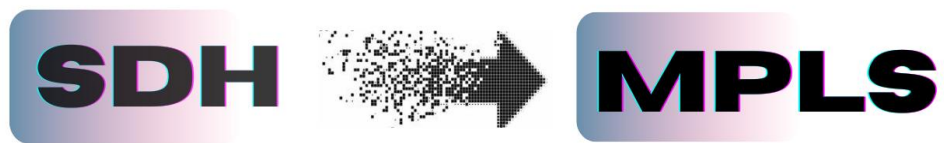




Report on Introduction of MPLS technology in ISTS Communication System



April 2025



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Acknowledgement

The Joint committee (JC) acknowledges the valuable cooperation extended by CEA, all RPCs, GRID-INDIA, POWERGRID, CSPTCL(Chhattisgarh), KSEB(Kerala), RVPNL(Rajasthan) and WBSETCL(West Bengal) for giving their essential inputs to finalize the recommendations for assessing the feasibility, integration & roll-out of MPLS in ISTS (Inter State Transmission System) Communication System, as per Terms of Reference (TOR) of the Joint Committee.

The JC also express its gratitude to MPLS OEMs/Service providers for their valuable inputs and suggestions in the preparations of this report. JC is grateful to TANTRANSCO for providing all support and guidance to perform the Interoperability Test at their sites.

Executive Summary

This report provides an in-depth analysis of the transition from Synchronous Digital Hierarchy (SDH) technology to Multiprotocol Label Switching (MPLS) technology within the Inter State Transmission System (ISTS) communication system. It aims to assess the feasibility, identify activities required for the transition, evaluate communication system requirements for power sector grid management, and recommend a comprehensive roll-out plan.

After detailed deliberations, the Committee submits the Report on “**Recommendations on the Introduction of MPLS Technology in the ISTS Communication System.**”

This report provides a comprehensive analysis of the feasibility of transition from SDH to MPLS, identifies key activities required for successful implementation, and outlines the communication system requirements essential for ensuring secure, efficient, and scalable operations.

MPLS technology offers significant advantages over SDH, including enhanced network flexibility, improved scalability, and superior resilience in handling dynamic traffic flows.

This report evaluates the technical and operational considerations for MPLS deployment, detailing network architecture, migration strategies, Make in India policy consideration and cybersecurity measures required to safeguard critical communication pathways. Additionally, it identifies potential challenges such as integration complexities and training requirements while providing mitigation strategies to ensure a smooth transition.

Based on detailed deliberations, the Committee recommends a phased rollover plan for MPLS adoption, emphasizing structured implementation, rigorous testing, and stakeholder collaboration. The transition strategy prioritizes minimizing disruptions, maintaining service continuity.

By embracing MPLS technology, ISTS communication systems will evolve into a future-ready framework, equipped to meet the growing demands of modernized power grid management. This report serves as a guiding document for decision-makers to facilitate informed adoption, drive technological advancements, and enhance the resilience of national power transmission networks.

Committee Members:

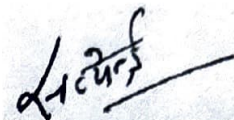
CEA has nominated following personnel for the Joint-Committee from CEA, all RPCs, CTU, GRID-INDIA, POWERGRID, CSPTCL-Chhattisgarh, KSEB-Kerla, RVPNL-Rajasthan and WBSETCL-West Bengal.



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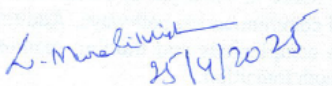
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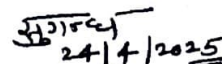
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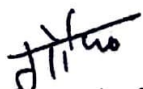
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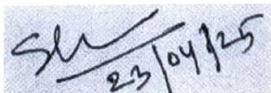
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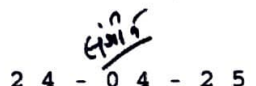
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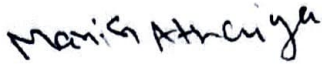
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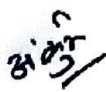
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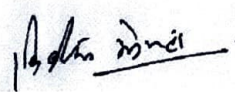
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Surata Ram
Chief Engineer,
ET&I, CEA
Member, JC

*The original JC members nominated by NPC have been changed due to superannuation/transfer etc.. The alternate concerned member has signed the report.

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Chapter 1: INTRODUCTION

1.1 Background

The SDH technology is being used very efficiently till date by the power sector captive networks and public domain communication provided by telecom service providers (TSPs). However, this technology is now gradually becoming obsolete worldwide as the growing number of users and the increasing demand for diverse applications place greater strain on existing infrastructure. Consequently, the TSPs are migrating to adopt new technologies which can efficiently cater the growing needs. This shift signals the end of life of SDH technology, which is expected to become obsolete soon.

It is also important to note that power sector is also booming with introduction of renewable power generators, microgrids, battery storage, smart grids and electric vehicle charging infrastructure. This expansion necessitates a more diverse and expandable network, leading to increasingly complex O&M (Operation & Maintenance) requirements. The design of such networks having diversity of applications necessitates dynamic allocation of bandwidth which is not feasible with current SDH network in present scenario. Additionally, the existing SDH network is not having sufficient Bandwidth efficiency due to large overheads.

As a result, SDH technology users are migrating into new adaptable technologies, which has reduced globally the chip production of SDH equipment. Consequently, SDH OEMs are advising existing users to transition to newer technologies, as maintaining SDH equipment is becoming increasingly challenging. The global trends also depict that there is paradigm shift by Global Power Utilities, who are migrating from conventional SDH (circuit switching) to MPLS (Packet Switch Network).

Some of the power sector utilities migrating to MPLS in various countries are attached at **Annexure-A.1**

In view of the above, the matter was deliberated in the 13th Meeting of National Power Committee (NPC) held on 05.07.2023 at Kolkata. CTU representative made a presentation regarding the Introduction of MPLS Technology for ISTS Communication Networks. During the presentation CTU highlighted the need for the MPLS technology in lieu of the existing SDH Networks due to the obsolescing SDH technology and more benefits with the latest technology MPLS. CTU also highlighted that several STUs like KSEB, Tamil Nadu, Chhattisgarh, Rajasthan etc. have already taking advanced steps to go for MPLS Technology in their state transmission and distribution networks. Further CTU requested the NPC Committee to foster the technology for ISTS communication system as this is required in all the regions.

MS, NPC informed that state like Kerala, Tamil Nadu, Jharkhand, and Telangana (taken grant from PSDF for implementation of OPGW based communication system in the state) has requested for change in technology for implementation of MPLS TP in place of SDH.

The PCD Division, CEA submitted the following inputs: Central Electricity Authority (Technical Standards for Communication System in Power System Operation) Regulations, 2020, as such, provides no limitations on usage of MPLS technology in power sector.

1. As per recommendations of CIGRE in its Green Book, MPLS-TP seems more promising packet-switched network technology, providing all features of the existing SDH system and delivering new capabilities with similar management processes and skills, as the ones already existing in the power utilities.
2. In the seminar organized by CTUIL in January 2023 on “Introduction of MPLS Technology in Indian Power Sector”, vendors gave presentation on both IP-MPLS and MPLS-TP vis-à-vis their advantages and application in power system. However, further deliberations in this regard are required to be held with respective technology providers, CTUIL and STUs to ascertain the performance of MPLS-TP and IP-MPLS vis-à-vis SDH, particularly in respect of tele-protection requirement of the Power System.
3. A few vendors have expressed interest for lab demonstration of these technologies. It is proposed that a subcommittee may be formed for verifying the technical suitability of these technologies in Power System. Based on the findings, pilot project may be taken up for recommended technology.
4. For smooth transition of technology from SDH to MPLS without hindrance, the feasibility of deploying hybrid FOTE (SDH cum MPLS technology) can also be explored. The same has been incorporated by TANTRANSCO in its “Reliable communication scheme” tender at 38 nos. 230 KV sub stations. The Proof of Concept with major FOTE vendors such as M/s. Siemens India Limited, M/s. ABB Limited, M/s. Hirschmann Limited and M/s. Huawei Limited was conducted in TANTRANSCO substations and witnessed by the expert P&C engineers. TANTRANSCO may share the performance results of the same.

During the 13th NPC Meeting, Chairperson, CEA suggested that a committee may be formed with the representation from RPCs, CTU, POWERGRID, NLDC, RLDCs, PCD Division, CEA, NPC and some of the prominent states to discuss and recommend on the introduction of MPLS technology in ISTS Communication system. The draft framework for introduction of MPLS technology in ISTS Communication system may be provided by CTU.

1.2 Joint-Committee Formation

NPC vide letter ref. CEA-GO-15-14/1/2021-NPC Division/256-277 dtd. 14.09.2023 (attached at **Annexure-I**) constituted a Joint Committee to assess feasibility, integration & roll-out of MPLS in ISTS Communication System.

The composition of the Joint Committee is as follows:

S. No.	Designation/ Organization	Name	Member
1.	Sr. General Manager, CTUIL	Shri H. S. Kaushal	Member Convener
2.	Chief Engineer, DPT, CEA	Shri Vivek Goel	Member
3.	Chief Engineer, ET&I, CEA	Shri Surata Ram	Member
4.	Superintending Engineer, SRPC	Shri Meka Ramakrishan	Member
5.	Superintending Engineer, WRPC	Shri P. D. Lone	Member
6.	Representative from ERPC	#	Member
7.	Superintending Engineer, NRPC	Shri. Anzum Parwej	Member
8.	Superintending Engineer, NERPC	Shri. S M Aimol	Member
9.	Director, PCD, CEA/	Shri Len J.B./	Member
10.	Director, NPC, CEA/ Deputy Director, NPC, CEA	Shri Satyendra Kumar Dotan/ Shri. Himanshu Lal	Member
11.	Chief General Manager, SRLDC	Shri T R Ganesh	Member
12.	Sr. General Manager, NERLDC	Shri S P Barnwal	Member
13.	General Manager, WRLDC	Shri. S K Saha	Member
14.	Sr. Deputy General Manager, ERLDC	Shri. L. Muralikrishna	Member
15.	Deputy General Manager, NRLDC	Shri Ankur Gulati	Member
16.	Deputy General Manager, POWERGRID	Ms. Shyama Kumari	Member
17.	Addl. Chief Engineer, WBSETCL	Shri Biswajit Madhu	Member
18.	Superintending Engineer, RVPN	Shri Manish Athaiya	Member
19.	Executive Engineer, KSEBL	Shri Rafeeqe K P	Member
20.	*Superintending Engineer, CSPTCL	Shri K K Yadav Shri Ashish Rai	Member

*CSPTCL has submitted their nomination for MPLS JC to NPC-CEA vide letter dtd. 22.04.2024 (Attached at **Annexure-IA**)

Nomination not received.

1.3 Terms of reference (TOR) of Joint-Committee:

- Study the feasibility/relevance of SDH technology in upcoming years.
- Identify all activities required for transition from SDH to MPLS.
- Assess the requirements of the communication system for Power Sector Grid Management.
- To roll out methodology for implementation of MPLS in ISTS communication system, if required.
- Dovetailing the MPLS network with the legacy SDH network of ISTS and interfacing STU networks, if required.

- Formulate the broad specification of MPLS in ISTS communication system, if required
- Any other suggestions/recommendations on related matters

1.4 Deliberations during various JC (Joint Committee) Meetings

1.4.1 1st JC Meeting held on 19.09.23

The **first meeting** of the JC was convened by CTU on **19.09.23** on virtual mode in which detailed discussion was done about “Assessment of present ISTS communication network”.

In the Meeting, constraints of the existing SDH based system were identified and Inputs were sought from STUs on MPLS network implemented. During the Meeting, issues such as SDH getting obsolete, roadmap and compatibility with UNMS and legacy network was discussed. The Minutes of Meetings are attached at **Annexure-II**.

Gist of 1st JC Meeting held on 19.09.2023

- Input from STUs on their MPLS network acquired
- Input from POWERGRID on MPLS POC acquired
- Feasibility of different power system applications over MPLS was deliberated.
- Roadmap of JC deliberated

1.4.2 2nd JC Meeting held on 17.10.2023

The **Second meeting** of the JC was convened by CTU on **17.10.23** on virtual mode in which detailed Presentations on MPLS-TP and MPLS-IP were given by OEMs/Service Providers.

In the Meeting, presentations on MPLS-TP and MPLS-IP were given by Hitachi and Nokia respectively and constraints for wider participation of OEM/Vendors as per GoI/DoT/MII Orders were discussed. It was deliberated that committee should move as per ToR and MII-related aspects can be taken up at the time of adoption of this technology during implementation phases. The Minutes of Meetings are attached at **Annexure-III**

Gist of 2nd JC Meeting held on 17.10.2023.

- Members to provide the inputs to be covered w.r.t. Step-I of the committee roadmap.
- Presentation on MPLS TP/IP done by MPLS OEMs/Service providers.
- ERLDC to present use cases/ case studies on OTN in power-sector and if possible, arrange for respective presentation by a vendor in consultation with CTUIL

1.4.3 3rd JC Meeting held on 15.12.2023

The **Third meeting** of the JC was convened by CTU on **05.12.23** on virtual mode in which CTUIL explained briefly about the agenda points of the 3rd meeting to the JC.

- (i) Functional requirement for new network technology
- (ii) Operational latency of different protection mechanisms at present
- (iii) Presentation on OTN by ERLDC
- (iv) Comparison of MPLS features of different OEM/suppliers (CISCO, HITACHI, GE, SIEMENS, NOKIA)
- (v) PoC to be deliberated w.r.t. ISTS applications

Gist of 3rd JC Meeting held on 05.12.2023.

- Presentation on OTN technology given by Tejas.
- Assessment of POWERGRID POC done
- Operational latency of different protection mechanism was discussed, Presentation on OTN technology was given by Tejas/ERLDC and comparison of MPLS features of different OEM/SUPPLIERS (CISCO, HITACHI, GE, SIEMENS and NOKIA) was discussed.

Following was concluded in the meeting:

- CTUIL to contact IP/TP vendors to conduct the suggested PoC.
- OTN technology presentation by TEJAS was viewed as overdesigned by JC and for the time being with next ten years MPLS/latest technology capacity shall be sufficient as access and core network.

The Minutes of Meetings are attached at **Annexure-IV**

A meeting was organised among CEA, CTUIL, POWERGRID, and CISCO on **13.12.2023** in online mode in which CISCO provided details about conduction of PoC. Minutes of the meeting were published on **14.12.2023** and are attached at **Annexure-V**

A meeting was organised among CEA, CTUIL, POWERGRID, and NOKIA on **15.12.2023** in online mode in which NOKIA provided details about conduction of PoC. Minutes of the meeting were published on **18.12.2023** and are attached at **Annexure-VI**

1.4.4 4th JC Meeting held on 24.01.2024

The **Fourth meeting** of the JC was convened by CTU on **23.01.2024** on virtual mode in which CTUIL explained briefly about the agenda points of the 4th meeting to the JC.:

In the Meeting, Operational Latency figures for various applications were provided by POWERGRID.

Following was concluded in the meeting:

- POWERGRID to provide operational latency data for remaining applications.
- POWERGRID shall finalize the location/network for PoC in consultation with CEA - PCD & CTU.

Gist of 4th JC Meeting held on 23.01.2024.

- POC discussions with MPLS – IP service providers with interoperability to be done on SDH & MPLS-TP deliberated
- Study of such network in power sector utility discussed
- Network requirement for POC deliberated.

The Minutes of Meetings are attached at **Annexure-VII**

1.4.5 5th JC Meeting held on 12.03.2024

The **Fifth meeting** of the JC was convened by CTU on **12.03.24** at **CTU Office** in which CTUIL explained briefly about the agenda points of the 5th meeting to the JC.

Gist of 5th JC Meeting held on 12.03.2024 at CTU office

- Requirement of hybrid MPLS equipment and their specifications deliberated.
- MPLS/OEMs/Vendor issues deliberated.
- Feedback and experience of STUs on MPLS (RRVPNL & TANTRANSCO) deliberated alongwith their presentation
- Field Visit by JC members at RVPNL & TANTRANSCO sites agreed in the JC meeting
- POC to be conducted on different make MPLS IP/TP equipment on TANTRANSCO or RRVPNL network was deliberated.

The Minutes of Meetings are attached at **Annexure-VIII**

1.4.6 Field visit carried out at RRVPNL sites on 17.05.2024 by team of JC members (Field visit report attached at **Annexure -IX)**

A team comprising of members from NPC-CEA, CTU, Grid India, NRPC & POWERGRID visited the RRVPNL control centre Heerapura (Jaipur). This control centre has been set up by RRVPNL for STNAMS network for the functioning of remote monitoring and control of STU stations. The scheme consists of a main ring on DWDM network for the long-haul links. The short haul links are interconnected between DWDM & IP/MPLS equipment at stations optically. Separate fibers have

been provided for STNAMS network besides ULDC network. The team observed the tele-Protection (distance) successfully through E1 interface of MPLS-IP network with latency figure of 3ms avg. (round trip). SCADA data latency was also found to be within 3 ms avg. (round trip).

1.4.7 Field visit carried out at TANTRANSCO sites on 23.05.2024 team of JC members (Field visit report attached at **Annexure-X**)

Observations of the Visiting Team:

A team comprising of members from NPC-CEA, CTU, Grid India, POWERGRID & KSEB visited the TANTRANSCO stations Pullinathope 400/230 kV GIS SS & Sriperumbudur 400/230/110 kV AIS. The team observed the following:

- Hybrid equipment used in the nodes of the backbone network to form a double ring network for redundancy with one ring on STM-16 SDH protocol and another ring on 10G MPLS-TP protocol.
- Tele-Protection (distance) over Ethernet interface of MPLS-TP network with latency figure of 3.24ms was successfully observed.
- SCADA data latency was measured by Ethernet frames ping test and the same was found to be 1.3 ms.

1.4.8 Online meeting with vendors on 27.05.2024.

The following was concluded in the meeting:

- TANTRANSCO to provide suitable 3 node of their MPLS-TP network alongwith technical details within a week.
- After information received from TANTRANSCO, all OEMs shall submit their Test Plans accordingly within 3 days.
- Detail logistics plan for all the requirement at TANTRANSCO sites to be provided by each OEM for the POC.
- CTU/TANTRANSCO shall prepare the schedule of witnessing the POC by JC Team.
- All the POC expenses shall be borne by the OEMs.

Minutes of meeting are attached at **Annexure-XI**

1.4.9 Online meeting with vendors on 21.06.2024

This meeting was convened to discuss their Test Plan / Schedule for interoperability testing.

Salient points of online meeting held on 21.06.2024 are attached to **Annexure-XII**

1.4.10 6th JC Meeting held on 08.08.2024

The **Sixth meeting** of the JC was convened by CTU on **08.08.24** on virtual mode in which CTUIL explained briefly the agenda points of the 6th meeting to the JC.:

In the Meeting, Locations were finalized for interoperability testing and Test Setup shared with the JC members were discussed.

Letter received by CTU from TANTRANSCO regarding consent of POC is attached at **Annexure- XIII**.

Proposed details for interoperability test proposed at TANTRANSCO site alongwith the site Test Plan is attached at **Annexure-XIV**.

1.4.11 7th JC Meeting held on 20.12.2024

The **Seventh meeting** of the JC was convened by CTU on **20.12.24** on virtual mode in which CTUIL explained briefly the agenda points of the 7th meeting to JC and the following were concluded in the Meeting:

- POWERGRID and Grid India to provide their comments/views/suggestions as discussed.
- In the next meeting report shall be reviewed in view of the above comments/views/suggestions.

Minutes of the Meeting are attached at **Annexure-XIV(A)**

1.4.12 8th JC Meeting held on 19.02.2025

The **Eighth meeting** of the JC was convened by CTU on **19.02.25** on virtual mode in which CTUIL explained briefly the agenda points of the 8th meeting to the JC and the following were concluded in the Meeting:

- Final Report shall be circulated by CTU to all the JC members for their comments/observations with a timeframe of 10 days.
- The report shall be signed by all the JC members and to be submitted to NPC CEA by CTU for further necessary action.

Minutes of the Meeting are attached at **Annexure-XIV(B)**

1.5 Inputs from POWERGRID on MPLS interoperability

POWERGRID informed that they have done their PoC on MPLS-TP technology in ER connecting Jeerat – Behrampur - Farakka (NTPC) - GokarnaWB – Rajarhat –Subhasgram - Kasba WB - ERLDC and WB SLDC. POWERGRID explained that the testing was done on a mixed network of SDH & MPLS-TP to test the interoperability and compatibility of both. They explained that they have tested the MPLS signal for 180km distance (on a 126 km distance using attenuators) with amplifiers available at present. The Bandwidth (BW) limit was 1Gbps signal from MPLS router was terminated on 1Gbps optical ethernet port of SDH. All the main applications presently being used were tested on this MPLS network.

POWERGRID also informed about the switching time of ethernet circuit implies the time taken for the data to be switched from main path to standby path at the control centre end i.e. if one path is down then time taken for data to switch on the backup path at control centre end is around 27ms. POWERGRID informed that DTPC latency was not measured as the POC was conducted to test the performance of the link on live traffic and there is no ready tool to capture latency data on regular basis . Latency only can be measured in a planned scenario by putting testers and disrupting traffic.

Report provided by POWERGRID are attached at **Annexure-XV**

1.6 Discussions & Reviews with MPLS OEMs/Service Providers

1.6.1 Nokia Network Solutions

Nokia Network Solutions presented their solutions on implementing MPLS technology with the legacy ISTS network. M/s Nokia explained the various technical aspects along with the advantages of MPLS-IP and MPLS-TP technology.

Nokia explained that their solution can meet the requirement of latency (using QoS) (Quality of Service) and bandwidth. Nokia further explained that their solution has three levels of priority with several QoS functions, and their end-equipment can provide multiple interfaces for connecting to any application.

Regarding MII, M/s Nokia stated that currently there is no regulation for IP-Routers which are manufactured in their plant located in Mexico and presently MII regulations are not affecting their operations in India.

