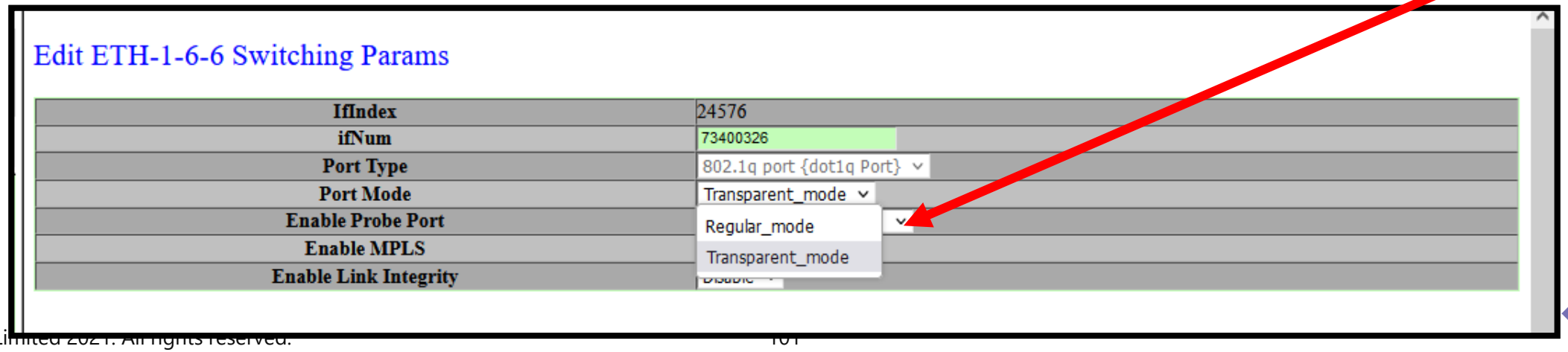


Step 4: L2 services->Port configuration-> Choose VCG and ETH port->Edit switching parameters.