Presentation is attached at **Annexure-XVI**

1.6.2 Hitachi

M/s Hitachi presented their solution on MPLS TP in respect of ISTS communication. M/s Hitachi gave the presentation vide which they explained needs of power sector and grid management applications and how MPLS technology befits these requirements. During the presentation, they emphasized on a single-box technology with single NMS which can provide all interfaces for every power application desired. However, replying to a question on STM-64 capacity to be integrated with MPLS M/s Hitachi replied that they have commercially operated upto STM-16. However, they have done some trial links on STM-64 also and they can gear up for such integration also, if required

Hitachi focused on its FOX-615 product which could take SDH traffic as well as MPLS traffic also with a lifespan of 20-25 years. Regarding the delivery timelines, it stated that in today's scenario, there is a delivery time of 3-4 months for hardware being faced globally.

M/s Hitachi representative from Switzerland also explained that there are very few vendors which support both MPLS TP and IP technology whereas the others are on either TP or IP. In case of MPLS-TP, several vendors are available with experience of deploying this technology for large utilities. Vendors such as Huawei and Cisco are providing both MPLS-IP and MPLS-TP based solutions to its customers. It was also conveyed that SDH chips are going out-of-market due to decrease in its customer base and recently a 7-digit investment was made by Hitachi to support its existing SDH customers due to these problems.

During the presentation, CTUIL requested Hitachi to express their status with respect to MII policy. Hitachi stated that their FOTE equipment is manufactured in Switzerland works and remaining activities like survey, installation & commissioning and training are provided by Hitachi India. In view of this, Hitachi India does not meet the present MII policy of GoI; however, they are approaching the relevant authorities in this regard.

Presentation is attached at **Annexure-XVII**

1.6.3 TEJAS NETWORKS

During the presentation, TEJAS stated that as the data requirement is growing at a faster pace, we should have main core network of OTN which caters for higher bandwidth around 100g and not the entire network as data congestion is more in core network. They further stated that the core network however shall be integrated by access network running on various other technology like SDH, MPLS etc.

POWERGRID stated that congestion is not the reason for migration of existing SDH system but, the primary reason is the obsolescence of SDH technology worldwide. CTUIL further stated that at present SDH technology is only being used for access as well as core network and is mostly of the capacity of STM 16 with few links of STM 64. This implies that the communication network required for grid management purpose can be sufficiently managed upto 10g capacity. Thus, OTN capacity seems to be overdesigning for the purpose of our grid

management communication network. Moreover, all the applications for grid management can be run on the same access and core networks.

On a query by CTUIL for the presence of networks based on OTN in power utilities worldwide or PoC conducted, TEJAS informed that same shall be checked and confirmed. CTUIL stated that they plan based on systems proven and operating successfully and TEJAS shall provide some details on the same.

Presentation is attached at **Annexure-XVIII**

1.7 Inputs from STUs on their MPLS Migration

1.7.1 KSEBL

KSEBL stated that they have planned MPLS for their state network and at present it is in tendering phase. They also informed that they are operating differential protection through dark fibres for which channel latency is around 3ms and it can be measured through relays and distance protection can be measured by looping.

1.7.2 TANTRANSCO

TANTRANSCO stated that their project is under execution and agreed to share details after successful implementation. Presentation given by TANTRANSCO is attached at **Annexure-XIX**

1.7.3 WBSEB

WBSEB stated that they are also planning to switch from SDH to MPLS based communication system.

1.7.4 RRVPNL

RRVPNL made a presentation on the MPLS-IP deployed in their network. They stated that they started a project “smart grid platform” in the year 2016-17 in which around 14500 kms fibre was laid with MPLS equipment at around 552 locations with Network Management System (NMS). Presentation given by RRVPNL is attached at **Annexure-XX**

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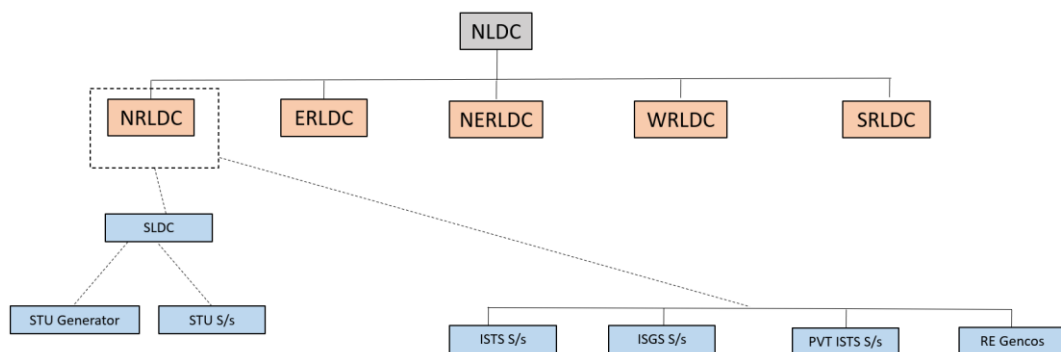
Chapter 2: ISTS Communication System

2.1 Overview

The preferred media used for Fiber Optic Communication System FOCS is optical fibre (mostly OPGW) due to its large bandwidth (BW) capacity and availability, however, where optical fibre is not available, PLCC, VSAT and Lease line from telecom service providers is used as an interim arrangement.

ISTS communication system is divided into five regions i.e. NR, SR, ER, WR, NER in line with ISTS system.

Network Architecture:



2.2 Present ISTS Communication system

The Present ISTS Communication system comprises of a Fiber Optic communication system. At present, ISTS OPGW (24F) of around 85000 Kms has been laid throughout the country connecting various substations/generating stations/control centres amounting to around 800 communication nodes. These nodes are interconnected with approx. 672 communication links. The capacity of these links varies from STM-1 (155Mbps) to STM-64 (10Gbps). This network was initially deployed in the Year 2000 and is being upgraded/ renewed from time to time, which is under use till date.

To monitor this vast network, it has been broken into 5 regional networks having one regional Load despatch centre (RLDC) in each region, one state load despatch centre (SLDC) for each state. The stations of the state essential for ISTS system report to the respective SLDC which further report to respective RLDC. The stations of the central sector utilities are made to report directly to respective RLDC. Finally, all the RLDCs report to the NLDC. All the control centres

also have their backup centres which are integrated in the ISTS communication system. Each regional network has been provided with multiple NMSs (Network Management System) of different communication equipment OEMs which are proprietary in nature. Besides this there are some communication equipment nodes which are monitored through FCT as they cannot be mapped into existing NMSs.

The above mentioned 800 nodes of the legacy network are added time to time as per the requirement, in a phased manner. These nodes have been equipped with SDH FOTE equipment which are assigned to be depreciated completely within seven years as per CERC regulations. Thus, the legacy network consists of operational SDH equipment which are new/within seven years/ and about to be replaced.

The ISTS communication network needs a shift in the communication data transmission technology which shall be compatible with the functional requirements of the users. In view of this various communication technology options are reviewed below:

2.3 Options for migration of Present ISTS communication system

2.3.1 OTN: Optical transport networks

Optical Transport Network (OTN) is a standardized digital transport protocol that provides a robust, high-capacity method for transmitting large volumes of data over optical fibre networks. It is designed to support multiple types of traffic (such as voice, video, and data) and enables high-speed, efficient, and reliable long-distance communication. OTN uses WDM technology to carry multiple data signals simultaneously over a single optical fibre by assigning different data streams to different light wavelengths (channels). This significantly increases the bandwidth available on the fibre. Brief points about OTN:

1. New technology evolved in 2010-2015
2. Operates at Layer -1/Layer 0 -operates at photonic layer.
3. Connection oriented
4. Dedicated BW
5. Deterministic
6. It can integrate with all legacy technologies except at E1 level (slowly it is phasing out)

Pros:

1. It is the latest technology.
2. More immune to cyber threats as compared to SDH & MPLS -TP technology since it operates at an Optical level

Cons:

1. BW of more than 100 G are only available, which is overdesign for ISTS requirement.
2. Testing is to be done for adaptation of technology with respect to Power system applications.

2.3.2 SDDN: Software defined digital network:

A **Software-Defined Digital Network (SDDN)** is a network architecture that enables the management and configuration of network resources through software, rather than traditional hardware-based methods. It separates the control plane (which makes decisions about how traffic should flow) from the data plane (which forwards traffic), allowing for more flexible, programmable, and efficient network operations. Some key points are:

1. Latest technology evolved in 2015 -2020
2. Specialized site equipment is used to separate Data plane, control plane and Manage plane of equipment
3. Automation and programmability

Pros:

1. Centralized network provisioning
2. Lower operating costs
3. Dynamic allocation of bandwidth as per traffic requirements

Cons:

1. It requires a change in the entire network infrastructure to implement the protocol and the controller required for SDDN.
2. It requires a complete reconfiguration of the network. which increases the overall cost.
3. A new management tool needs to be procured, and everyone should be trained to use it.
4. Security is a big challenge.

2.3.3 DWDM: Dense Wavelength Division Multiplexing

Dense Wavelength Division Multiplexing (DWDM) is an optical communication technology that significantly increases the bandwidth of fibre optic cables by multiplexing multiple data signals onto the same fibre. Each data signal is transmitted at a different wavelength (or channel) within a narrow spectrum, allowing for the simultaneous transmission of many channels without interference.

Pros:

High capacity

Cons:

1. Not cost-effective for low channels.
2. Wide band channel, CAPEX and OPEX high.

2.3.4 Multiprotocol Label Switching (MPLS) Technology

i. Multiprotocol Label Switching (MPLS)

MPLS is a versatile data-carrying technique that assigns labels to packets, enabling efficient and scalable routing through a network. It operates between the data link layer (Layer 2) and the network layer (Layer 3) of the OSI model, facilitating the creation of predetermined, highly efficient paths for data traffic.

MPLS-TP (Multiprotocol Label Switching - Transport Profile) and MPLS-IP (Multiprotocol Label Switching – Internet Protocol) are two variants of MPLS technology designed to address different networking needs.

ii. MPLS-TP (Transport Profile)

MPLS-TP is a variant of MPLS specifically designed for transport networks. It incorporates features from both MPLS and traditional transport technologies (like SDH/SONET and OTN), making it suitable for carrier-grade networks that require high reliability, management, and protection mechanisms. Key characteristics of MPLS-TP include:

- **OAM (Operations, Administration, and Maintenance):** Enhanced capabilities for fault detection, performance monitoring, and network management.
- **Deterministic Behaviour:** Ensures predictable performance and reliability, crucial for transport networks.
- **Static Provisioning:** Supports static setup and management of label-switched paths (LSPs), reducing complexity in certain scenarios.

iii. MPLS-IP (Internet Protocol)

MPLS-IP refers to the standard implementation of MPLS within IP networks. It leverages dynamic routing protocols and a control plane (such as LDP or RSVP-TE) to manage label distribution and path selection dynamically. MPLS-IP is widely used in service provider networks for applications like traffic engineering, VPNs, and QoS (Quality of Service) management.

iv. Salient features of MPLS Technology

➤ Network Monitoring and Management

- **Unified Network Management Systems:** Developing or adapting NMS to monitor both legacy and new MPLS systems concurrently.
- **Performance Metrics:** Establishing performance metrics to assess the effectiveness of MPLS in real-time operational scenarios.

➤ Latency and Quality of Service

- **Real- Time Applications:** Ensuring that latency requirements for critical applications (e.g., SCADA, Tele-protection systems) are met during and after the transition.
- **Traffic Prioritization:** Implementing QoS mechanisms to prioritize traffic effectively.

➤ Advantages of MPLS

- **Scalability:** Leveraging MPLS's scalability to support a wide range of services and traffic types.
- **Reliability:** Combining MPLS-TP's transport-grade reliability with MPLS-IP's dynamic routing ensures high availability and robust performance.
- **Operational Efficiency:** Unified management and OAM simplify network operations, reducing complexity and operational costs.
- **Service Flexibility:** Ability to offer both traditional transport services and modern IP-based services over the same network infrastructure.
- **Futureproofing:** Preparing the network for future demands by supporting evolving service requirements and technologies.

New vulnerabilities introduced by MPLS technology, if any are also being addressed suitably to provide adequate security from potential cyber threats.

From the above, it is seen that MPLS technology befits our present requirements very closely and is also being followed in various power sector utilities globally.

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Chapter 3: Challenges in Migration of SDH to MPLS

3.1 Functional requirements for POC on IP and TP Technology

- a. ISTS applications e.g. SCADA, PMU, AGC, Voice to be transmitted over MPLS
- b. Latency requirement for protection applications.
- c. Interoperability issues (other equipment like SDH)
- d. Repeaters requirement
- e. Hybrid equipment capacity STM-4 / STM-16 / STM-64
- f. Monitoring through UNMS

3.1.1 ISTS applications e.g. SCADA, PMU, AGC, Voice to be transmitted over MPLS.

The applications of Information Systems and Telecommunications Systems (ISTS), such as SCADA (Supervisory Control and Data Acquisition), PMU (Phasor Measurement Unit), AGC (Automatic Generation Control), and voice communications, can effectively be transmitted over MPLS (Multiprotocol Label Switching) networks. MPLS is widely used in utility networks due to its ability to provide efficient, secure, and reliable data transport with Quality of Service (QoS) capabilities. Benefits of these applications from MPLS:

i. SCADA over MPLS

SCADA systems require reliable, real-time communication to monitor and control industrial processes. MPLS provides:

- Low latency and high reliability for real-time monitoring and control.
- QoS for prioritizing SCADA traffic over other data types.
- Redundancy and fault tolerance, ensuring consistent data flow even in case of link failure.

ii. PMU over MPLS

Phasor Measurement Units (PMUs) are critical in electrical grids for measuring electrical waves to monitor grid stability in real time. MPLS helps by:

- Minimizing latency to ensure real-time measurements and data transmission for grid monitoring and control.
- High bandwidth for transferring time-synchronized measurements.
- QoS mechanisms that ensure PMU data is prioritized due to its time-critical nature.

iii. AGC over MPLS

Automatic Generation Control (AGC) is used in power systems to maintain the system frequency and power output of generating units. MPLS supports AGC by:

- Providing deterministic paths with minimal jitter for sending control commands.
- Redundancy features ensuring AGC.

3.1.2 Latency requirement for protection applications.

Latency for Tele-protection: **Distance <10ms & Differential < 5ms** by main and redundant routes.

Redundant routes may have multiple nodes (hops) which may increase latency.

3.1.3 Interoperability Issues (other equipment like SDH)

Compatibility with Legacy Systems: Ensuring MPLS can seamlessly integrate with existing SDH infrastructure and other legacy communication systems.

Vendor Diversity: Different MPLS vendors may have varying protocols and standards, leading to potential compatibility issues.

3.1.4 Repeater requirements

OEMs informed that with EDFA amplifier the repeaterless distance in general can be achieved up to 150 Km and with RAMAN amplifier up to 200 Km, depending on the losses, SNR etc. At present, repeaterless link length are generally at 225 Km. in the SDH networks operating with STM-16, thus an optimization in this regard is also required to collocate the repeaterless distances of MPLS environment with the legacy network.

3.1.5 Hybrid equipment capacity STM-4 / STM-16 / STM-64

Hybrid MPLS equipment should be compatible with legacy SDH. TANTRASNCO has deployed 40+ hybrid MPLS-TP equipment which support concurrent communication over MPLS-TP and SDH.

3.1.6 Monitoring through UNMS

POWERGRID informed in the JC meeting that both MPLS-IP and MPLS-TP network management system (NMS) can be integrated with Unified Network Management System (UNMS).

Besides the above-mentioned functional requirements of the ISTS communication system, the support of the following shall also be required to operate the Grid Management adequately and foster the existing network:

- Maintaining high availability & reliability
- Optimization of existing Infrastructure
- Maintaining grid management with all power sector applications
- Making the system smart & future-proof for upcoming technologies

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Chapter 4: Interoperability Test at TANTRANSCO Chennai

4.1 Introduction

The POC proposed for interoperability functions among cross technology and OEMs was tied up with TANTRANSCO. However, due to the sharing of TANTRANSCO operational network and shifting of the equipment by the OEMs, it could not be extended for a longer time. In view of this the POC was curtailed as an interoperability test after stabilization of the links and lasted for around two weeks.

The test report of the interoperability test presents the findings of a comprehensive MPLS testing initiative aimed at evaluating its suitability for power transmission communication networks. The primary objective was to assess the technical feasibility of migrating from legacy TDM-based SDH technology to packet-based MPLS technology, ensuring interoperability between different MPLS vendors and technologies, and integration with existing legacy SDH systems.

4.2 Testing team

The testing team constituted with the members from the following organizations:

1. NPC, CEA
2. PCD, CEA
3. CTU
4. SRPC
5. SRLDC
6. POWERGRID
7. KSEBL

4.3 Test Plan

The testing involved various combinations of MPLS-TP, MPLS-IP & SDH equipment from different OEMs. The focus was on evaluating the performance and interoperability of these implementations in terms of **distance Tele-protection, differential Tele-protection, VoIP, SCADA/PMU/AMR and E1 services.**

4.4 Participating OEMs

For the ease of interoperability to be tested, it was decided by the JC that since the test is to be conducted at TANTRANSCO which is already operating with MPLS -TP (M/s Hitachi) along with the legacy SDH network shall be coordinated by the Hitachi team. Further, since POWERGRID has already carried out POC successfully with M/s Tejas

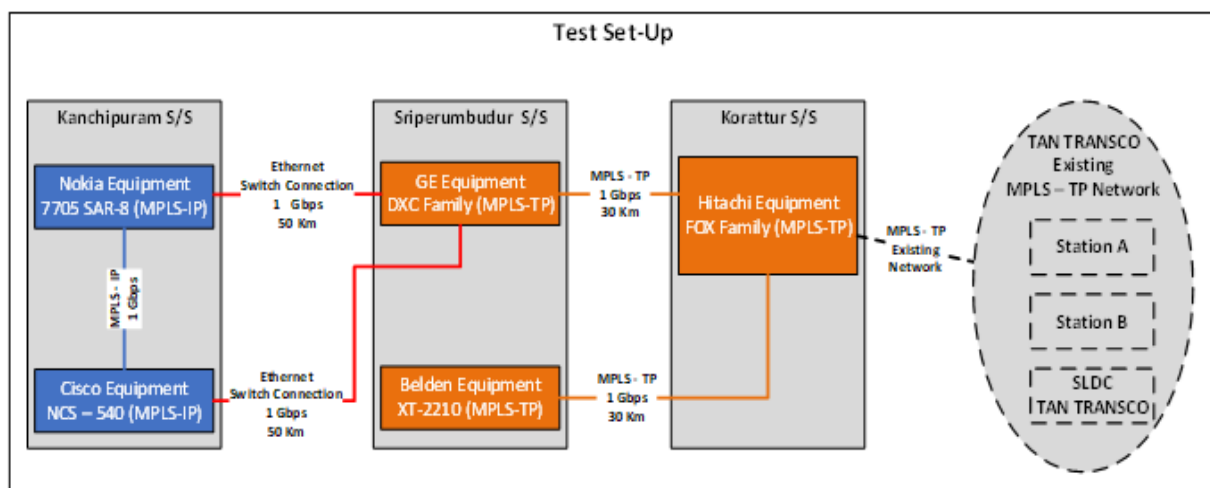
and report is enclosed at **Annexure- XV**. Further, as per the implementations of IP & TP OEMs in various countries by GE, HITACHI, SIEMENS, CISCO, NOKIA etc. it was considered that two IP and two TP OEM equipment links shall be made available for the said interoperability test supported by Hitachi.

1. GE (MPLS-TP)
2. Hitachi (MPLS-TP)
3. Belden (MPLS-TP)
4. Cisco (MPLS-IP)
5. Nokia (MPLS-IP)

4.5 Objectives

1. To evaluate the technical feasibility of MPLS technology for Power Transmission communication networks for migration from legacy SDH technology to MPLS technology.
2. To assess the feasibility of interoperability between different OEM's MPLS-TP with MPLS-TP, different OEM's MPLS-IP and MPLS-IP and MPLS-TP with MPLS-IP equipment.
3. To verify the integration capabilities of MPLS technologies with legacy SDH systems, including the ability to handle SDH tributaries (STM, E1, Ethernet services).

4.6 Test Set-Up



4.7 Tests Conducted

a. MPLS-TP to MPLS-TP

- i. Hitachi – Belden
- ii. GE – Hitachi

b. MPLS-IP to MPLS-IP

- i. Cisco – Nokia

c. Between MPLS-TP and MPLS-IP

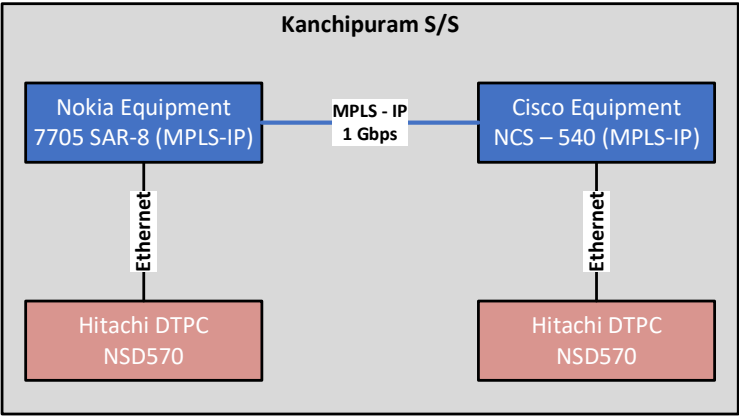
- i. Nokia-----Cisco-----GE-----Hitachi-----Belden
 --over IP-- -----Ethernet Switch----- --over TP-- --over TP--

4.8 Unresolved Tests and Issues

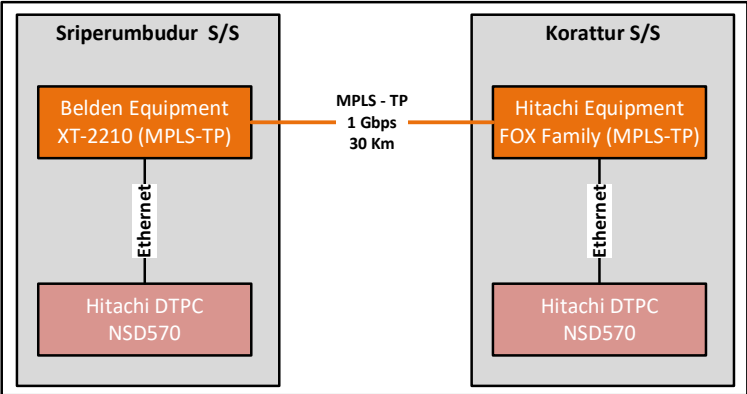
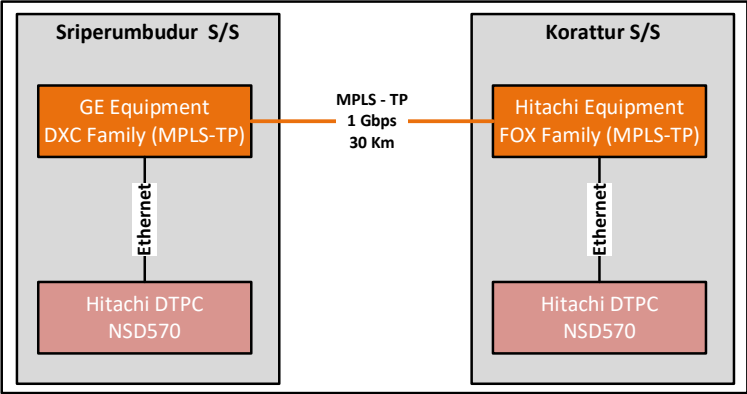
- a. MPLS-TP level connectivity between GE & Belden is unresolved due to MPLS label range mismatch.
- b. E1 to E1 integration between different MPLS OEMs is not yet universally successful.

4.9 Details of Tests performed with various services and findings.

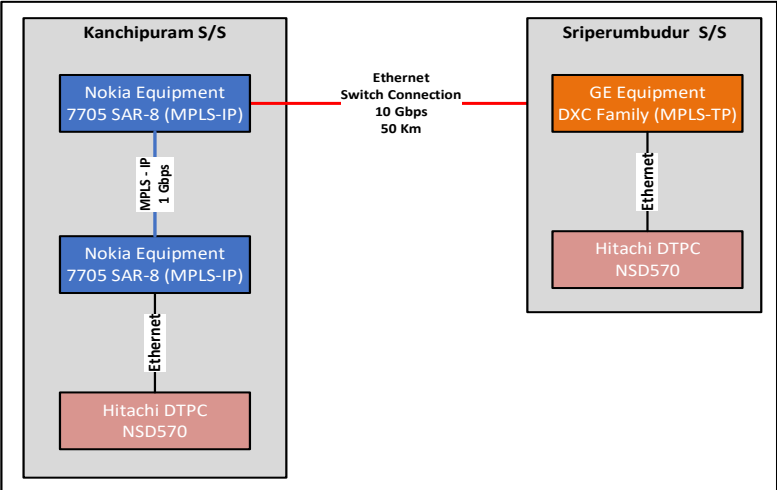
i. Between MPLS-IP to MPLS-IP



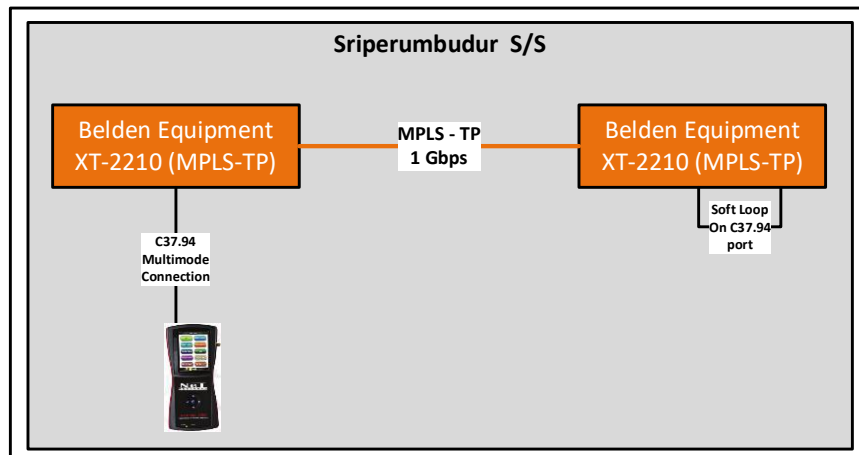
ii. Between MPLS-TP to MPLS-TP



iii. MPLS-TP to MPLS-IP (by extending Ethernet port as a service on a switch)

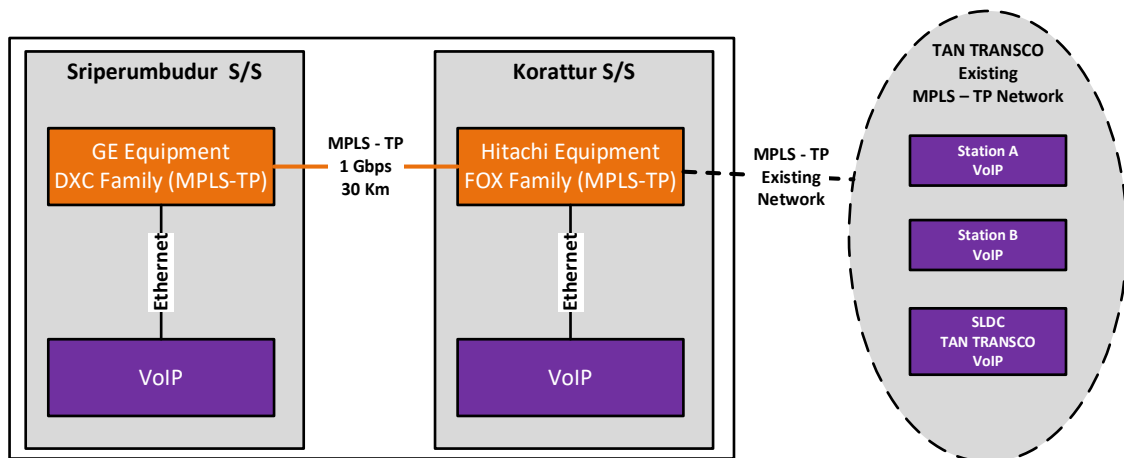


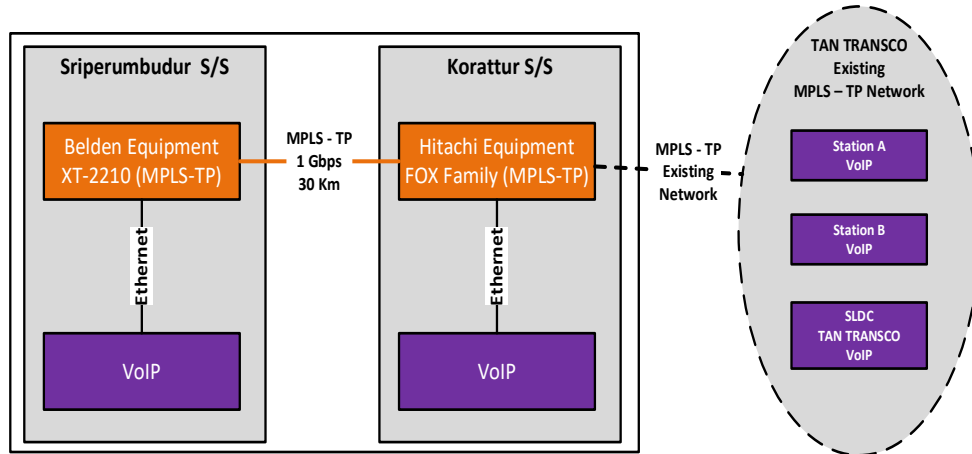
4.9.1 Differential protection (C37.94) over MPLS-TP to MPLS-TP between same OEM works



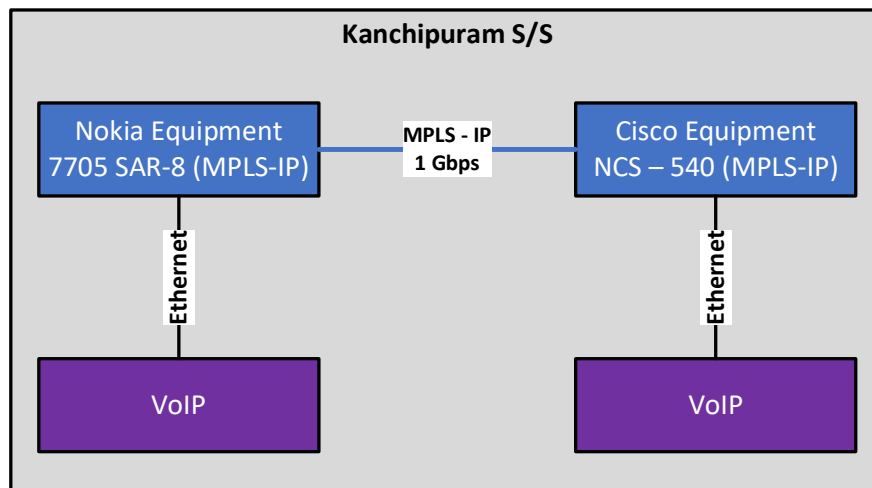
4.9.2 VoIP (Voice Over IP) - VoIP is supported across different MPLS-TP and MPLS-IP systems, and interoperability between MPLS-TP and MPLS-IP is achievable through service-level switching.

i. Works between different MPLS-TP OEMs

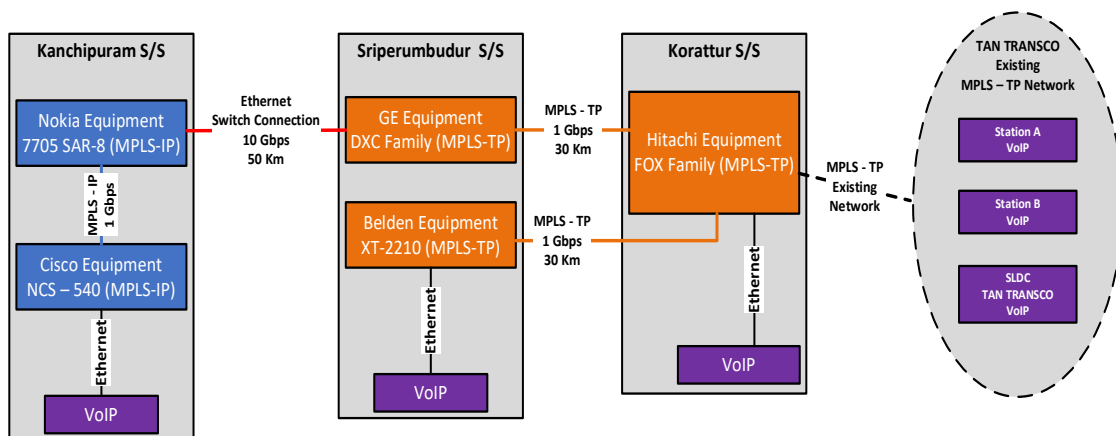




ii. Works between different MPLS-IP OEMs



iii. Works between MPLS-TP & MPLS-IP through switch at service level



4.10 Test Observations:

1. Distance Tele protection Testing on over MPLS Path

OEM-1	OEM-2	Latency	Remark
HITACHI (MPLS TP) Korattur S/s	GE (MPLS TP) Sriperumbudur S/s	3.1 ms (One way time)	Using DTPC (DTPC should be of same make at both ends)
HITACHI (MPLS TP) at Korattur S/s	BELDEN (MPLS TP) Sriperumbudur S/s	3.6 ms (One way time)	Using DTPC (DTPC should be of same make at both ends)
CISCO (MPLS IP) Kanchipuram S/s	GE (MPLS TP) Sriperumbudur S/s	3.56 ms	Using DTPC (DTPC should be of same make at both ends) using ethernet
CISCO (MPLS IP) Kanchipuram S/s	NOKIA (MPLS IP) Kanchipuram S/s	< 1 ms	CISCO & NOKIA equipment are connected with Laptops

2. Testing of C37.94 Differential Protection on MPLS

Tested only between MPLS TP (M/s BELDEN) to MPLS TP (M/s BELDEN). It is to mention that M/s GE (MPLS TP) could arrange only one set of their equipment, so it could not be tested for GE equipment link. Further, due to the label mismatching issue of GE and BELDEN equipment, the same could not be tested for cross OEM MPLS-TP links. The MPLS TP vendor/s responded on CTU query that cross-OEM TP equipment links can be made operational for the tele-protection provided the label matching and the same make DTPC equipment are ensured. However, the vendor stated that cross technology links of MPLS are not feasible for tele-protection.

It is to mention that M/s CISCO & M/s NOKIA (MPLS IP) could arrange only one set of their equipment and no C37.94 interface cards, so tele-protection could not be tested for their equipment links either for same OEM or cross OEMs.

The MPLS IP vendor/s had not responded in the stipulated time given in the CTU query. It is understood that the differential tele protection has not been implied by the IP vendors as it is seen from above that IP links in RRVPNL network are also being used for distance protection only.

4.11 Test report signed by witness team is attached at **Annexure – XXI**

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Chapter 5 Observations and Recommendations

5.1 Overall Observations

With the present technologies available on MPLS and the detailed deliberations in JC meetings, OEMs inputs, various field visits and interoperability test conducted at TANTRANSCO, JC proposes the following:

5.1.1 Integration of legacy SDH networks with MPLS networks

- a. MPLS TP network can be integrated with legacy SDH networks with hybrid or any intermediate interfaces supporting SDH technology provided the labels supported by the MPLS TP equipment being integrated shall match.
- b. MPLS IP network can be integrated with legacy SDH networks with suitable intermediate interfaces supporting SDH technology provided the labels supported by the MPLS IP equipment being integrated shall match.

5.1.2 Interoperability with MPLS TP & MPLS IP networks

- a. **Data Communication** is possible through MPLS payload on TP-TP equipment of different OEMs and on IP-IP equipment of different OEMs provided the labels supported by the MPLS equipment of different OEMs being integrated shall match. However, with IP-TP equipment integration, data communication is feasible at tributary (ethernet) level and not through MPLS payload.
- b. **VOIP Communication** is possible through MPLS payload on TP-TP equipment of different OEMs and on IP-IP equipment of different OEMs provided the labels supported by the MPLS equipment of different OEMs being integrated shall match. VOIP functionality was also successful among all the nodes of TANTRANSCO through intervening IP/TP MPLS links.

Tele-Protection applications

- i. **Distance Tele-Protection:** This protection works on two types of interfaces i.e. E1 & Ethernet
 1. **Distance Tele-Protection (Ethernet):** This works on MPLS payload on TP-TP equipment of different OEMs and on IP-IP equipment of different OEMs provided the labels supported by the MPLS equipment of different OEMs being integrated shall match. Moreover, the DTPC equipment shall be of same make at both ends. The latency is within the limits of CEA standards. However, with IP-TP equipment integration, Distance Tele-Protection (Ethernet) works at tributary (ethernet) level and not at MPLS payload.

2. **Distance Tele-Protection (E1):** This could not be conducted due to inadequate availability of E1 cards with the OEMs during the testing.
3. **Differential Tele-Protection (C37.94):** This was successfully conducted on MPLS payload on TP-TP equipment of same OEM. Tested only between MPLS TP (M/s BELDEN) to MPLS TP (M/s BELDEN). The MPLS TP vendor/s confirmed that cross OEM TP equipment links can be made operational for the tele-protection provided the label matching and the same make DTPC equipment are ensured. However, the vendor stated that cross technology links of MPLS are not feasible for tele-protection.

Due to no response of IP vendors as stated above, it is understood that the differential tele protection has not been implied by the IP vendors. However, IP links in RRVPNL network are being used for distance protection only.

5.2 Migration from SDH to MPLS Scenario

Migration to MPLS from SDH may be possible by adopting a hybrid approach, which should be capable of integrating with both MPLS technologies (MPLS-TP / MPLS-IP) and legacy SDH systems.

- With hybrid solution, the transition to packet based MPLS technology can be achieved without disrupting existing services while maintaining compatibility with existing infrastructure. This will help to ensure a seamless and cost-effective transition while paving the way for future scalability. The integration of MPLS with SDH legacy system should also provide full feature support for adding and dropping SDH tributaries (STM, E1, Ethernet service) on the node. This approach will enable a smooth transition from SDH to MPLS without sacrificing the ability to handle traditional SDH services.
- Various OEMs of MPLS should work in collaborative manner to resolve the various interoperability issues, particularly for label range mismatches, cross technology integration, cross-vendor E1/C37.94 etc.

Globally, it is observed that power utilities often deploy both MPLS-TP and MPLS-IP to create robust communication networks tailored to following diverse needs:

- MPLS-TP is favoured for Operational Technology (OT) traffic due to its deterministic nature, high reliability, and suitability for real-time grid control applications.

- MPLS-IP is employed for Information Technology (IT) traffic, which benefits from its flexibility, scalability, and cost-efficiency.

MPLS-IP is increasingly being adopted in the power sector for SCADA systems, often as part of a hybrid approach where critical OT traffic is routed through deterministic networks like MPLS-TP or SDH, while MPLS-IP supports both SCADA and IT traffic with appropriate QoS configurations. This deployment model allows utilities to leverage the scalability, flexibility, and cost-effectiveness of MPLS-IP while ensuring that the stringent requirements of SCADA systems are met.

Utilities deploying MPLS-IP for SCADA must carefully manage QoS, redundancy, and security to ensure reliable performance. Hybrid MPLS-TP and MPLS-IP solutions are likely to remain common, allowing utilities to balance the needs of both operational and business networks.

5.3 Methodology

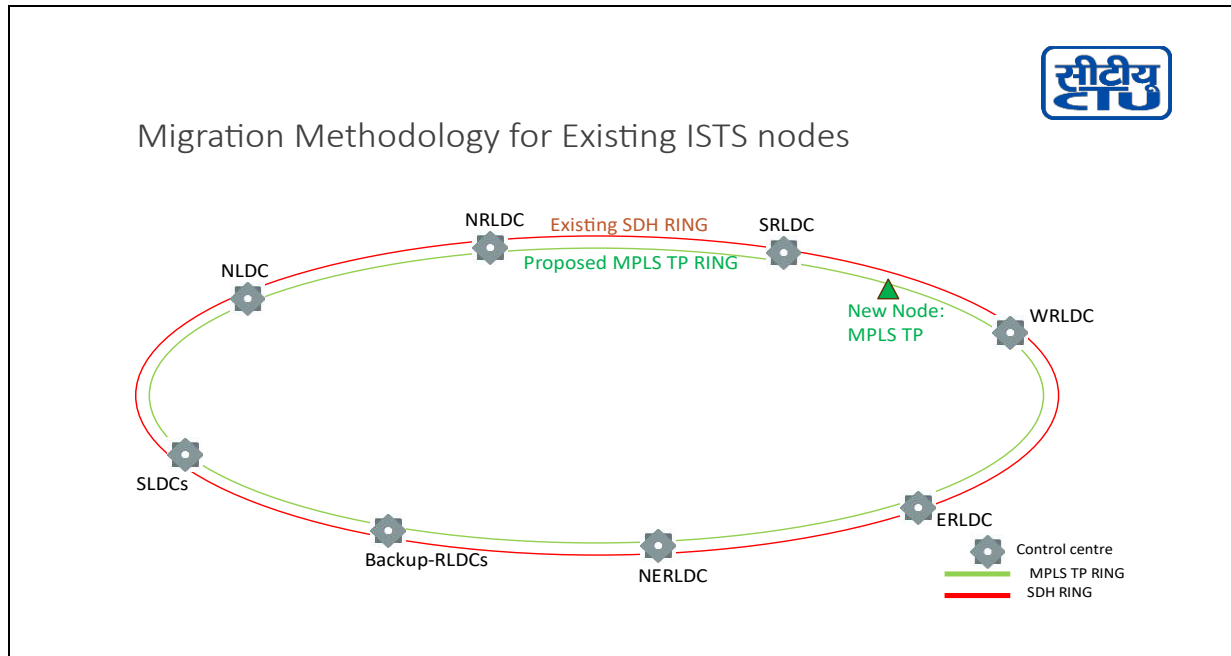
5.3.1 MPLS Network integration for existing/new ISTS nodes

It is proposed to have a connectivity of all the control centres preferably in ring topology with the more deterministic MPLS TP network along with the existing SDH network. In the existing SDH network, MPLS TP equipment shall be suitably provided with proper configuration on Regional/ National UNMS to meet the following:

- Link feasibility design requirements to route the existing data efficiently.
- To substitute the SDH equipment if it has lived the depreciated life (i.e. 7 years).
- Wherever SDH is not substituted, MPLS TP equipment may be required as per the network designed.

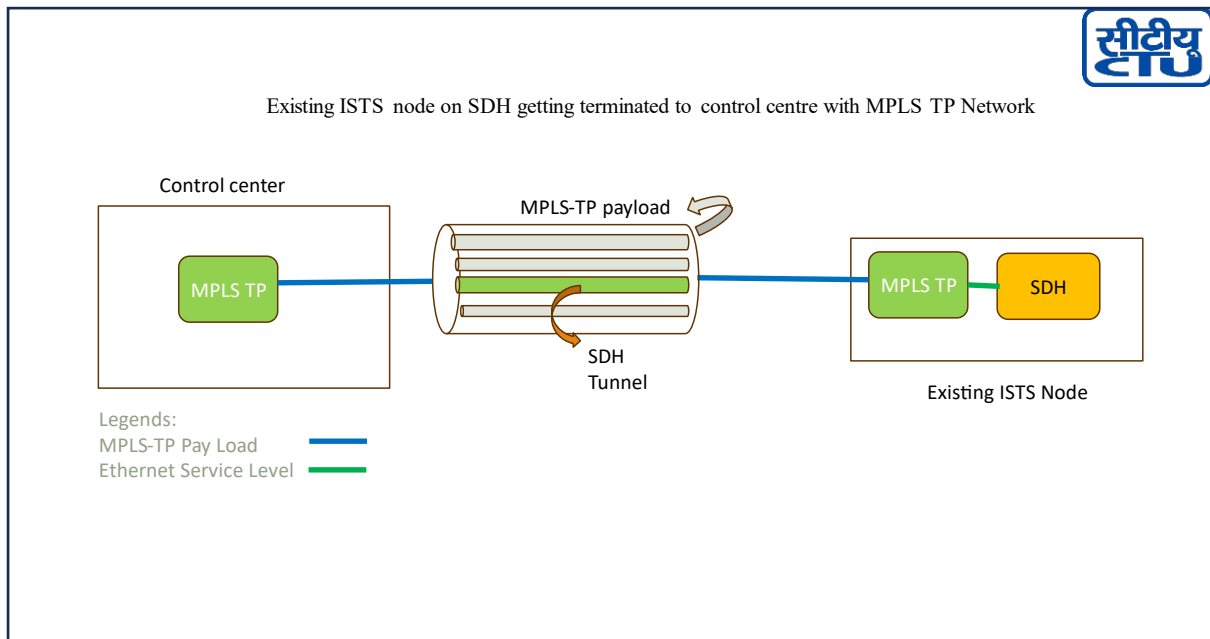
All nodes coming in the path interconnecting control centres shall be proposed with MPLS TP equipment.