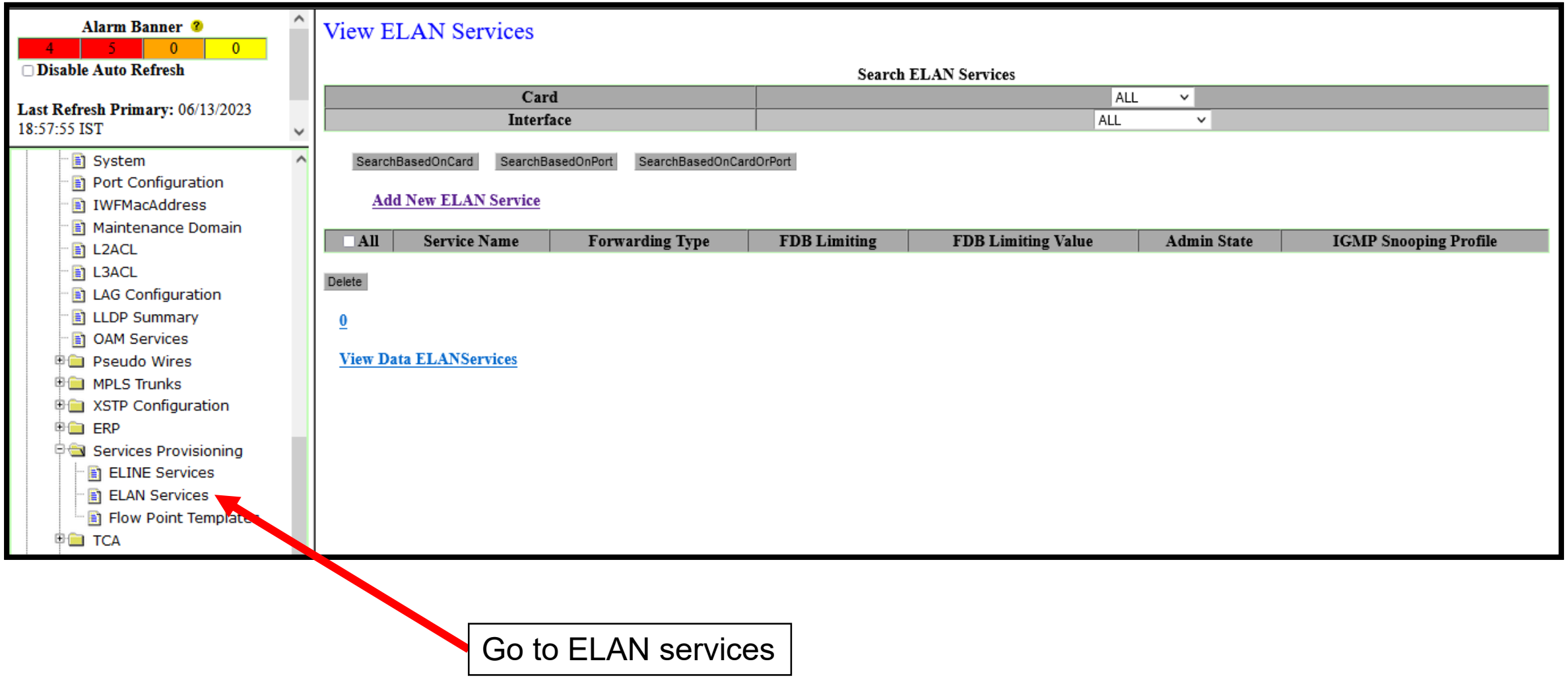


View	Admin Status	Link Status	Port Type	Port Mode	MEP Status	Performance Counters	Edit Switching Parameters	Edit Physical Parameters
ETH-1-6-1	Down		-NA-	Transparent	-NA-	Performance Counters	edit	edit
ETH-1-6-2	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
ETH-1-6-3	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
ETH-1-6-4	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
ETH-1-6-5	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
ETH-1-6-6	Up		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
INT-ETH-1-6-7	Up		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
VCG-1-6-101	Up		-NA-	Transparent	-NA-	Performance Counters	edit	edit
VCG-1-6-102	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
VCG-1-6-103	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
VCG-1-6-104	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
VCG-1-6-105	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
VCG-1-6-106	Up		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
VCG-1-6-107	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
VCG-1-6-108	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit
VCG-1-6-109	Down		802.1q port {dot1q Port}	Regular	-NA-	Performance Counters	edit	edit

Port mode->Transparent



Step 5: L2 Services-> Services Provisioning --->ELAN services



EOS

Step 6: Add new ELAN service, provide name and submit

Provision New ELAN Service

VBI Service Type	ELAN_EVC
Service Name	ELAN Service
Trail Identifier	0
CustomerName	Customer1
Forwarding Type	CVLAN_Forwarding
FDB Limiting	Disable
FDB Limiting Value	
FDB Limiting Action	
VBI Admin State	Up

IGMP Snooping

IGMP Snooping profile	none

Create

Edit ELAN Service : ELAN Service

Service Name	ELAN Service
Trail Identifier	0
Customer Name	Customer1
VBI Service Type	ELAN_EVC
Forwarding Type	CVLAN Forwarding
FDBLimiting State	Disable
FDBLimiting Value	
FDBLimiting Action	
Admin State	Up

FDB Configuration

Add Static Unicast FDB entry	View Static Unicast FDB entries	View Dynamic Unicast Fdb Entries
Add Static Multicast FDB entry	View Multicast FDB entries	

FlowPoint Configuration

Add new FlowPoint

Split Horizon Group Id	FlowPoint	PM Counters	FlowPoint Template	MEPS	MIPS	Admin State	IGMP Profile	Delete