Connectivity of PAN India control centres preferably in ring topology with the more deterministic MPLS TP network alongside the existing SDH network is shown below:

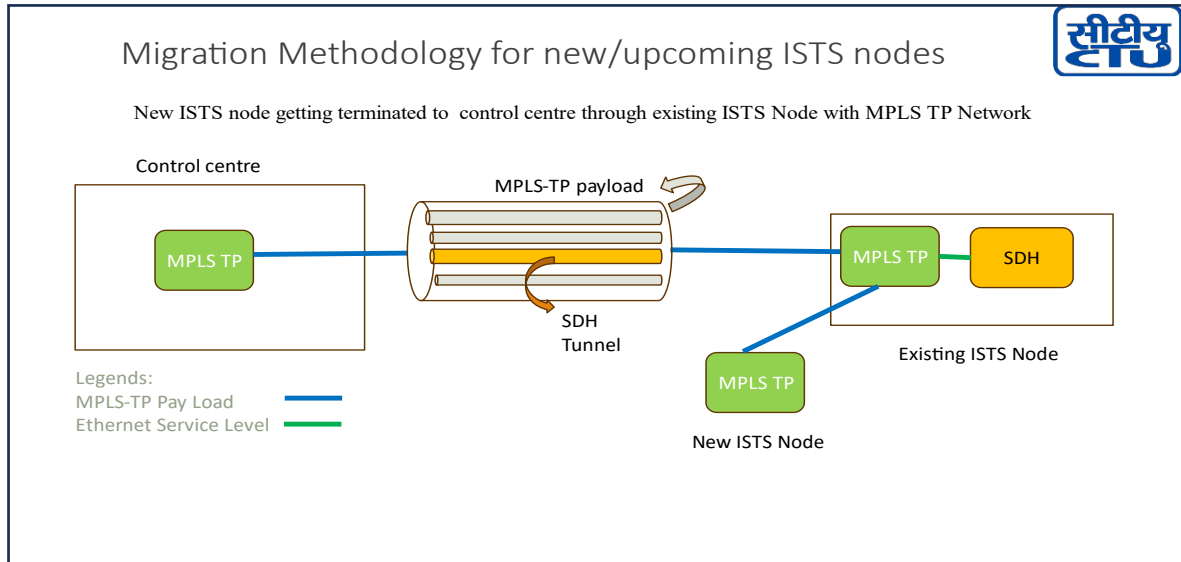


Various Scenerios of Node Integration

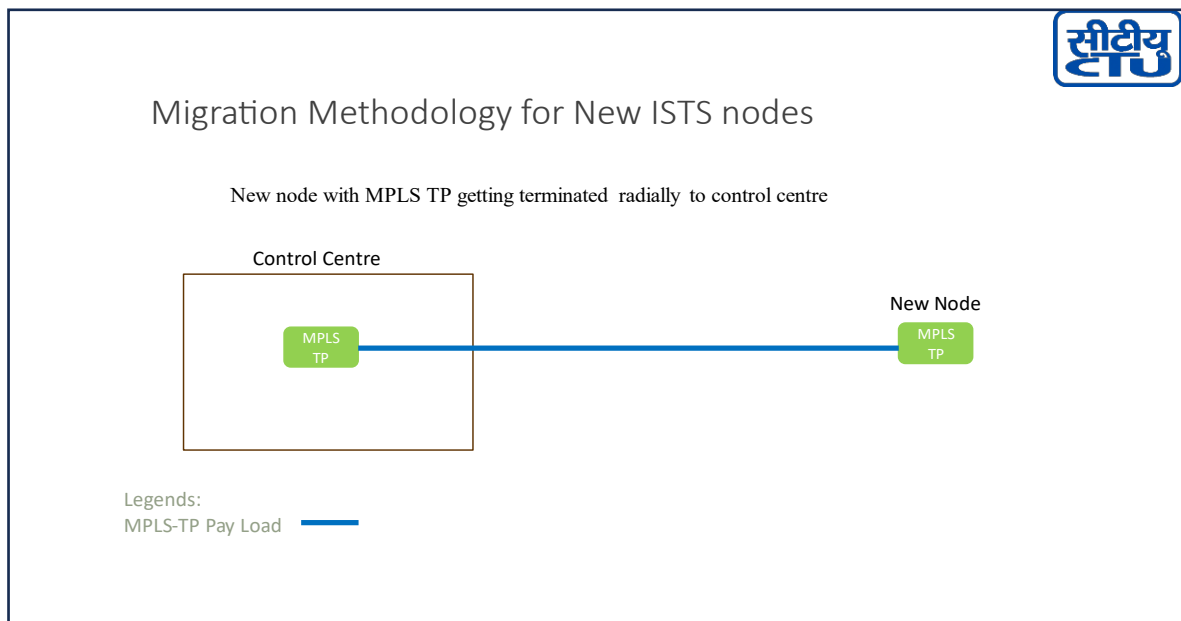
- 1) Connectivity of Existing ISTS Node on legacy Network with the proposed MPLS TP Network is shown below:



- 2) Connectivity of New ISTS node getting terminated to control centre through existing ISTS Node with MPLS TP Network is shown below:



- 3) Connectivity of New radial ISTS Nodes with the proposed MPLS TP Network is shown below:

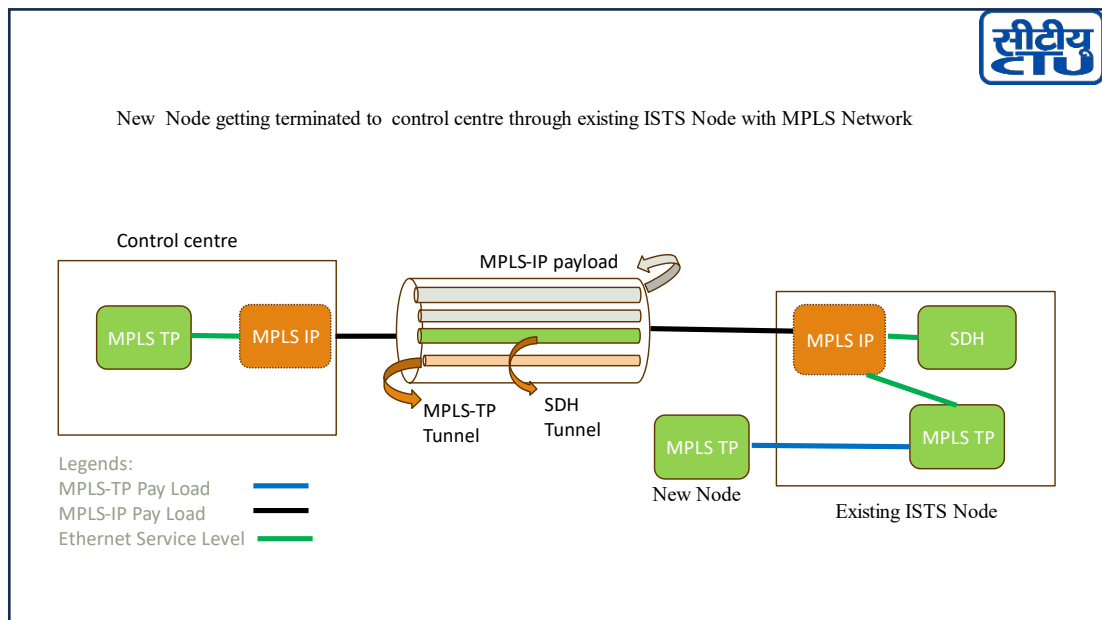


5.3.2 MPLS Network integration for new/existing nodes other than above ISTS Nodes

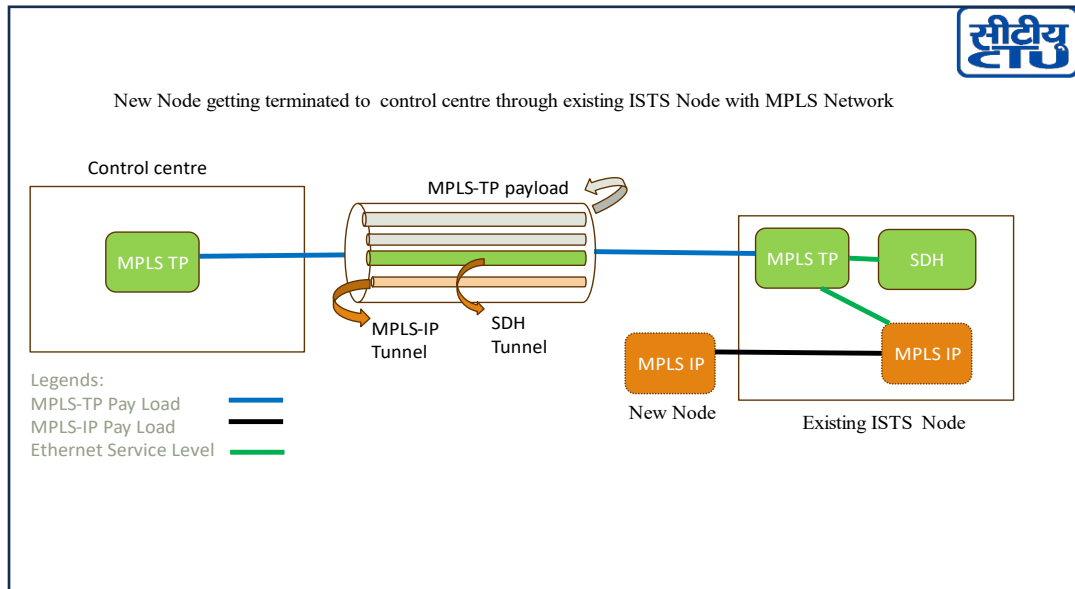
For Nodes other than those discussed in 5.3.1 (viz. IPP/RE/Bulk consumers etc.) are proposed to be reviewed and engineered for either MPLS IP or MPLS TP equipment. The new/existing nodes of IPP/RE/Bulk consumers etc. can be adopted and integrated through MPLS TP/IP equipment with the evolved ISTS MPLS TP Network with proper configuration on Regional/National UNMS Following situations arise in this connectivity as under:

Various Scenerios of Node Integration

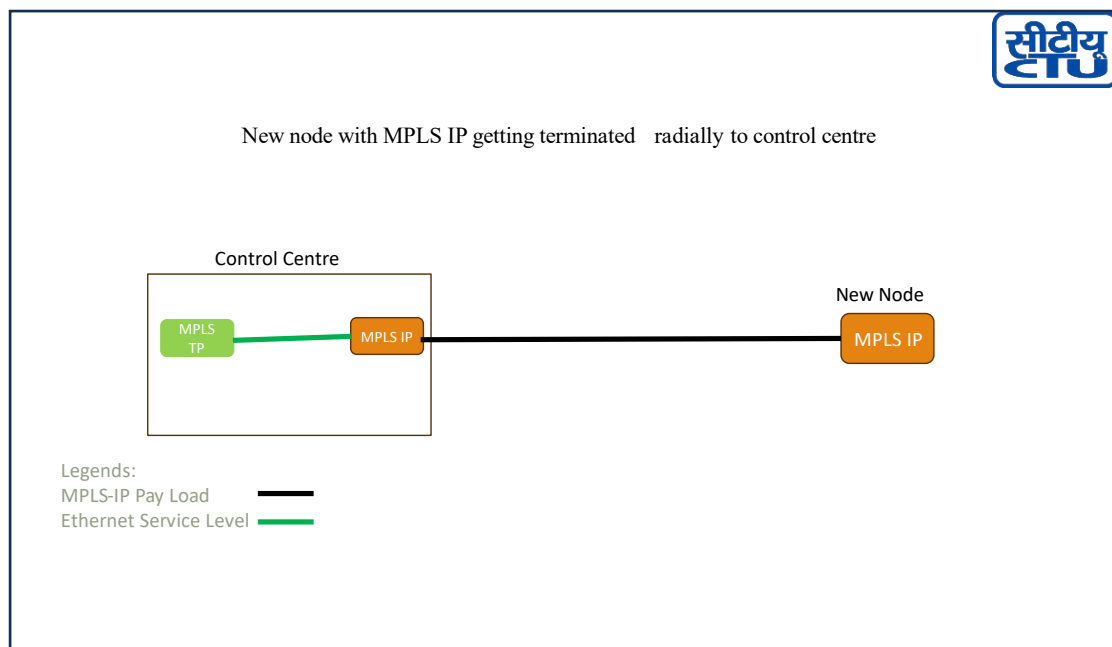
- 1) New node with MPLS TP getting terminated to an existing ISTS Node with MPLS Network to reach the control center. In this case MPLS TP traffic shall be fed in the MPLS IP node via ethernet and further transmitted through MPLS TP tunnel.



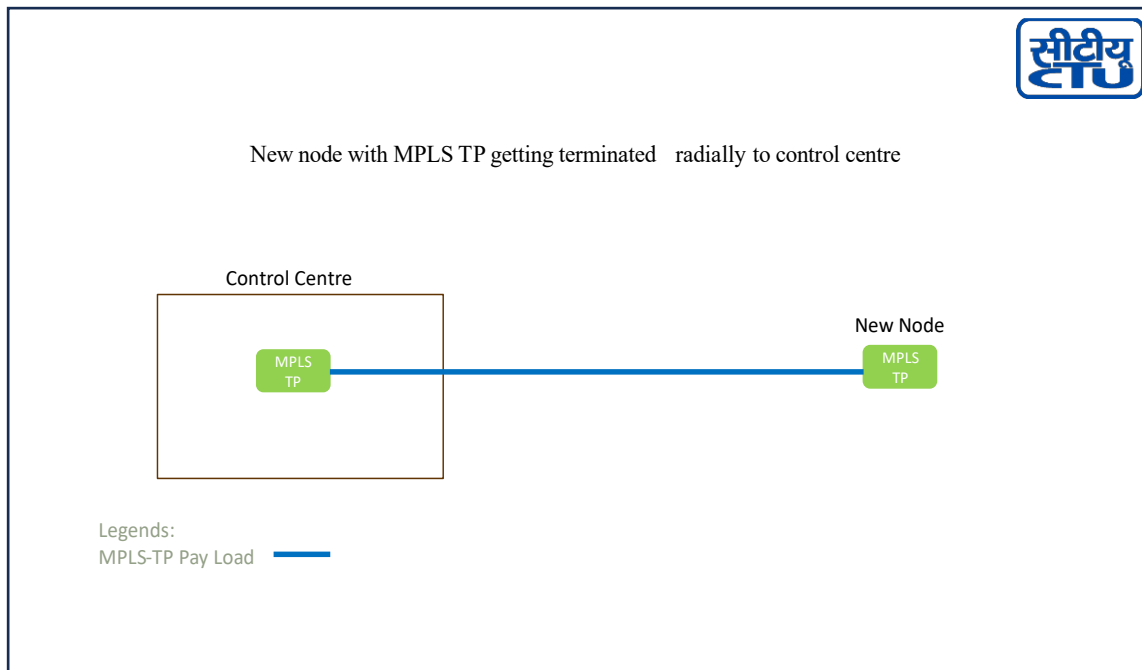
- 2) New node with MPLS IP getting terminated to an existing ISTS Node with MPLS Network to reach the control center. In this case MPLS IP traffic shall be fed in the MPLS TP node via ethernet and further transmitted through MPLS IP tunnel.



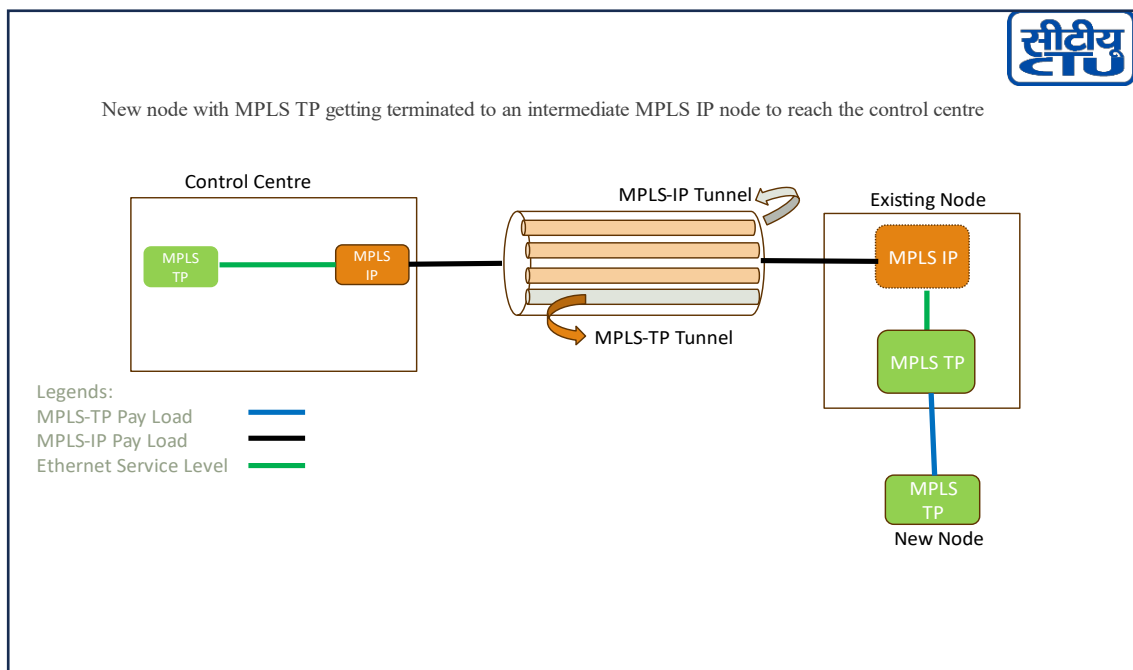
- 3) Connectivity of New radial MPLS IP Nodes with the proposed MPLS TP Network is shown below:



- 4) Connectivity of New radial MPLS TP Nodes with the proposed MPLS TP Network is shown below:



- 5) Connectivity of New MPLS TP Nodes through existing MPLS IP Node with the proposed MPLS TP Network is shown below:



5.3.3 Roll-over Plan from SDH to MPLS

1. The Rollover from SDH to MPLS of the existing Main & Backup control centers (SLDCs & RLDC) alongwith their existing ISTS stations (RTM/TBCB) is suggested to be implemented first in a smaller region like NER.
2. This Rollover is suggested to be connected through additional pairs of fibers on MPLS TP Network with suitable and optimized provision of repeaters and proper configuration on Regional/National UNMS. Moreover, to meet the space constraints in the Control Room (CR) of the stations, the equipment panels can be optimized for SDH & MPLS equipment.
3. There may be some intervening STU nodes on the ISTS paths, which shall also be taken up after deliberations in appropriate RPC forums for the said network implementations.
4. One of the two (2) standby channels of the above nodes, shall be fed through this MPLS TP N/w.
5. The network shall be monitored and stabilized for at least 6 months or the closing of the non-conformities observed, whichever is later. After stabilization of this 1st standby channel on MPLS TP N/w, 2nd standby channel shall also be fed to the MPLS TP N/w.
6. After stabilization of the 1st standby channel on MPLS TP N/w of the above-mentioned NER N/w, Rollover Plan from SDH to MPLS of the remaining regions for the existing Main & Backup control centers (SLDCs, RLDCs & NLDC) alongwith their existing ISTS stations, can be initiated for recommendations of RPCs and approval of NCT.
7. After approval of NCT, the steps mentioned above from point no. 2 to 5 (for NER) shall be implemented for each of the remaining regions.
8. Finally, both main operational channels of the SDH equipment shall be fed to the MPLS TP Network at the corresponding nodes as and when the SDH equipment needs to be removed. Gradually, all SDH equipment will be phased out after reaching the end of its useful life.
9. Thus, now the complete 2+2 configuration of channels shall be on MPLS TP N/w.
10. The commercial aspect for the implementation at RTM & TBCB stations shall be taken up suitably at appropriate forums.

After completion of the rollover of MPLS TP Network in the ISTS system, the existing nodes of IPP/RE/Bulk consumers etc. shall be required to ensure integration of their existing communication equipment in line with the above-mentioned steps for rollover to MPLS TP Network and proper configuration on Regional/National UNMS.

5.3.4 Phase wise Roll-over Plan with Timeline (for NER Region)

Phases	Rollover Plan for NER			Tentative Timeline
	Existing Network	Required transition to MPLS Network	Outcome	
Existing	SDH N/w (2 Main + 2 STBY)	Existing SDH N/w	-	CTU shall award after NCT approval (Zero date)
Phase- 1	SDH N/w (2 Main + 2 STBY)	Readiness of additional 1 st fibre pair on existing OPGW for proposed MPLS TP equipment	First additional Fiber pair for MPLS TP is ready	24 months
Phase- 2	SDH N/w (2 Main+ 1 STBY) + MPLS TP (1 STBY on additional 1 st fibre pair)	Procurement of MPLS equipment and Shifting of 1 st standby channel from SDH to MPLS N/w on 1 st additional fiber pair	RLDC receiving main data through SDH N/w & Standby data through SDH and MPLS N/w	
Phase-3		Monitoring of MPLS channel and resolving the non-conformities	RLDC receiving main data through SDH N/w & Standby data through SDH and MPLS N/w	
Phase-4	SDH N/w (2 Main+ 1 STBY) + MPLS TP (1 STBY on additional 1 st fibre pair)	Readiness of additional 2 nd fibre pair on existing OPGW for proposed MPLS TP equipment	SDH N/w (2 Main) + MPLS TP (2 STBY on additional 1 st fibre pair)	Parallely done during Phase-2 & Phase-3
		Shifting of 2 nd standby channel from SDH to MPLS N/w on 2 nd additional fiber pair	RLDC receiving main data through SDH N/w & Standby data through MPLS N/w	≥ 31 months (1 months from Phase-3 completion)
Phase-5	SDH N/w (2 Main) + MPLS TP (2 STBY) (2 Main on additional 1 st and 2 nd fibre pairs)	Shifting of Both Main channels on additional 1 st & 2 nd fiber pairs subject to point no. 8 of clause 5.3.3	All Main and Standby channels on MPLS TP N/w	≥ 32 months (1 months from Phase-4 completion)
	MPLS TP (2 STBY on 1 st and 2 nd fibre pairs) + MPLS TP N/w (2 Main on additional 1 st and 2 nd fibre pairs)	Monitoring of MPLS channels migrated from legacy N/w and resolving the non-conformities	RLDC receiving data of main & Standby channels through MPLS N/w	36 months

5.3.5 PAN India Timeline for Migration of legacy network to MPLS

The PAN India migration shall start from the timeline of the stabilization of NER MPLS N/w with both standby channels on additional pair of fibers and closing of the observed non-conformities.

The timeline for the said migration in each region depends on two factors:

- a. Number of ISTS/ISGS nodes in the region
- b. Insertion of new Repeater Nodes for MPLS equipment
- c. Completion of depreciated life of legacy equipment i.e. SDH

At present there are around 41 ISTS/ISGS locations in NER and the completion time accessed by migrating both standby channels on both additional pair of fibers is tentatively 36 months. At the end of Phase 4 of Clause 5.3.4, the work of readiness of both additional fiber pairs can be taken up after the formal recommendation by RPC and approval in NCT. Simultaneously, the procurement of MPLS equipment shall also be initiated and after receipt of equipment both standby channels shall be migrated from SDH equipment to MPLS equipment/Network. On the basis, of this all the remaining regions completion timeline is tabulated below

Region	ISTS/ISGS Nodes (Number)	Tentative Completion Time (Months)
ER	86	30
WR	96	30
SR	139	36
NR	184	42

Finally, based on the completion of depreciated life of the legacy equipment i.e. SDH both Main channels shall also be migrated to MPLS Network on Node-by-Node basis. Thus, it can be stated that the PAN India timeline for migration to MPLS network shall be around 42 months after the completion of Phase 4 of Clause 5.3.4, which is already ≥ 31 months (Depends on closing of the non-conformities of Phase 3 of Clause 5.3.4).

Hence, the Total Timeline for MPLS Migration (subject to migration of both standby channels on MPLS Network) shall be around ***atleast 73 months from the date of NCT approval for NER Region.***

5.3.6 Training and Skill Gap

- **Personnel Training:** Existing staff may require training to manage and maintain the new MPLS technology effectively.
- **Knowledge Transfer:** Ensuring that knowledge about legacy systems is properly transferred to the new MPLS system.
- **Training and Expertise:** Network operators may require training to manage and troubleshoot integrated MPLS-TP/MPLS-IP environments effectively.

5.3.7 OAM (Operation, Administration & Maintenance) Integration

- Integrating MPLS-TP OAM allows for comprehensive monitoring and maintenance across the entire MPLS infrastructure, improving fault detection and performance management. The UNMS (Unified Network Management System) for ISTS communication system is being deployed in all the regions presently. This UNMS shall be used to integrate the legacy SDH and MPLS TP/IP environments efficiently.

5.3.8 Redundancy Measures

- Implementing adequate redundancy to prevent service disruptions during the migration. For this new channel can be configured in the legacy network to mitigate the disruption in channel redundancies while migrating from SDH to MPLS environment.

5.3.9 Cyber Security

- Implement robust security measures to protect both MPLS-TP and MPLS-IP traffic in line with the CEA cyber security Guidelines, 2021. CTU/implementing agency shall ensure that OEMs have their equipment complied with certification specified in CEA Cyber Security Regulations (under process). The OEMs shall review their equipment to comply the requirement fully, in case their equipment is not fully compliant they may approach Cyber Security division, CEA for further clarifications before participation in bidding and act accordingly.

5.3.10 Make in India (MII)

During the 15th NPC Meeting, Chairperson, CEA/NPC advised CTU to prepare a demand trajectory for MPLS equipment required during the migration from SDH to MPLS over the next 7–10 years. CEA is in process of taking up this matter with the Ministry of Power (MoP) to optimize the MII percentage for MPLS equipment.

5.4 Recommendations

The committee has recommended the following

1. The methodology for migration & rollover from legacy SDH to MPLS TP technology for existing ISTS network including control center shall be adopted as stated under **clause 5.3.1 above**. However, for the upcoming/future ISTS nodes shall be provided with MPLS TP equipment and suitably integrated with the evolved ISTS MPLS TP Network with proper configuration on Regional/ National UNMS as per **clause 5.3.1 above**.
2. For the upcoming nodes of IPP/RE/Bulk consumers etc. MPLS TP/ MPLS IP can be adopted and integrated with the evolved ISTS MPLS TP Network with proper configuration on Regional/ National UNMS as stated under **clause 5.3.2 above**.
3. As per the Terms of Reference (ToR) of the Joint Committee and the MoM of the 15th NPC held on 14.11.2024, the Technical Specifications (TS) for MPLS technology in ISTS communication, shall be formulated by the Joint Committee.
4. Accordingly, the Joint Committee shall submit the final Technical Specifications (TS) for MPLS technology in ISTS communication within six months.

5.5 Way Forward

As the technology is improving day by day, the focus lies on bridging the gaps of seamless integration of MPLS technology with all availabilities of IP and TP make equipment, besides other upcoming state of art technologies.

Some of the power sector utilities migrating to MPLS in various countries is given below:

S. No.	Country	Power Sector Utility
1.	USA	Austin Energy, Great River Energy, Pacific Corp, American Electric Power, Southern California Edison, Duke Energy, S&P, Hawaiian Electric, Maui Electric, Hawai'i Electric Light, NV energy, Smud, Cps, Nipsco, DoE, Ouc
2.	UK	ORES, WPD
3.	Germany	50 HERTZ, OVAG
4.	Denmark	Energinet
5.	Norway	BKK, TENAGA NASIONAL, Østfold Energi
6.	Belgium	MVEM Energie
7.	France	RTE
8.	Croatia	HEP/HOPS
9.	Finland	TVO
10.	Mexico	CFE
11.	Peru	Engie
12.	Paraguay	ANDE
13.	Australia	AusNet
14.	Japan	Tohoku
15.	Korea	KEPC
16.	Indonesia	JKMRT



भारत सरकार/Government of India
विद्युत मंत्रालय/ Ministry of Power
केन्द्रीय विद्युत प्राधिकरण/Central Electricity Authority
राष्ट्रीय विद्युत समिति प्रभाग/NPC Division
1st Floor, Wing-5, West Block-II, R.K. Puram, New Delhi-66

No. CEA-GO-15-14/1/2021-NPC Division/ 304-347

Date: 14.09.2023

To,

(As per distribution list)

विषय:- आईएसटीएस संचार प्रणाली में एमपीएलएस प्रौद्योगिकी की शुरूआत पर चर्चा और सिफारिश करने के लिए संयुक्त समिति का गठन के संबंध में।

Subject: - Constitution of Joint Committee to discuss and recommend on the introduction of MPLS technology in ISTS Communication system-reg.

It was decided in the 13th NPC meeting held on 05.07.2023 at Kolkata that a Joint Committee may be formed with the representation from RPCs, CTU, POWERGRID, NLDC, RLDCs, PCD Division, CEA, NPC, CEA and some of the prominent states to discuss and recommend on the introduction of MPLS technology in ISTS Communication system.

In this regards, NPC division vide letter No- CEA-GO-15-14/1/2021-NPC Division/256-277 dated 24.08.2023 requested RPCs, CTU, POWERGRID, NLDC, RLDCs, PCD Division, CEA, NPC, CEA and some of the prominent states to send nomination for Joint Committee to discuss and recommend on the introduction of MPLS technology in ISTS Communication system.

Accordingly, based on the nomination received from RPCs, CTU, POWERGRID, NLDC, RLDCs, PCD Division, CEA, NPC, CEA and some of the prominent states, the Constitution of the Joint Committee is as follows:-

Chief Engineer ,DPT,CEA	Shri Vivek Goel	Member
Chief Engineer ,ET&I,CEA	Shri Surata Ram	Member
Chief Engineer GM,CEA	Shri Chandra Prakash	Member
Superintending Engineer, SRPC	Shri Meka Ramakrishna	Member
Superintending Engineer, WRPC	Shri P.D.Lone	Member
Representative from ERPC	Nomination not received yet.	Member
Superintending Engineer, NRPC	Shri Anzum Parwej	Member
Superintending Engineer NERPC	Shri S M Aimol	Member

Director, PCD, CEA/Assistant Director, PCD,CEA	Shri Len J. B./ Shri Prateek Srivastava	Member
Director, NPC, CEA/Deputy Director,NPC,CEA	Shri Satyendra Kumar Dotan/Shri Himanshu Lal	Member
Chief General Manager, SRLDC	Shri T R Ganesh	Member
Sr. General Manager, NERLDC	Shri S P Barnwal	Member
General Manager, WRLDC	Shri S. K. Saha	Member
Sr. Deputy General Manager, ERLDC	Shri L. Muralikrishna	Member
Deputy General Manager, NRLDC	Shri Ankur Gulati	Member
Deputy General Manager, POWERGRID	Ms. Shyama Kumari	Member
Addl. Chief Engineer, WBSETCL	Shri Biswajit Madhu	Member
Superintending Engineer RVPN	Sh. Manish Athaiya	Member
Executive Engineer, KSEBL	Shri Rafeeqe KP	Member
Representative from CSPTCL	Nomination not received yet.	Member
Sr. General Manager, CTUIL	Shri H. S. Kaushal	Member Convener

2. Terms of Reference of the Committee is as follows:-

- Study the feasibility/relevance of SDH technology in upcoming years.
- Identify all activities required for transition from SDH to MPLS.
- Asses the requirements of communication system for Power Sector Grid Management.
- To roll out methodology for implementation of MPLS in ISTS communication system.
- Dovetailing the MPLS network with the legacy SDH network of ISTS and Interfacing STU networks.
- Formulate the broad specifications of MPLS in ISTS communication system.
- Any other suggestions/recommendations on related matters.

Joint Committee can co-opt any member, if required.

भवदीय/Yours faithfully

(Handwritten signature)
14/09/23

(ऋषिका शरण/Rishika Sharan)

मुख्य अभियन्ता एवं सदस्य सचिव, रा. वि. स /
Chief Engineer & Member Secretary, NPC

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20. Shri Rajib Sutradhar, Executive Director, ERLDC, 14, Golf Club Road, ERPC Building, Tollygunje, Kolkata-700033. [Email: rajibsutradhar@grid-india.in]
21. Shri V. Balaji, Executive Director, WRLDC, Plot No- F-3, MIDC Area, Marol, Opp. SEEPZ, Central Road, Andheri (East), Mumbai-40093. [Email: vbalaaji@grid-india.in]
22. Shri Nabarun Roy, Executive Director, NRLDC, 18-A, Shaheed Jeet Singh Marg, Katwaria Sarai, New Delhi-110066. [Email: nroy@grid-india.in]
23. Shri Amaresh Mallick, Executive Director, NERLDC, Dongtiéh, Lower Nongrah, Lapalang, Shillong-793006, Meghalaya [Email: amareshmallick@grid-india.in]

**CHHATTISGARH STATE POWER TRANSMISSION COMPANY LTD.**

(A Government of Chhattisgarh Undertaking)

OFFICE OF EXECUTIVE DIRECTOR (TRANSMISSION)

CIN - U 40108CT2003SGC015820

Address:- Qua. No. C-8/11 First Floor, Danganiya, Raipur (C.G.) 492013

No. 02-19/ 88

Raipur, Date- 22 APR 2024

To,

Smt. Rishika Sharan
Member Secretary (NPC)
Central Electricity Authority
1st Floor, Wing-5, West Block-II,
RK Puram, New Delhi-66
Email Id- rishika@nic.in

Sub: Regarding nomination of member from Chhattisgarh (CSPTCL) for Joint Committee (JC) constituted by National Power Committee (NPC), which is mandated to carry out detailed study of MPLS/IP SERVICE.

Ref: Minutes of 5th MPLS Joint committee Meeting held at CTU Gurugram on 11.03.2024

-000-

As per the Minutes of 5th MPLS Joint committee Meeting held at CTU Gurugram on 11.03.2024 nomination from CSPTCL was desired. Accordingly, name of following officials from Chhattisgarh (CSPTCL) are nominated to become member of Joint Committee (JC) to carry out detailed study of MPLS/IP SERVICE as constituted by National Power Committee (NPC) :-

Sr. No.	Name of Officer's	Name of Entity	Contact Details
1	Er. Karunesh Kumar Yadav	CSPTCL	SE (400KV S/s) Circle, CSPTCL, Raipur. Mob.No.-9907432665 Email Id- se.400kvss.circle.trans@gmail.com
2	Er. Ashish Rai	CSPTCL	SE O/o ED (Project), CSPTCL, Raipur. Mob. No.- 84351-77900

This is for information & further needful please.


(Er. R C AGRAWAL)
Executive Director(Transmission)
CSPTCL, Raipur

Copy To:

1. The ED (Project) CSPTCL Raipur,
2. The SE O/o MD CSPTCL, Raipur..... This is for information with reference to approval granted vide UO NO. 792 Dtd. 18.04.2024
3. Er. Karunesh Yadav, SE (400KV S/s) Circle, CSPTCL, Raipur.
4. Er. Ashish Rai, SE O/o ED (Project), CSPTCL, Raipur.
5. Shri T. P. Verma, Chief Manager (Comm), CTU 1st Floor, Suadamini, Plot No. 2, Sector-29, Gurugram (Haryana) Mo. +91-9650598191..... This is for information with reference to your email dtd. 13.03.2024.

Annexure-II

Minutes of 1st MPLS Joint Committee Meeting held in Virtual Mode on 19th Sept. 2023

A meeting of Joint Committee (JC) was held on 19-Sep-2023, 1100 Hrs. through MS-Teams Online Meeting platform to discuss and recommend on the “Introduction of MPLS technology in ISTS Communication System”.

The list of participants is attached at *Annexure-I*.

Sr. General Manager (CTUIL) welcomed all the participants at the meeting and appraised the participants regarding formation of JC on the MPLS technology regarding its feasibility for adoption in ISTS network. He mentioned that as per MoM of 13th NPC Meeting held on 05th July 2023 (refer https://cea.nic.in/wp-content/uploads/nat_power_com/2023/08/Minutes_of_the_13th_Meeting_of_NPC_held_on_05.07.2023_at_Kolkata.pdf), it has been stated that the aforementioned JC has to discuss and recommend upon the MPLS technology. It was then requested to take up the agenda points after a brief introduction of all the participants.

1.0 CTU elaborated the ToR of the committee in detail emphasizing on requirement of MPLS technology and the constraints being faced with the existing SDH technology. This shall be followed up with all the activities to be taken up for review, analysis and implementation of migrating from SDH to MPLS and the process of dovetailing the MPLS network with the legacy SDH network wherever existing SDH equipment has yet not completed its life (presentation attached at *Annexure-II*). The JC shall also formulate the broad specification of MPLS technology for ISTS communication system. Some of the major points of 13th NPC meeting related to Joint Committee are as follows:

- Project Monitoring Group of PSDF has already been approved implementation of MPLS TP in place of SDH for Kerala and Tamil Nadu.
- CTUIL and STUs to ascertain the performance of MPLS-TP and IP-MPLS vis-à-vis SDH, particularly in respect of tele-protection requirement.
- Pilot project may be taken up for recommended technology.
- Deploying hybrid FOTE (SDH cum MPLS technology) can also be explored. The same has been incorporated by TANTRANSCO in its “Reliable communication scheme” tender at 38 nos. 230 KV sub stations.
- A draft framework for introduction of MPLS technology in ISTS Communication system may be provided by CTUIL.
- A committee may be formed with the representation from RPCs, CTU, PowerGrid, NLDC, RLDCs, PCD Division, CEA, NPC and some of the prominent states to discuss and recommend on the introduction of MPLS technology in ISTS Communication system.

2.0 Constraints of the existing SDH based system

CTU explained that in the existing SDH system, it is getting shifted as an obsolete technology as major telecom players forming majority of the usage-base for manufacturers have moved towards latest proven technologies such as MPLS-TP/MPLS-IP etc. and slowly with time the availability of necessary chipsets and other spares will not be easily available for maintaining SDH technology.

3.0 Inputs from STUs on MPLS network implemented

CTU invited the state utilities who are planning/implementing the MPLS in their state communication network to share their feedback on the urge to go for MPLS, implementation/operational problems (if any), regulatory and other issues. CTU further also sought the performance of Tele-protection signal if made operational through this technology. The experiences shared by different utilities are as follows –

- **Kerala State Electricity Board (KSEB):** They stated that they have planned MPLS for their state network which is at present in tendering phase as they are seeking clarifications from CEA w.r.t. Make in India (MII) policy. They also explained about the new protocols, applications & Voice being used in Power system are being built-up on IP protocols which are more compatible with MPLS technology. Apart from this, due to shift in power transmission applications, vendors have also upgraded from SDH based to MPLS based equipment.

KSEB further stated that presently they have 28 SDH nodes. While implementing MPLS in their network, nodes interfacing with ISTS will be kept as SDH itself. Under the reliable communication scheme 165 MPLS TP/ IP equipment will be installed creating a ring using separate fiber all around the Kerala. The state services at the tributary level operational on Ethernet or 2Mbps E1 shall be connected over MPLS network upto the nearest ISTS station.

- **TANTRANSCO:** They stated that they are facing problems with SDH as one or two vendors are only available for SDH. They also stated the other vendors have declared that SDH has become obsolete technology now. Chip availability has also fallen to large extent as it is not a standard chip. They further suggested that as a public utility one should safeguard public's money while investing in obsolete SDH technology in view of lack of competitiveness and long-term support for maintenance. Also, SDH is not bandwidth efficient and new packet-based applications in MPLS require less inventory. WRLDC enquired about the interoperability of MPLS TP and Hybrid. TANTRANSCO confirmed that hybrid FOTE and MPLS TP are interoperable and they have successfully tested it in one of their substations but they want some standard organization to ascertain the interoperability test between vendors as per the standards.

TANTRANSCO further informed that their project is under execution based on hybrid FOTE supporting both SDH as well as MPLS-TP. MPLS-TP has the capacity as 1G and 10G at present. It is envisaged as a backbone network around the state, which will cover SLDC at

Chennai, Backup SLDC at Madurai and sub-load dispatch center at Erode. Backbone ring network will be over 2 rings, one will be on the MPLS-TP and the other one will be over the SDH. Hybrid FOTE are being installed in the 230kV and above substations connected in the ring. However, 110kV and some hydro stations are connected through MPLS-TP equipment. They have also approved a DPR to install about 10,000 kilometers of OPGW connecting approx. 620 nos. of 110kV substations on MPLS-TP under reliable communication project. They are also implementing differential and distance protection through MPLS. Cyber security concern is also being taken care by using Pseudo wire mode. CTU requested them to share the successful operation of these networks after implementation.

- **WBSEB:** They stated that presently they are using SDH and are planning to implement MPLS. Their SDH system has still 8-9 yrs. of life remaining but its capacity is full and has started choking at some point causing data blackout. So, they are planning to switch over to MPLS for communicating some vital data to SLDC.

4.0 Inputs from POWERGRID on PoC conducted

CTU requested POWERGRID to share their experience in MPLS as they have done PoC in Eastern Region (ER). POWERGRID stated that they have done their PoC on MPLS-TP technology in ER connecting Jeerat – Behrampur - Farakka (NTPC) - GokarnaWB – Rajarhat – Subhasgram - Kasba WB - ERLDC and WB SLDC. POWERGRID explained that the testing was done on a mixed network of SDH & MPLS-TP to test the interoperability and compatibility of both. They explained that they have tested the MPLS signal for 180km distance (on a 126 km distance using attenuators) with amplifiers available at present. The Band-width (BW) limit was 1Gbps signal from MPLS router was terminated on 1Gbps optical ethernet port of SDH. All the main applications presently being used were tested on this MPLS network.

Teleprotection (distance protection) was tested using bandwidth between Subhasgram to Rajarhat station which had no hops. POWERGRID stated that Line differential protection has not been tested.

5.0 Feasibility of different power system applications over MPLS

POWERGRID finally stated that the major purpose of the PoC conducted in Eastern Region was to check whether the applications which are being used for data communication to RLDC can be run on MPLS with the same performance parameters or not and to see how the amplifier solutions are working.

SRLDC also conveyed that as POWERGRID has done the PoC for MPLS, they shall submit their report along with statistics to the committee for some more insight. SRLDC stated that the ISTS communication system is integrated with state networks from the SLDCs to RLDCs and NLDC and besides this, the central sector ISTS and ISGS nodes are also to be reported at respective

RLDCs. This calls for an integrated PoC covering the control centers and stations to test the various requirements on this technology. Committee requested POWERGRID to submit the MPLS POC report along with statistics

SRLDC also enquired whether this committee will take into consideration the States network also for upgrading to MPLS. CTU clarified that state transmission network is not in the scope of this committee but integration of the state network with the ISTS network will be in the scope of this ToR. CTU further clarified that equipment installed in state-network under ULDC schemes will also be upgraded to MPLS based on the methodology i.e. hybrid/ standalone, as approved by NPC.