IGMP Snooping Configuration

IGMP Snooping profile	none

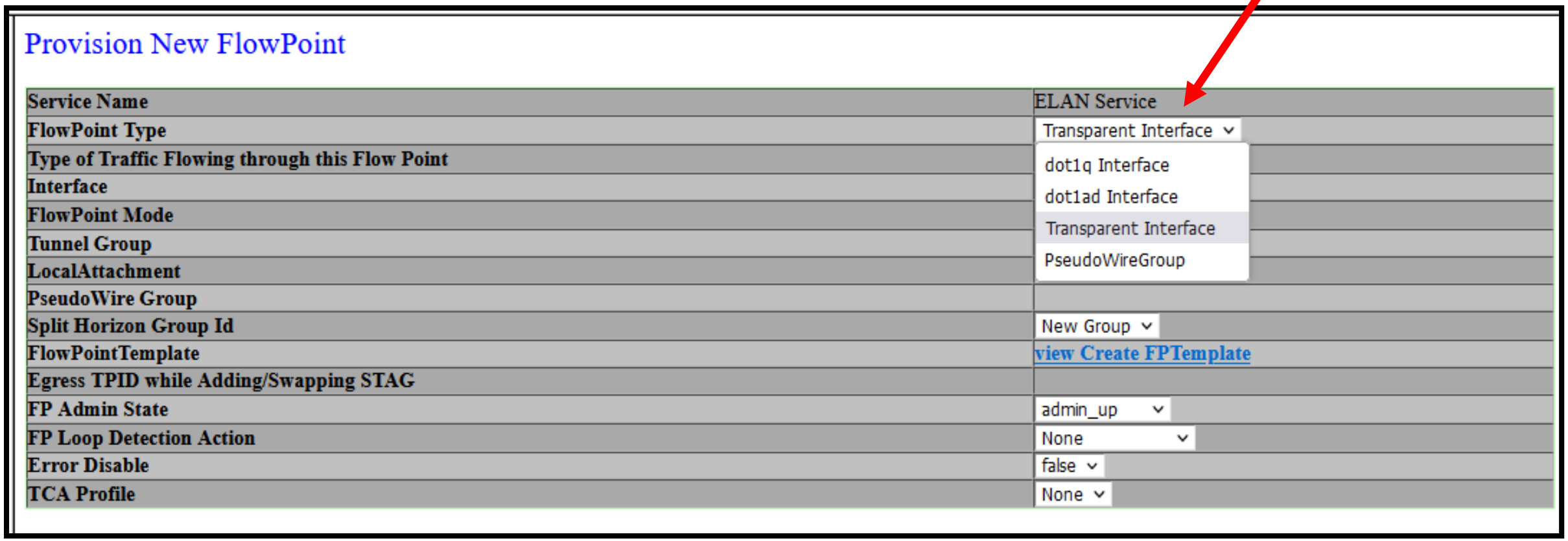
Reset Submit

Go to Add new flowpoint

TEJAS® NETWORKS

Step 7: Flowpoint Type=Transparent

Choose Transparent Interface



EOS

Step 8: Interface=>Select the required interface from drop down

Provision New FlowPoint

Service Name	ELAN Service
FlowPoint Type	Transparent Interface
Type of Traffic Flowing through this Flow Point	Data Traffic
Interface	VCG-1-6-106
FlowPoint Mode	
Tunnel Group	
LocalAttachment	
PseudoWire Group	
Split Horizon Group Id	New Group
FlowPointTemplate	view Create FPTemplate
Egress TPID while Adding/Swapping STAG	
FP Admin State	admin_up
FP Loop Detection Action	None
Error Disable	false
TCA Profile	None

Provision New FlowPoint

Service Name	ELAN Service
FlowPoint Type	Transparent Interface
Type of Traffic Flowing through this Flow Point	Data Traffic
Interface	ETH-1-6-6
FlowPoint Mode	
Tunnel Group	
LocalAttachment	
PseudoWire Group	
Split Horizon Group Id	New Group
FlowPointTemplate	view Create FPTemplate
Egress TPID while Adding/Swapping STAG	
FP Admin State	admin_up
FP Loop Detection Action	None
Error Disable	false
TCA Profile	None

EOS

Step 9: ELAN service is created

Edit ELAN Service : ELAN Service

Service Name	ELAN Service
Trail Identifier	0
Customer Name	Customer1
VBI Service Type	ELAN_EVC
Forwarding Type	CVLAN Forwarding
FDBLimiting State	Disable
FDBLimiting Value	
FDBLimiting Action	
Admin State	Up

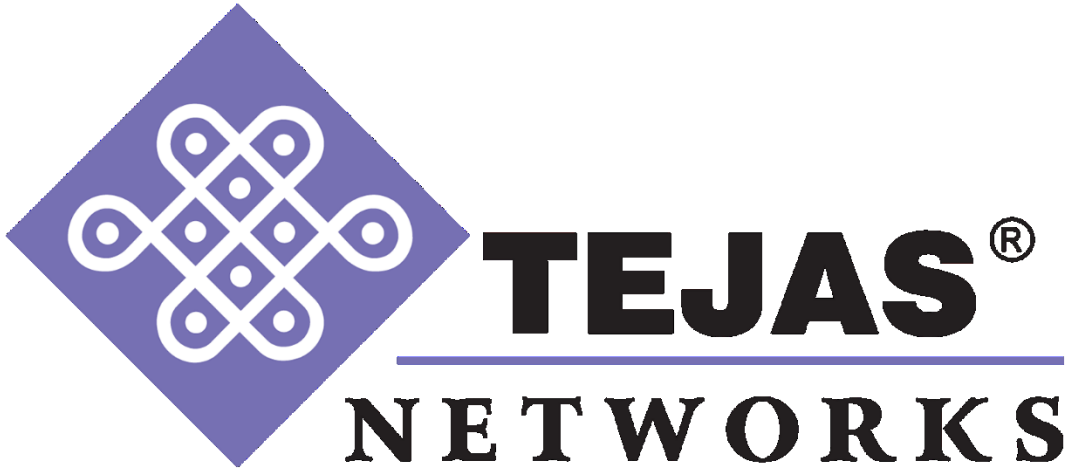
FDB Configuration

Add Static Unicast FDB entry	View Static Unicast FDB entries	View Dynamic Unicast Fdb Entries
Add Static Multicast FDB entry	View Multicast FDB entries	

FlowPoint Configuration

Add new FlowPoint

Split Horizon Group Id	FlowPoint	PM Counters	FlowPoint Template	MEPS	MIPS	Admin State	IGMP Profile	Delete
0	ELAN Service::FP_ETH-1-6-6	Performance Counters	Not Applicable	MEPS	N.A.	admin_up	N.A.	delete
0	ELAN Service::FP_VCG-1-6-106	Performance Counters	Not Applicable	MEPS	N.A.	admin_up	N.A.	delete



Thank you!

Contact Us:

trg@tejasnetworks.com