6.0 Integration with Unified NMS (U-NMS)

NERLDC enquired about whether MPLS will have a separate NMS and any challenges in getting it integrated with the U-NMS system. CTU informed that POWERGRID has already clarified that UNMS will integrate new technologies.

7.0 Upgradation/Replacement of SDH in ongoing projects

NERLDC enquired about the upgradation / replacement of SDH equipment in the ongoing projects, some of which are Central sector nodes. CTU replied that it may be upgraded/ replaced in phased manner for ISTS as per recommendations of JC & approval by NPC. The committee was of the view that states may go ahead with their current projects after taking approvals from their SERCs or other associated state bodies, as applicable, till there is any such instruction from regulatory body for transition towards MPLS technology.

8.0 Detailing of MPLS/ SDH Technology

CTU gave a brief presentation about the MPLS/ SDH technology (presentation attached at *Annexure-III*). CTU also stated various constraints of SDH technology and benefits of migrating to MPLS technology. CTU also stated that global communication market is moving from SDH to MPLS resulting in decrease of chip production for SDH system due to declining demand. On the other side, market is flooded with MPLS-based system and if power-sector communication system won't match with the markets trends, then it will be very difficult in maintaining existing SDH system as well as procurement of new SDH equipment.

POWERGRID agreed and stated that as MPLS is being preferred by all, no new innovation/ R&D is taking place for SDH. Also, various new power system applications are also packet based, hence it is advisable that users should adapt this new proven technology.

CTU further explained that presently “repeater distance span” is around 225 km in case of STM-16. If the MPLS routers could maintain the 225 km distance, it can be optimized with the existing repeaters but if in MPLS case the distance is less than that, then new repeater locations will be required with detailed design and specification, optimizing the existing ones.

NPC enquired about the cost-estimate of MPLS-TP & MPLS-IP. CTU stated that session from the equipment provider, suppliers or OEM's will be arranged in the subsequent meetings where JC can interact for the same. Also, the Make-in-India aspects can also be discussed during this time.

9.0 Participation from certain State-Utilities in JC

CTU conveyed to the JC for the request made by NERLDC for joining of AEGCL-Communication division (from Assam) representative to be a part of this committee on MPLS. Same request was also made by SRLDC/ CTU to add TANTRANSCO as committee member. NPC stated that AEGCL (Assam) and TANTRANSCO (Tamil Nadu) may submit requisition for consideration.

CTU stated that member from Chhattisgarh and ERPC have not been nominated which shall be taken care by NPC for the subsequent meetings. NPC agreed the same.

10.0 Road-map for the Joint Committee

CTU presented a step-by-step roadmap for the JC so that the report can be finalized till 31st December 2023. The major steps proposed by CTU are as follows –

- **Step 1:** Assessment of present ISTS communication network.
- **Step 2:** Meeting with MPLS OEMs/ Service Providers.
- **Step 3:** Deliberation & finalization of functional requirements of ISTS network for PoC of IP/TP MPLS.
- **Step 4:** Review of PoC, deliberation & finalization of broad specifications.
- **Step 5:** Roll-out plan.
- **Step 6:** Preparation deliberation and finalization of report.

11.0 Miscellaneous Points

ERLDC stated that SDH and MPLS may be integrable to each other but both of them are old technologies. Service provider network has different type of challenges regarding scalability, frequent upgradation of network and applications. Power system communication requirements are different as in view of Bandwidth requirements, latency & jitter requirements, cyber security and other operational challenges. ERLDC further stated that Power system communication shall explore new communication technologies as well keeping in view of challenges that may come in operations in upcoming 15-20 years. CTU appreciated the concern and suggested that as the ToR of JC is regarding introduction of MPLS technology for ISTS communication system, the mandate of the JC has to follow the same. However, ERLDC may submit their valuable suggestions during the subsequent meetings.

NERPC and NERLDC requested that the matter of transition towards MPLS may be explained by CTU in form of a brief presentation in upcoming NETeST sub-committee meeting so that DPRs being prepared by state-utilities under State-Reliable Communication Scheme with 90% PSDF

funding (for e.g. 1200 kms. OPGW project under planning by AEGCL) can also incorporate this technology, if required. CTU conveyed that although this matter need not be taken up to any RPC-level sub-committee at this stage but knowledge sharing presentation can always be given if requested by NERPC.

CTU finally concluded the meeting thanking all the members and especially NPC for forming the JC.

--xx--

List of Participants

CEA		
1.	Sh. Len J.B.	Director, PCD, CEA
2.	Sh. Sateyendra Kr. Dotan	Director, NPC, CEA
3.	Sh. Vivek Goel	Chief Engineer, CEA DP&T
4.	Sh. Himanshu Lal	Deputy Director, NPC CEA
5.	Ms. Priyam Srivastava	PCD, CEA
SRPC		
1.	Sh. Meka Ramakrishna	Superintending Engineer, SRPC
NRPC		
1.	Sh. Anzum Parwej	Superintending Engineer, NRPC
2.	Ms. Priyanka	NRPC
NERPC		
	Sh. S.M. Aimol	Superintending Engineer, NERPC
SRLDC		
1.	Sh. T.R. Ganesh	CGM, SRLDC
NERLDC		
1.	Sh. Akhil Singhal	DGM, NERLDC
2.	Ms. Gargi Dutta	Ch. Mgr., NERLDC
3.	Sh. Sakal Deep	Asst. Mgr, NERLDC
4.	Sh. R.Sutnga	NERLDC
5.	Sh. Amba Prasad Tiwari	NERLDC
WRLDC		
1.	Sh. Sandeep	WRLDC
ERLDC		
1.	Sh. L. Murlikrishna	Sr. DGM, ERLDC
NRLDC		
1.	Sh. Ankur Gulati	DGM, NRLDC
POWERGRID		

1.	Ms. Shyama Kumari	DGM, POWERGRID
2.	Sh. Gaurav Awal	Ch. Mgr., POWERGRID
WBSETCL		
1.	Sh. Biswajit Madhu	Addl. Chief Engineer, WBSETL
KSEBL		
1.	Sh. K.P. Rafeeqe	Executive Engineer, KSEBL
TANTRANSCO		
1.	Sh. K N Srinivasan	EE, TANTRANSCO
CTUIL		
1.	Sh. H.S. Kaushal	Sr.GM
2.	Sh. Shiv Kumar Gupta	Sr. DGM
3.	Ms. Kalpana Shukla	DGM
4.	Sh. Tej Prakash Verma	Ch. Manager
5.	Sh. Kaushal Suman	Manager
6.	Sh. Divesh Kamdar	Engineer



Joint-Committee to discuss and recommend on
the introduction of MPLS technology in ISTS
Communication System
Welcome committee members on the
1st meeting on 19.09.2023

Major Milestones

Activity	Date
Joint- Committee formation Date	24.08.2023
Members Nominated Date*	14.09.2023
Tentative Committee Report (Expected)	31.12.2023

* Nominations from CSPTCL & ERPC yet to be received



-  Study the feasibility/relevance of SDH technology in upcoming years
-  Identify all activities required for transition from SDH to MPLS
-  Assess the requirements of communication system for Power Sector Grid Management.
-  To roll out methodology for implementation of MPLS in ISTS communication system, if required
-  Dovetailing the MPLS network with the legacy SDH network of ISTS and interfacing STU networks, if required
-  Formulate the broad specification of MPLS in ISTS communication system, if required
-  Any other suggestions/recommendations on related matters.

Agenda Points for First Meeting

- Constraints of the existing SDH based system
- Inputs from the STUs on MPLS network implemented
- Inputs from POWERGRID on POC conducted
- Tele-Protection feasibility over MPLS
- Feasibility of different power system applications over MPLS
- Any other point

Adoption of New Technologies

- **Regulation**
- As per clause 22 of CEA (Technical Standards for Communication System in Power System Operations) Regulations 2020
- *Adoption of new technologies. Plan shall be made for introduction and adoption of new technologies, with the approval of the appropriate Commission or as per the regulations or pursuant to the reforms programme of the appropriate Government.*

Power System Applications/Requirements:

1. SCADA
2. PMU to PDC
3. Tele protection
4. Telecontrol
5. AGC
6. Voice (VoIP)
7. Automated Metering Application (Upcoming)
8. Video conferencing
9. ICCP (between control centers)
10. PDC to PDC
11. Supervision of communications System (NMS/UNMS)
12. Video Surveillance
13. Data Sync between MCC & BCC



Presentation on MPLS Technology in Indian Power Sector



Current Technology Scenario

- Existing FO Network for ULDC requirements is around 70000Kms.
- Supported by FOTEs (SDH) of capacity STM-64/ STM-16/ STM-4/ STM-1.
- The SDH equipment of various capacities have been provided by different OEMs whose NMSs are propriety.

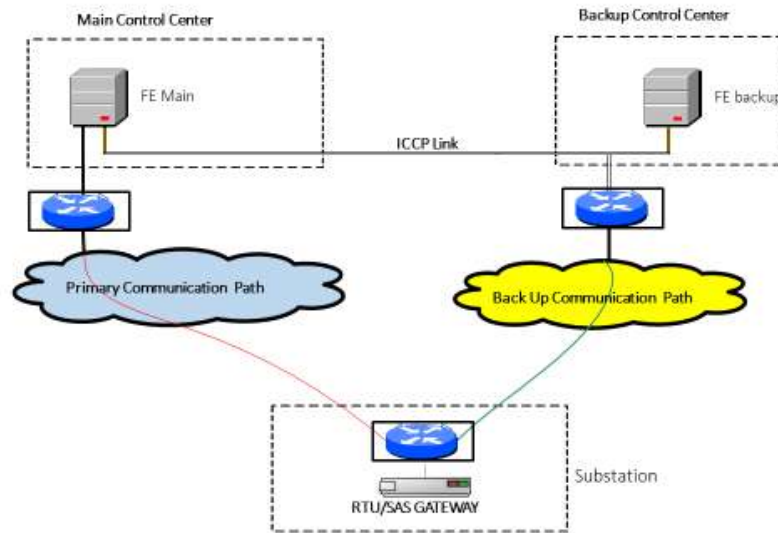
Why migrate from SDH?

- End of life of SDH technology, will be obsolete soon, (Last development- 2000).
- SDH network difficult to maintain with greater penetration of solar power, microgrids, battery storage, and electric vehicle charging.
- SDH is having fixed bandwidth channels for various communication applications and not as per use.
- Bandwidth efficiency is not high because of large overheads.
- SDH OEMs are advising to go for new technologies as globally chip production of SDH equipment is reduced and thus maintenance of SDH equipment is getting difficult.
- Trend in technology change, Globally Power Utilities are migrating from conventional SDH (circuit switching) to MPLS-TP (Packet Switch Network) such as Energinet Denmark, ORES UK, Austin Energy USA etc.
- A platform needed for growth using flexible protocols to support future applications.

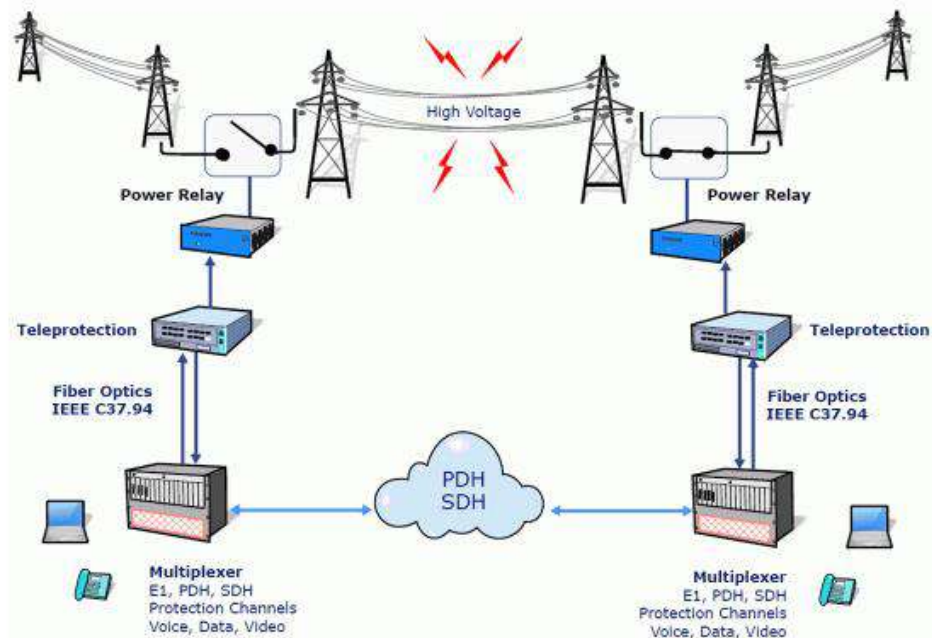
Why go for MPLS?

- Use of new IP-based applications, including GOOSE and CCTV in Power Sector.
- MPLS is Packet Switch Network technology, no reservation of data bandwidth (BW), high BW efficiency.
- MPLS-TP Operations, Administration, and Maintenance (OAM) tools, feature rich like SDH OAM.
- Long term availability of spares as new technology.
- No need of protocol conversion unlike in SDH IEC 60870-5-104/ 101 gateway/protocol.
- Various Class of Service available for different applications data.
- Different services can be mapped in different VPNs through single physical port.

Typical Data Communication from Substation to Control Centers

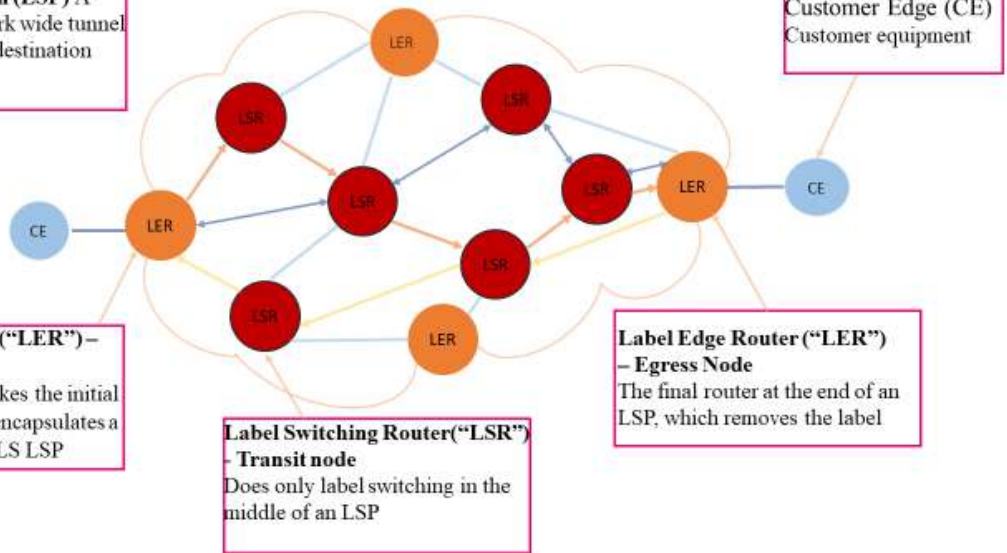


Protection by SDH Network



MPLS BASIC CONCEPTS

Label Switched Path (LSP) A unidirectional network wide tunnel between source and destination routers.



Comparison of Technologies

Factors	SDH	IP-MPLS	TP-MPLS
Channel routing	Static user defined	Dynamic network defined	Static user defined
Channel directions	Bidirectional (same To-Fro paths)	Unidirectional (different To-Fro paths)	Bidirectional (same To-Fro paths)
Channel Supervision	End to end	Link wise	End to end
Data channel	Deterministic	Non-deterministic (without special measures)	Nearly deterministic (if network planned properly)
NMS & Control Panel	Same	Different	Same
Resilience (Protection mechanism switching)	<50ms	>>50ms	<50ms
Latency	0.06ms	> 0.06 ms	0.02ms
Bandwidth efficiency	Fixed BW	Efficient	Efficient
CoS choice	same class of service,	Multiple Choice for different application	Pre defined choice can be made for different application.
QoS	Determined by BER	Determined by Packet loss	Determined by Packet loss

Adoption of MPLS

Regulation

As per clause 22 of CEA (Technical Standards for Communication System in Power System Operations) Regulations 2020

Adoption of new technologies. Plan shall be made for introduction and adoption of new technologies, with the approval of the appropriate Commission or as per the regulations or pursuant to the reforms programme of the appropriate Government.

Minutes of 2nd MPLS Joint Committee Meeting held in Virtual Mode through MS-Teams Platform on 17th October 2023

The 2nd meeting of Joint Committee (JC) constituted by NPC was held on 17-Oct-2023 through Online mode to discuss and recommend the “Introduction of MPLS technology in ISTS Communication System”.

The list of participants is attached at ***Annexure-I***.

Sr. General Manager (CTUIL) welcomed all the participants at the meeting and proceeded with the agenda items. The summary of discussion is mentioned below:

1.0 Confirmation of minutes of 1st MPLS JC meeting

CTUIL took confirmation regarding the MoM of 1st JC Meeting held on 19th September 2023. Representative from NPC stated that based on MoM of 21st Project Monitoring Group meeting of PSDF chaired by Member (GO&D, CEA) held on 4th and 8th March 2022, they had sent comments as under –

- Para 6.6 KSEBL, Kerala (Proposal-141), (c) (i): As tele-protection is a critical service and MPLS being comparatively new technology in the Indian Power Sector, it is recommended that main channel for tele-protection should be through SDH/PLCC and alternate channel may be through MPLS-TP/MPLS-IP.
- Para 6.6 KSEBL, Kerala (Proposal-141), (c) (ii): For speech and data communication, MPLS-TP/MPLS-IP technology can be used.

Further, NPC asked to share the performance report regarding use of MPLS technology with PCD Division- CEA and NPC Division- CEA for analyzing its future prospects.

In reply to this, CTUIL stated that as implementation aspects of MPLS in KSEB (Kerala) and TANTRANSCO (Tamil Nadu) is a matter between STUs and PSDF Committee(s), so CTUIL has no provisions as per Terms of Reference (ToR) to include these comments in MoM of 1st meeting. However, CTUIL requested NPC to provide the MoM regarding these issues of the states which is attached at ***Annexure-II*** with the MoM for reference purposes but there is no further need of issuing a corrigendum for 1st JC MoM. Forum agreed for the same.

2.0 Completion of Step-I of Committee Roadmap

CTUIL while stating the progress of the JC highlighted the Step-I i.e. “*Assessment of present ISTS communication network*” of the committee road-map which was covered at a large extent in the previous JC meeting. Representatives from GRID-INDIA stated that the step-I has some gaps to be filled for which suitable replies were given by CTUIL as mentioned in *table* below.

Sl. No.	Observations from Grid-India/CEA on Step-I (Assessment of present ISTS communication network)	Replies from CTUIL (as member coordinator)
GRID - INDIA		
1	Preparing comprehensive list of equipment based on SDH technology at present.	Not under ToR of JC; may be required at the time of adoption of this technology and preparing region-wise implementation plans.
2	Details of the equipment such as make/model, useful life left (w.r.t. 15 years general life), STM-4/16, nodes of congestion, integrated map, etc.	Not under ToR of JC; may be required at the time of adoption of this technology and preparing region-wise implementation plans.
3	Preparing functional requirements such as list of power-system applications, bandwidth required, bit-error rate, max. acceptable latency, etc.	List of power system applications/functionalities was presented by CTUIL to JC and any additional requirements can be submitted in next JC meeting. Detailed technical parameters will be taken as per respective Technical Standards by CEA.
4	Expected interface nodes between SDH and MPLS devices for dovetailing.	Shall be required after the approval of the JC report by NPC for the adoption of this technology and preparing region-wise implementation plans.
5	Including cost-comparisons under Roll-out plan	Shall be required at the time of adoption of this technology and preparing region-wise implementation plans after the approval of the JC report by NPC. Roll-out plan mentioned in the JC ToR implies mainly the modus operandi of the schemes to be taken up on national/regional/ state level basis.
6	Carrying out a pilot project as mentioned in MoM of 13 th NPC meeting.	This was deliberated during 13 th NPC meeting and is to be considered by JC, although it is not mentioned in the ToR of JC. CTUIL stated that as several states are adopting this technology and have gone through POC as per their requirements, they can provide their feedback. Moreover in the 1 st meeting of JC, POWERGRID also gave the feedback of the POC conducted. In view of this,

Sl. No.	Observations from Grid-India/CEA on Step-I (Assessment of present ISTS communication network)	Replies from CTUIL (as member coordinator)
		additional POC shall be conducted for the requirements/aspects which are still not covered, if any, for the ISTS communication system.
CEA-PCD		
7	CEA-PCD stated their observation on presentation of CTUIL depicting first step of assessment of committee roadmap of ISTS network needs further analysis. Factors like latency, bandwidth, criticality of service etc. needs to be finalized.	CTUIL requested POWERGRID and GRID INDIA to provide the data for further analysis.

3.0 Presentations on MPLS-TP and MPLS-IP by OEMs/Service Providers

CTUIL introduced Nokia Network Solutions for presenting their solutions on implementing MPLS technology with the legacy ISTS network. The presentation is attached as **Annexure-III**. M/s Nokia explained the various technical aspects along with the advantages of MPLS-IP and MPLS-TP technology.

ERLDC enquired about bandwidth availability and latency for PMU data communication using MPLS. In addition to that, TANTRANSCO stated that in implementation of MPLS in their state-network, they have provision of 10 Mbps for each station. Nokia replied that their solution can meet the requirement of latency (using QoS) and bandwidth.

Further, POWERGRID clarified that however, each PMU is considered for a bandwidth of 2 Mbps but several VPN rings are also designed with multiple PMUs on the ring and sharing the common bandwidth of 2 Mbps.

CEA-PCD stated whether SDH is able to meet the latency requirement as per CEA regulations, if so, can the same be met by MPLS. This will help JC to finalize the needs and specifications for ISTS network for Implementation of MPLS in line with prevailing requirements.

TANTRANSCO asked whether priority levels for different applications can be arranged, as some applications require higher priority such as tele-protection. Nokia stated that their solution has three levels of priority with several QoS functions. TANTRANSCO further asked

about interfaces available on their end-equipment. Nokia replied that their end-equipment can provide multiple interfaces for connecting to any application.

CTUIL enquired about Make-In-India (MII) regulations/policy or other difficulties faced by Nokia for implementation of MPLS. M/s Nokia stated that currently there is no regulation for IP-Routers which are manufactured in their plant located in Mexico and presently MII regulations are not affecting their operations in India.

After the presentation by M/s Nokia, CTUIL welcomed M/s Hitachi for the presentation on MPLS TP in respect of ISTS communication. The presentation is attached as **Annexure-IV**. M/s Hitachi gave the presentation vide which they explained needs of power sector and grid management applications and how MPLS technology befits these requirements. During the presentation, they emphasized on a single-box technology with single NMS which can provide all interfaces for each and every power application desired. However, replying to a question on STM-64 capacity to be integrated with MPLS M/s Hitachi replied that they have commercially operated upto STM-16. However, they have done some trial links on STM-64 also and they can gear up for such integration also, if required.

Hitachi focused on its FOX-615 product which could take SDH traffic as well as MPLS traffic also with a life-span of 20-25 years. Regarding the delivery timelines, it stated that in today's scenario, there is a delivery time of 3-4 months for hardware being faced globally.

M/s Hitachi representative from Switzerland also explained that there are very few vendors which support both MPLS TP and IP technology whereas the others are on either TP or IP. In case of MPLS-TP, several vendors are available with experience of deploying this technology for large utilities. Vendors such as Huawei and Cisco are providing both MPLS-IP and MPLS-TP based solutions to its customers. It was also conveyed that SDH chips are going out-of-market due to decrease in its customer base and recently a 7-digit investment was made by Hitachi to support its existing SDH customers due to these problems.

CTUIL requested Hitachi to express their status with respect to MII policy. Hitachi stated that their FOTE equipment is manufactured in Switzerland works and remaining activities like survey, installation & commissioning and training are provided by Hitachi India. In view of this, Hitachi India does not meet the present MII policy of GoI; however, they are approaching the relevant authorities in this regard.

CTUIL thanked M/s Hitachi & enquired about the suitability in power sector of the upcoming technologies i.e. SD-WAN. In respect to that, Hitachi representative from Switzerland stated that SD-WAN is a non-established technology based upon software adaptations and also non-standardized to a stable extent. It has limitations of legacy interfaces also. Moreover, for OT systems, the SD-WAN technology is not seen anywhere in the world as per knowledge of Hitachi.

4.0 Optimization of MPLS system with present infrastructure of ISTS

CTUIL requested the JC panel to focus on the proposal provided by ERLDC and give their views on the same. CTUIL further explained the proposal of ERLDC which had comparison of several existing and upcoming communication technologies with their pros and cons. In view of this, CTUIL requested all JC members to give their views on these considerations providing within the framework of ToR for the JC.

ERLDC stated that MPLS technology is also being projected as obsolete by some vendors & could be fading out within 2 years. This was a big concern for the JC and CTUIL asked TANTRANSCO regarding the life of the MPLS system deployed by them. TANTRANSCO replied that it has been planned and agreed by the service provider/OEM for at least 10 years with service guarantee.

Further, ERLDC again raised their views of adopting new & long-living technologies and suggested Optical Transport Network (OTN) as one of the probable options. POWERGRID stated that this technology is not adopted in power-sector till now to the best of their knowledge and the same views were also stated by other members. CTUIL then requested ERLDC to provide case studies / Use cases proven on OTN-based technology in power sector. ERLDC agreed for the same.

Chief Engineer (Grid Management, CEA) stated that as per ToR para 2 (i) and 2(iii), the concerns of ERLDC is well within the scope of the JC and new technologies can also be explored as found feasible by JC members. Forum requested ERLDC to share some use-cases/case-studies for discussion in next meeting along with brief presentation from an OTN vendor, if possible.

5.0 Constraints for wider participation of OEM/Vendors as per GoI/DoT/MII Orders

KSEB representative mentioned that only 1 vendor for MPLS-TP with MII compliance participated in its associated tender. However, vendors are parallelly taking up the things with appropriate ministries at their level.

It was observed by the committee that major vendors approaching power-sector utilities globally are GE, Nokia and Hitachi with few others. JC Members agreed to restrict themselves to ToR of committee limited to usage of MPLS and its feasibility with not extending the scope which could further complicate the things with no substantial benefits.

All joint committee members were requested for the following –

- Members to provide the inputs to be covered w.r.t. Step-I of the committee road-map.
- ERLDC to present use cases/ case studies on OTN in power-sector and if possible, arrange for respective presentation by a vendor in consultation with CTUIL.

6.0 Other points

CTUIL requested NPC that it will be beneficial for the JC to have participation from ERPC and Chhattisgarh also from next meeting onwards.

CTUIL stated that members from ERPC, RVPN, SRPC, ET&I-CEA could not attend the meeting may be due to other important engagements. This may kindly be taken care by NPC-CEA.

Meeting ended with noting of the above.

Annexure-I

CEA		
1.	Sh. Len J.B.	Director, PCD, CEA
2.	Sh. Sateyendra Kr. Dotan	Director, NPC, CEA
3.	Sh. Vivek Goel	Chief Engineer, CEA DP&T
4.	Sh. Chandra Prakash	Chief Engineer, CEA GM
5.	Sh. Prateek Srivastava	Asst. Director, PCD, CEA
6.	Sh. Subba Reddy	PCD, CEA
WRPC		
1.	Sh. Pramod Lone	WRPC
NRPC		
1.	Ms. Priyanka Patel	Manager, NRPC
NERPC		
1.	Sh. Rajib Das	Assistant Director, NERPC
SRLDC		
1.	Sh. T.R. Ganesh	CGM, SRLDC
NERLDC		
1.	Sh. Sugandh Prasad Barnwal	Sr. General Manager, NERLDC
2.	Sh. Akhil Singhal	Dy. GM, NERLDC
3.	Ms. Gargi Dutta	Ch. Manager, NERLDC
4.	Sh. Sakal Deep	Asst. Mgr, NERLDC
5.	Sh. Gaurav Bhattacharya	Asst. Mgr, NERLDC
6.	Sh. Royal Sutnga	Engineer, NERLDC
6.	Sh. Amba Prasad Tiwari	Engineer, NERLDC
WRLDC		
1.	Sh. S.K. Saha	WRLDC
ERLDC		
1.	Sh. L. Murlikrishna	Sr. DGM, ERLDC
NRLDC		
1.	Sh. Ankur Gulati	DGM, NRLDC
POWERGRID		
1.	Ms. Shyama Kumari	DGM, POWERGRID
2.	Sh. Gaurav Awal	Ch. Mgr., POWERGRID
WBSETCL		
1.	Sh. Biswajit Madhu	Addl. Chief Engineer, WBSETL
KSEBL		

1.	Sh. K.P. Rafeeqe	Executive Engineer, KSEBL
TANTRANSCO		
1.	Sh. K N Srinivasan	EE, TANTRANSCO
2.	Sh. K. Umarani	EE, TANTRANSCO
3.	Sh. T.G. Kannagi	AEE, TANTRANSCO
M/s Nokia Solutions & Networks		
1.	Sh. Aashutosh Varma	Director-Technical
2.	Sh. Yogesh Pandey	Head- Govt. & PS Business
3.	Sh. Vishal Verma	-
M/s Hitachi Energy		
1.	Sh. Mathias Karanich	-
2.	Sh. Yogendra Patwardan	Associate Sales Director
3.	Sh. Girish Sonparote	
CTUIL		
1.	Sh. H.S. Kaushal	Sr. GM
2.	Sh. Shiv Kumar Gupta	Sr. DGM
3.	Ms. Kalpana Shukla	Dy. GM
4.	Sh. Tej Prakash Verma	Ch. Manager
5.	Sh. Kaushal Suman	Manager
6.	Sh. Divesh Kamdar	Engineer
7.	Sh. Prakhar Pathak	Assistant Engineer Trainee

Minutes of 3rd MPLS Joint Committee Meeting held on 05th December 2023 through Virtual Mode

The 3rd meeting of Joint Committee (JC) constituted by NPC was held on 05-Dec-2023 through virtual mode to discuss and recommend the “*Introduction of MPLS technology in ISTS Communication System*”.

The list of participants is attached at **Annexure-I**.

Sr. General Manager (CTUIL) welcomed all the participants at the meeting and apprised with the concern of NPC to finalize the JC report at the earliest so that the SDH obsolescence is not a constraint. CTUIL then proceeded with the agenda items. The summary of discussions is mentioned below:

1.0 Confirmation of minutes for 2nd MPLS JC meeting

CTUIL took confirmation regarding the MoM of 2nd JC Meeting held on 17th October 2023 and informed JC that no inputs w.r.t. Step-1 of the committee roadmap i.e. **Assessment of present ISTS communication network** were received from any JC member. This implies that all the issues discussed in the previous meeting have been confirmed by the JC.

2.0 Presentation of CTUIL for 3rd MPLS JC meeting

CTUIL explained briefly about the agenda points of the 3rd meeting to the JC as under:

- Functional requirement for new network technology
- Operational latency of different protection mechanism at present
- Presentation on OTN by ERLDC
- Comparison of MPLS features of different OEM/Suppliers (CISCO , HITACHI, GE , SIEMENS , NOKIA)
- POC to be deliberated w.r.t. ISTS Applications

3.0 Deliberations

3.1 Functional requirement for new network technology

CTUIL explained the functional requirements which need to be met by the technology to be migrated, e.g. interoperability, optimization of repeater location, monitoring, latency etc. The presentation is attached at **Annexure-II**.

NPC Division, CEA suggested to add scalability, Cyber security, Make in India also in the functional requirement. However, NPC further suggested Backup Data storage & analysis, faster fault detection & Recovery, incorporate Predictive maintenance shall be taken care by the respective NMS/UNMS system. The MPLS system shall comply with applicable standards and regulations of CERC/CEA etc. It is understood that the functionalities called for, are applicable to the entire communication system which shall remain intact. The JC agreed to the same.

3.2 Operational latency of different protection mechanism at present

CTUIL informed JC that a format for collecting operational latency data of various applications was mailed to RLDCs and TSPs (POWERGRID, INDIGRID, ADANI POWER and STERLITE) but was not responded by anyone. POWERGRID in their response mentioned that latency data cannot be provided as the same is not available in the NMS. CTUIL reiterated the requirement of this data, explaining that as the same is being run on the SDH network for healthy grid and operational data shall provide a view of this data vs as specified by CEA guidelines. CEA clarified that latency data which CEA has specified is for general recommendation.

GRID INDIA -NRLDC stated that they cannot provide channel latency data as they don't have this. POWERGRID also stated that they cannot measure the latency data as the same is not available in the NMS. The only way to measure this data is through tester and that too requires disrupting the traffic. WRPC stated that the latency data can be obtained from disturbance recorder (DR) and through the tripping time recorded in the relays. Moreover, the line differential takes place through dark fibre and the pilot protection is also similar and takes place through a separate fibre.

KSEBL informed that they are operating differential protection through dark fibres for which channel latency is around 3ms and it can be measured through relays and distance protection can be measured by looping. PCD Division, CEA informed that they had witnessed the POC conducted by GE for TANTRANSCO. The channel latency data for differential protection through FOTE (i.e. by Bandwidth) for MPLS TP was around 5.1ms and for SDH with FOTE was around 3.5ms whereas for distance protection channel latency for MPLS TP was around 3.5ms and for SDH it is around 1.5ms.

KSEBL has submitted that they are currently in the tendering stage for implementing an MPLS-TP/IP MPLS network. Further they have provided test set up for latency measurement and details regarding channel delay for line differential protection and Tele protection (distance protection). These details are attached at **Annexure-III**.

In view of above CTUIL requested POWERGRID to provide the desired data for some of the sampled stations. POWERGRID stated that they shall try to collect channel latency data for SCADA/VOIP/PMU/Tele-Protection (Distance & Differential-Bandwidth) services through testers. POWERGRID told that they shall try to install tester at the new substations for the measurement and also requested other utilities to do the same. CTUIL requested POWERGRID to provide channel latency data after confirming from sites within a week.

3.3 Presentation on OTN by ERLDC

CTUIL requested GRID INDIA-ERLDC to give their presentation on OTN and suggest the suitability of this technology in respect of the ToR requirements of JC. GRID INDIA -ERLDC informed that they have arranged the same with M/s TEJAS NETWORKS (TEJAS) who is also an OEM of MPLS .

TEJAS made a nice presentation on the requirement of OTN technology at the core network supported by other technologies like MPLS TP/IP, SDH etc. at the access network.

During the presentation, stated that as the data requirement is growing at a faster pace, we should have main core network of OTN which caters for higher bandwidth around 100g and not the entire network as data congestion is more in core network. They further stated that the core network however shall be integrated by access network running on various other technology like SDH, MPLS etc.

POWERGRID stated that congestion is not the reason for migration of existing SDH system but, the primary reason is the obsolescence of SDH technology worldwide. CTUIL further stated that at present SDH technology is only being used for access as well as core network and is mostly of the capacity of STM 16 with few links of STM 64. This implies that the communication network required for grid management purpose can be sufficiently managed upto 10G capacity. Thus, OTN capacity seems to be overdesigning for the purpose of our grid management communication network. Moreover, all the applications for grid management can be run on the same access and core networks.

On a query by CTUIL for the presence of networks based on OTN in power utilities worldwide or PoC conducted, TEJAS informed that same shall be checked and confirmed. CTUIL stated that they plan based on systems proven and operating successfully and TEJAS shall provide some details on the same.

3.4 Comparison of MPLS features of different OEM/SUPPLIERS (CISCO, HITACHI , GE , SIEMENS , NOKIA)

CTUIL showed and explained the replies received on the queries asked by JC from different MPLS vendors i.e. CISCO, HITACHI, GE, SIEMENS, NOKIA. Replies received from different vendors are attached at **Annexure-IV**.

TAN TRANSCO enquired about the 4th point of Annexure-IV i.e. Interoperability of MPLS TP and MPLS- IP OT sub-networks of a single utility communication system and suggested that it must be tested by some competent authority and CIGRE views can also be seen on this. CTUIL stated that as per the data received from the OEMs interoperability is either not possible or possible in a limited manner however Siemens has only mentioned this feature as possible. CTUIL informed the JC that this aspect shall be further explored with Siemens. TAN TRANSCO also enquired about the UNMS monitoring to which POWERGRID replied that UNMS monitoring is possible for every technology i.e. MPLS, OTN etc.

3.5 PoC to be deliberated w.r.t. ISTS applications

CTUIL requested POWERGRID to clarify some issues regarding maximum & average ingress of PMU data, ethernet circuit switching time and DTPC latency as mentioned in the report of POC conducted on MPLS TP by TEJAS on ISTS network owned by POWERGRID.

POWERGRID replied that average calculation of PMU ingress data is for a time period and not just the average of minimum and maximum values for the day and they also stated that high values of maximum ingress PMU data on some specific days may be due to some particular event.

POWERGRID also replied about the switching time of ethernet circuit implies the time taken for the data to be switched from main path to stand by path at the control centre end i.e. if one path is down then time taken for data to switch on the backup path at control centre end is

around 27ms. POWERGRID stated that DTPC latency was not measured as the PoC was conducted to test the performance of the link on live traffic and there is no ready tool to capture latency data on regular basis. Latency only can be measured in a planned scenario by putting testers and disrupting traffic.

In view of above, CTUIL summarized that PoC has been successfully conducted for all applications of grid management through MPLS TP as per POWERGRID PoC report. Further PCD Division, CEA has also witnessed the distance and differential (Bandwidth) protection through MPLS TP at TAN TRANSCO as stated in 3.2 above. CTUIL further stated that differential protection conducted through dark fibres is of not much relevance for latency as signal travels without FOTE in this case.

For better clarity on MPLS technology, it was suggested to go for PoC through MPLS IP for verifying the latency of all the applications including distance and differential protection and interoperability with MPLS TP node/network. CTUIL stated that they shall explore the same with MPLS IP/TP vendors/OEMs/service providers and coordinate for the PoC to be conducted by POWERGRID or any other TSP. Further, CTUIL informed that if PoC to be conducted on MPLS IP technology, extra time may be required for final submission of final report of JC.

NPC Division, CEA also suggested to have a physical meeting for discussion and call all the vendors. CTUIL stated that during the meetings of JC prominent vendors have already made their presentations and exhaustive deliberations have taken place. CTUIL shall explore the possibility of the suggested PoC and if required a physical meeting may also be conducted.

4.0 Following was concluded in the meeting

- (i) CTUIL to contact IP/TP vendors for conducting the suggested PoC.
- (ii) OTN presentation by TEJAS was viewed as overdesign by JC and for the time being with next ten years MPLS/SDH capacity shall be sufficient as access and core network.

5.0 Other points

CTUIL stated that some of the members could not attend the meeting due to other important engagements. This may kindly be taken care by NPC-CEA.

Meeting ended with a vote of thanks.

Minutes of the Meeting held on 13.12.2023 among CEA, CTU, POWERGRID, CISCO to discuss PoC requirement on MPLS/IP

1. A meeting was held among CEA, CTU, POWERGRID & M/s CISCO on 13.12.2023 on virtual mode to explore PoC possibility for MPLS/IP technology on POWERGRID ISTS communication network as decided in the 3rd meeting of Joint Committee on the “Introduction of MPLS Technology in ISTS Communication System”. List of Participants is attached at **Annexure-I**.
2. At the outset, Sr. GM (CTU) welcomed all the participants in the meeting and explained the agenda.
3. CISCO stated that they have implemented MPLS/IP based communication network for various power utilities in many countries such as Canada, Malaysia, Norway, Mexico etc. They also stated that in the above operational networks various services like Distance & Differential Protection, SCADA, PMU, VoIP and surveillance have been tested successfully.
4. On query regarding latency of above operational applications, CISCO stated that they meet the latency figures mentioned in the CIGRE green book. However, they shall review the latency recommendations of IEEE/CEA standards and confirm the same.
5. CISCO also informed that with EDFA amplifier the repeaterless distance can be achieved up to 150 Km and with RAMAN amplifier up to 200 Km, depending on the losses, SNR etc. Moreover, they also stated that interoperability of IP/TP is possible for all real time data except line protection with limited network management system. CISCO further informed that they have done PoC for RVPNL on Heerapura– Sanganer line but it is not operational as of now.
6. CISCO stated that for line protection, identical types of equipment shall be required at the originating and terminating ends e.g. SDH -SDH, MPLS/TP-MPLS/TP, MPLS/IP -MPLS/IP. CEA proposed that while migrating from legacy to the new network, care should be taken to account this, and migration shall be carried out in clusters. POWERGRID also agreed for the same.
7. CTU stated that POWERGRID and few STUs viz. TSTRANSCO/TANTRANSCO/KSEB have already got conducted PoC for grid management applications and line protection through MPLS/TP technology. CTU further stated that as discussed in the JC, a PoC is required to be conducted on MPLS/IP for all grid management applications alongwith line protection and interoperability with MPLS/TP. POWERGRID stated that maximum duration of PoC shall be three months. However, CTU stated that the duration can be further deliberated in the JC.
8. CISCO agreed for conducting such PoC on MPLS/IP without any cost implications and providing the necessary equipment/interfaces/services/test gears at their own cost. They requested CTU/POWERGRID to consider the PoC preferably in the Northern Region.

CISCO stated that after reviewing at their end they shall be confirming the same through letter.

9. CTU requested POWERGRID to finalize a network section which shall be able to run all the desired requirements as under:
 - (i) Repeaterless network length of around 150/200 Km.
 - (ii) Selected nodes shall support SCADA, PMU, AGC, VoIP, Distance/Differential protections besides the other real time data.
10. CTU further requested POWERGRID to tie up with MPLS/TP vendor also for providing a section on MPLS/TP to ensure the interoperability of MPLS IP network.

Meeting ended with vote of thanks.

Annexure- I

List of Participants

CTUIL		
1.	Sh. H.S. Kaushal	Sr. GM
2.	Sh. S. K. Gupta	Sr. DGM
3.	Sh. T. P. Verma	Ch. Manager
4.	Sh. Prakhar Pathak	Assistant engineer
CEA -PCD		
1.	Ms. Priyam Srivastava	Dy. Director
2.	Sh. Prateek Srivastava	Assistant Director
POWERGRID- GA&C		
1.	Sh. Anjan Kumar Das	GM
2..	Ms. Shyama Kumari	DGM
3.	Sh. Gaurav Awal	Chief manager
CISCO		
1.	Sh. Manas Mehrotra	Leader – Utilities, Digital Transformation
2.	Sh. Sourav	

Minutes of the Meeting held on 15.12.2023 among CEA, CTU, POWERGRID, NOKIA to discuss regarding PoC for MPLS/IP technology on POWERGRID ISTS Communication Network.

1. A meeting was held among CEA, CTU, POWERGRID, NOKIA on 15.12.2023 on virtual mode to explore PoC possibility for MPLS/IP technology on POWERGRID ISTS communication network as decided in 3rd meeting of Joint Committee on “Introduction of MPLS technology in ISTS communication system”. List of Participants is attached at **Annexure-I**.
2. At the outset, Sr. GM, CTU welcomed all the participants in the meeting and explained the agenda.
3. NOKIA stated that they have implemented MPLS/IP based communication network for various power utilities in many countries such as U.S., New Zealand, Australia, etc. They also stated that these MPLS/IP networks are running in power utilities since 2012. The above operational networks are working for various services like Distance & Differential protection, SCADA, PMU, VoIP, and AMR successfully. NOKIA also informed that in India, they have done PoC in power distribution sector.
4. On query regarding latency of above operational applications, NOKIA stated that tele-protection latency for relay to relay is less than 20msec whereas channel latency is less than 5msec. They also stated that the latency figures for differential as well as distance protection are same for their MPLS/IP networks deployed. NOKIA shall share the reports of latency with CTUIL.
5. NOKIA informed that with EDFA (Erbium-Doped Fiber Amplifier) the repeaterless distance can be achieved up to 180 Km and with RAMAN amplifier greater than 200 Km.
6. NOKIA stated that interoperability of MPLS/IP with other equipment e.g. MPLS/TP, SDH etc. is possible. NOKIA also stated that for protection purpose, identical equipment is required at both originating and terminating ends. However, if mixed equipment is used latency will increase for protection applications. CTU requested NOKIA to provide details of mixed network. NOKIA agreed to demonstrate the working of MPLS/IP with mixed network in a TELCO company in Delhi NCR and shall confirm for the visit within a week. CEA also agreed for the same and stated that migration should be done in phased manner. CTU and POWERGRID also agreed with CEA.
7. CTU stated that POWERGRID and few STUs viz. TSTRANSCO/ TANTRANSCO/ KSEB have already got conducted PoC for grid management applications and line protection through MPLS/TP technology. CTU further stated that as discussed in the JC, a PoC is required to be conducted on MPLS/IP for all grid management applications along with line protection and interoperability with MPLS/TP. POWERGRID stated that maximum duration of PoC shall be three months. However, CTU stated that the duration can be further deliberated in the JC.

8. NOKIA stated that for conducting such PoC on MPLS/IP without any cost implications and providing the necessary equipment/interfaces/services/test gears, they need approval from their higher authority. NOKIA stated that after reviewing at their end they shall be confirming the same through letter. They requested CTU/POWERGRID to consider the PoC preferably in the Delhi NCR/Mumbai. NOKIA stated that after reviewing at their end they shall be confirming the same through letter.
9. CTU requested POWERGRID to finalize a network section which shall be able to run all the desired requirements as under:
 - (i) Repeaterless network length of around 180/200 Km.
 - (ii) Selected nodes shall support PMU, AGC, Distance & Differential protections besides the other real time data.
10. CTU further requested POWERGRID to tie up with MPLS/TP vendor also for providing a section on MPLS/TP to ensure the interoperability of MPLS/IP network.

Meeting ended with vote of thanks.

Annexure- I

List of Participants

CTUIL		
1.	Sh. H.S. Kaushal	Sr. GM
2.	Sh. S. K. Gupta	Sr. DGM
3.	Sh. T. P. Verma	Ch. Manager
4.	Sh. Kaushal Suman	Manager
5.	Sh. Prakhar Pathak	Assistant engineer
CEA -PCD		
1.	Ms. Priyam Srivastava	Dy. Director
POWERGRID- GA&C		
1.	Sh. Anjan Kumar Das	GM
2..	Ms. Shyama Kumari	DGM
NOKIA		
1.	Sh. Vishal Verma	

Minutes of 4th MPLS Joint Committee Meeting held in Virtual Mode through MS- Teams Platform on 23rd January 2024

The 4th meeting of Joint Committee (JC) constituted by NPC was held on 23-Jan-2024 through Online mode to discuss and recommend the “Introduction of MPLS technology in ISTS Communication System”.

The list of participants is attached at **Annexure-I**.

CTU welcomed all the participants at the meeting and proceeded with the agenda items.

Agenda for the 4th MPLS meeting is attached at **Annexure-II**.

The summary of discussion is mentioned below:

1.0 Explanation of agenda for 4th MPLS JC meeting

CTU took confirmation regarding the MoM of 3rd JC Meeting held on 05th December 2023 and explained the agenda points for the 4th meeting to the JC which are as follows:

1. POC discussions with MPLS – IP service providers with interoperability to be done on SDH & MPLS-TP
2. POC details to be finalized.
3. Operational Latency figures for various applications as per 3rd JC MoM– by POWERGRID
4. Study of such networks in power sector utilities

1. Agenda point: POC discussions with MPLS – IP service providers with interoperability to be done on SDH & MPLS-TP

CTUIL informed that they have discussed for PoC on MPLS -IP with NOKIA & CISCO which are the prominent suppliers of MPLS-IP in India. NOKIA has not yet confirmed for conducting PoC, but CISCO has confirmed that they can conduct PoC on FoC basis, but they also raised certain queries about interoperability with TP/SDH networks. Moreover, CISCO also raised issue that they need at least 45 to 50 days’ time to arrange for amplifier to cover long lengths.

CTU informed that for the interoperability with MPLS-TP, they have contacted Hitachi & Belden for providing their MPLS-TP equipment for the POC. POWERGRID stated that even MPLS-TP equipment of different makes shall also be tested for interoperability during POC. CTU also informed that as per the feedback from different vendors, the major issues being faced in conducting a PoC are commercial obligations because of their participation constraints for implementation due to Make in India (MII) policy.

2. Agenda point: POC details to be finalized.

CTUIL informed that details like topology, location, applications to be tested, interoperability etc. needs to be finalized and provided to the vendor for PoC. CTUIL requested POWERGRID to provide these details.

POWERGRID suggested to conduct PoC in a network where either MPLS IP or MPLS TP is already deployed so that interoperability between MPLS IP/TP and SDH can be done by deploying just one additional network. CTU stated that 9 km link of TSTRANSCO which was witnessed by CEA-PCD is a very small link as compared with ISTS network, so it is preferred to do PoC on a ISTS network. PCD-CEA also agreed for the same. CTU proposed that they shall along with CEA-PCD and POWERGRID finalize the network to be offered for PoC.

CTU enquired CSPTCL whether they have conducted any PoC, to which CSPTCL replied that due to lack of participation from the vendors they are not able to conduct PoC. They also stated that their PoC is part of the Bid documents. CSPTCL also stated that there was no response to their earlier RFP based on MPLS-IP.

KSEBL informed that PoC is part of their tender and there was no participation due to MII constraints. Hence PoC could not be conducted.

PCD -CEA informed that PoC in TSTRANSCO was conducted by GE where link length was around 9 Km. PCD-CEA suggested to get a detailed report of PoC from TSTRANSCO.

NPC Division, CEA highlighted that as per the Terms of Reference (TOR) of the committee, JC doesn't have any authority for any relaxation on MII constraints. So the solution shall be in accordance with the prevailing norms unless they are changed/amended by authorities. NPC Division-CEA further suggested that Mandatory Testing and Certification of Telecom Equipment (MTCTE) shall also be referred during finalization of report.

3. Agenda Point: Operational Latency figures for various applications as per 3rd JC MoM– by POWERGRID

CTU informed that we have received the latency data for SCADA and PMU from POWERGRID however the remaining data also needs to be furnished. POWERGRID agreed to the same.

Latency figures provided by POWERGRID are attached at ***Annexure-III***.

4. Agenda Point: Study of such networks in power sector utilities

CTU informed that since India has a complex power system communication network constituting of ISTS, STUs, DisComs, RE/IPP generators, control centres (RLDCs & SLDCs) etc. It would be prominent to make a detailed study for handling the said network so that the migration along with integration of legacy network can be maintained healthy.

Moreover, CTU stated that different STUs are coming up with specific MPLS technology i.e. TP/IP, which needs to be integrated with ISTS backbone communication system. For design and planning of ISTS communication system, study of such operational networks in similar power utilities is essential due to:

- i. Use cases details not furnished by suppliers/service providers due to Non-Disclosure Agreement (NDA).
- ii. Very less deployment of this technology in India for power sector applications.

NPC Division, CEA stated that the agenda on “Introduction of MPLS to ISTS system” shall be discussed in the next NPC meeting which is to be held on 03.02.2024 and CTU may raise their concerns in the NPC meeting.

2.0 Following was concluded in the meeting.

- (i) POWERGRID to provide operational latency data for remaining applications.
- (ii) POWERGRID shall finalize the network for PoC in consultation with CEA-PCD & CTU.
- (iii) To address the above constraints/issues in the upcoming NPC meeting.

Meeting ended with a vote of thanks.

Annexure-I

List of Participants

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AGENDA POINTS FOR 4th MEETING

1. POC Discussions With MPLS – IP Service Providers With Interoperability To Be Done On SDH & MPLS-TP
2. POC Details To Be Finalized
3. Operational Latency Figures For Various Applications as per 3rd JC MoM– By POWERGRID
4. Study Of Such Networks In Power Sector Utilities

POC discussions
with MPLS – IP
service providers
with
interoperability to
be done on SDH &
MPLS-TP

- a) Discussed with NOKIA & CISCO MPLS/IP service providers.
- b) As per interactions with them it is understood that there are challenges for the expected PoC.
 - i. Interoperability of MPLS/IP with TP/SDH networks-Teleprotection.
 - ii. Arrangement of amplifiers will take time.
 - iii. Commercial obligations not finalized so far.
 - iv. Arrangement & capacity (STM-4/16) of MPLS/TP equipment.

POC details to be
finalized

- a) Topology
- b) Location
- c) Applications to be tested
- d) Inter-operability with Legacy and MPLS-TP
- e) Observations & Test Results
- f) PoC Report

POWERGRID to review and finalize a network in the Northern region for the same.

Input data from
POWERGRID

Operational Latency Figures For Various Applications
As Per 3rd JC MOM—by POWERGRID

Study of MPLS with legacy networks in power sector utilities.

It is observed that different STUs are coming up with specific MPLS technology which needs to be integrated with ISTS backbone communication system. For design and planning of ISTS communication system, study of such operational networks in similar power utilities is essential due to:

- i. Use cases details not furnished by suppliers/service providers due to NDA.
- ii. Very less deployment of this technology in India for power sector applications.

Annexure III

VARIOUS COMMUNICATION APPLICATIONS WITH LATENCY REQUIREMENT

S. No	Application/Services		Channel Latency Standard /Operational
1	RTU/SCADA		100-1000 ms (5-7)
2	PMU/PDC		100-1000 ms (5-39)
3	Voice		100 ms ?
4	Telecontrol		1-5 sec ?
5	Telemetry		1-5 sec ?
6	Automatic Generation Control		0.1-1 sec ?
7	Teleprotection	Line Differential	<5 msec ?
		Pilot Protection	<8 msec ?
	Data not received from RLDCs/TSPs	Direct Transfer Trip	<10 msec ?

Minutes of the 5th MPLS Joint Committee Meeting held at CTU Gurugram on 11.03.2024

The 5th meeting of Joint Committee (JC) constituted by National Power Committee (NPC), CEA was held at CTU Gurugram on 11.03.2024 “To discuss and recommend on the Introduction of MPLS technology in ISTS Communication System”.

The list of participants is attached at ***Annexure-I***.

At the outset Sr.GM (CTU) welcomed the participants and gave a brief note about the formation of the Joint Committee (JC) and the deliberations held in the previous meetings. He said that the said JC was constituted on 14th September 2023. 1st meeting of the JC was held on 19th September 2023 followed by subsequent meetings on 17th October 2023, 5th December 2023 and 23rd January 2024. He also spoke about the activities of various STUs like Rajasthan, Tamil Nadu, Kerala, Chhattisgarh, Telangana on their migration to MPLS technology.

Member (PS), CEA made the opening remarks and welcomed the participants.

Dy.COO (CTU) in his opening remarks emphasized the importance of communication arrangements in Power System. He stated that failure of communication system may lead to difficulty in real time visibility in the grid and possibility of failure of the grid.

COO (CTU) added that several STUs and other cross border utilities are moving ahead with adoption of MPLS technology, thus it is pertinent that CTU may also have a review of the communication technology adoption road map.

Member (PS), CEA stated that migration to the new technology should be smooth and hassle free and legacy issues should be taken care. While selecting the technology option, Make in India policy should be given due attention. At the same time there should be adequate competition also.

Moreover, as it is a country level project, a uniform approach is essential for compatibility and conformity. Besides this it should be ensured that the integration of new technology with the legacy network shall ensure seamless data transmission and other functionality. Life of the system and obsolescence are other aspects which deserve due attention.

Agenda for the 5th MPLS meeting is attached at ***Annexure-II***.

The summary of discussion is mentioned below:

CTU took confirmation regarding the MoM of 4th JC Meeting held on 23rd January 2024 and explained the agenda points for the 5th meeting to the JC which are as follows:

1. Alternative of Proof of Concept (PoC).
2. Requirement of hybrid Multi-Protocol Label Switching (MPLS) equipment and their specifications.
3. MPLS Original Equipment Manufacturers (OEMs)/Vendors issues.
4. Make in India related issues.

5. Feedback and experience of State Transmission Utilities (STUs) on MPLS technology adopted in their system of Rajasthan Rajya Vidyut Prasaran Nigam Limited (RRVNL) and Tamil Nadu Transmission Corporation Limited (TANTRANSCO).
6. Any other points

1. Alternative of PoC

CTU stated that they understand that RRVNL is using Multiprotocol label switching – Internet Protocol (MPLS-IP) technology for Tele-protection along with other applications including grid management. The representative of RRVNL confirmed the same and stated that they have used both MPLS-IP for all IT/OT applications and Multiprotocol Label Switching – Transport Profile (MPLS-TP) for tele-protection applications. The presentation of their MPLS system is enclosed at **Annexure-III**.

CTU also mentioned that POWERGRID has also conducted PoC for all grid management applications except tele-protection on their network for MPLS-TP provided by M/s Tejas Networks (India). However, POWERGRID informed that they have also conducted the PoC on MPLS-TP for distance protection on a 40 km link for a duration of 3 months without having any deviations on latency issues but the same was not brought out in the PoC report clearly.

TANTRANSCO stated that they had conducted PoC on MPLS-TP and presently they have one path through SDH and other through MPLS-TP on their network in certain links. They also stated that they are to use Disturbance recorder (DR) and Transmission Wave Fault Locator (TWFL) which will also be an application using the communication network. TANTRANSCO gave a presentation regarding the same which is attached at **Annexure-IV**.

NRLDC raised the point of interoperability of these networks for different makes/OEMs and the interoperability of networks of MPLS-IP and MPLS-TP technologies.

M/s GE stated that they have integrated their MPLS equipment with MPLS equipment being provided by Hitachi and Siemens. Other vendors also stated that all other applications of grid management can be operated through different makes of MPLS-TP equipment network as well as MPLS-IP equipment network. The vendors/OEMs further stated that the tele-protection application is also met with different makes of IP or TP networks if the Digital Tele-Protection Coupler (DTPC) is a standalone equipment and not a built-in device. In case DTPC is built-in the main equipment [Fiber Optic Terminal Equipment (FOTE)] then same makes are essential to be on either side of transmission line for tele-protection purposes. This is also true for the Power Line Carrier Communication (PLCC) equipment being used.

In view of above the JC suggested for the PoC for interoperability of different makes of MPLS-TP equipment. For this it was suggested that the TANTRANSCO network shall be expanded for few more nodes on MPLS

equipment by deploying the devices of the vendors other than the devices of M/s Hitachi.

2. Requirement of hybrid MPLS equipment and their specifications

For the interoperability of MPLS-TP/MPLS-IP/SDH networks, the JC suggested that as the RRVPNL operational network comprises MPLS-TP, MPLS-IP and SDH networks, its experience will be useful.

POWERGRID stated that at present all their applications are running on ethernet ports, except for the tele-protection which is through E1 links. Hence if MPLS networks are to be used with ethernet ports then converters would be required for tele-protection interfacing. M/s Hitachi and M/s Valliant stated that their equipment supports E1 interfaces also, hence converters are not required.

TANTRANSCO stated that the Technical Specifications (TS) for their operational MPLS network can be downloaded from public domain whereas RRVPNL agreed to provide the specifications adopted in their system.

NPC informed that the Project Monitoring Group (PMG) of PSDF, in its 21st PMG held on 04.03.2022 & 08.03.2022, deliberated on the request of state utilities for change in technology from SDH to MPLS for the implementation of projects of reliable communications for the state's transmission network. In 21st meeting of PMG, with consideration of the inputs of PCD Division, CEA on the matter, the request of state utilities for change in technology from SDH to MPLS was approved under the following conditions:

(i) As tele-protection is a critical service and MPLS being comparatively new technology in the Indian Power Sector, it is recommended that the main channel for tele-protection should be through SDH/PLCC and alternate channel may be through MPLS-TP/MPLS-IP.

(ii) For speech and data communication, MPLS-TP/MPLS-IP technology may be used.

The above can be further evaluated for confidence building.

3. MPLS OEM/Vendors issues

(i) Interoperability

The interoperability issues of different makes of MPLS-IP or MPLS-TP equipment has been detailed at item No. 1. The interoperability aspects of MPLS-IP and MPLS-TP equipment shall be observed at system installed in RRVPNL. Moreover POWERGRID confirmed that both MPLS-IP and MPLS-TP network management system (NMS) can be integrated with Unified Network Management System (UNMS).

(ii) Make in India (MII) policy aspects

The STUs stated that they are not receiving wider participation from the vendors/OEMs for MPLS system, and they have to annul their bids for multiple times.

Representative from PCD Division, CEA stated that DPIIT, vide OM dated 06.09.2022, has conveyed that *“Ministry of Power is hereby advised to issue instructions to all procuring entities under its administrative control to adhere to the guidelines issued by Department of Telecommunication (DoT) in compliance to PMI and Local Content along with testing requirements for procurement of Fiber Optic Terminal Equipment (FOTE) and other Telecom Equipment used in power system network, as notified in DoT Notification No. 18- 10/2017-IP dated 29.08.2018 and Notification No. TEC/01/2017 dated 23.06.2020.”* There is a need to examine the local capacity and competition for MPLS based FOTE exclusively for power sector purposes as it would have direct implications on electricity grid monitoring and operation.

Nodal Officer for MII, CEA/MoP clarified that the STUs seeking funding support from the central funds are required to comply with the PPP-MII Orders of DPIIT, MoP and DoT, while the STUs tenders contained conditions restrictive to Make In India and deterred participation from indigenous vendors. Class-I local suppliers also raised the same concern, while some OEMs reporting themselves to be Class-II Suppliers stated that MLC requirement notified by MoP and DoT regarding FOTE equipment is restricting their participation.

Nodal Officer for MII, CEA/MoP stated that the MII issues viz. the higher Local Content (LC) content as stated in the Ministry of Communication (MoC, DoT) order dated. 29.08.2018 are applicable to all sectors uniformly and whereas MoP Order dated 26.11.2021 is applicable to the Power Sector.

The JC also opined that it would formulate the general specifications for FOTE keeping in view the functional requirement in respect of the telecommunication and tele-protection applications in the power sector and then would refer the same to CEA to examine the issue of MLC in this equipment based on the various provisions of Government of India's orders on MII and cyber security aspects. Member Secretary National Power Committee CEA [MS(NPC), CEA] also agreed with this point.

Out of the present vendors/OEMs only Tejas Networks stated that they fall under Class-I (LC $\geq$ 50%) for both MPLS-IP and MPLS-TP products. M/s Valliant Communications stated that they also fall under Class-I for MPLS-IP products. M/s Hitachi and M/s GE stated that they fall under Class-II (20% $\leq$ LC $\leq$ 50%).

4. Feedback and experience of STUs on MPLS installed in their communication network in respect of power system applications - RRVPNL, TANTRANSCO

(i) Presentation by RRVPNL

RRVPNL made a presentation on the MPLS-IP deployed in their network. They stated that they started a project “smart grid platform” in the year 2016-17 in which around 14500 kms fibre was laid with MPLS equipment at around 552 locations with Network Management System (NMS). For this project 50% grant was given from Power System Development Fund (PSDF). Main control centre is at Jaipur and backup control centres at Jodhpur and Ajmer. Moreover 480 MPLS routers are installed. Dense wavelength-division multiplexing (DWDM) was used on the top of MPLS layer to reduce latency. 206 Voice over Internet Protocol (VoIP) phones, 1261 video surveillance cameras were also installed at 220 kV and above locations. The main objective behind implementation of this project is that Renewable Energy (RE) integration is increasing so it is important to manage the complex network through improved communication system. A mobile application was also developed in which fault details and location are sent to the concerned person on mobile phones. Applications like Supervisory Control and Data Acquisition (SCADA) automation, line protection, Phasor measurement units (PMUs), voice, CCTV are presently implemented and working.

It was also presented that the testing of tele-protection on MPLS-IP with special tunnelling feature tested by them in FAT as well as one smaller line of 10-12 km in Jaipur City but widespread adoption for protection is yet not implemented. However, they are ready to coordinate for the testing of the feature as POC with concerned MPLS-IP vendor to showcase the integration of various technologies for taking suitable view by the study group.

(ii) Presentation by TANTRANSCO

TANTRANSCO stated that they had gone for PoC with Hitachi and Siemens separately. Finally after studying the pros and cons of MPLS -TP/IP technologies preferred to go for MPLS-TP networks to meet their functional requirements and have installed Hybrid FOTE (SDH cum MPLS-TP) and MPLS-TP FOTE equipments in certain links in their state transmission network. They are running these networks along with SDH equipment and configuring one path on SDH and other path through MPLS-TP in certain links. Their MPLS-TP network products are provided by Hitachi and they have commissioned some links for data and tele-protection applications and are in the process of commissioning certain other links including VoIP voice based communication.

(iii) It is observed that **Chhattisgarh** has been present in all the JC meetings however nomination for the JC is not received yet even after repetitive request from NPC, CEA. Hence, Chhattisgarh may submit a nomination to become a member of the JC in writing.

5. Following was concluded:

- (i) Experience of RRVPNL on interoperability of MPLS-TP, MPLS-IP and SDH to be shared. Field visits to be undertaken by a team of JC members.
- (ii) PoC to be conducted for different makes of MPLS-TP and MPLS-IP equipment on TANTRANSCO/RRVPNL network within one (1) month to assess/confirm

that both the technologies are suitable for functional requirements of power system with respect to data, voice and tele-protection. The JC in association with OEMs and STUs /POWERGRID will get the PoC conducted.

(iii) Technical specifications (TS) are to be prepared by the JC and same shall be circulated to OEMs/vendors/stakeholders for their inputs and feedback. It was opined that the specifications may be prepared keeping the technical/functional requirements of the power sector wrt ToR of JC. The technical specifications may be prepared by the JC on priority and afterwards, the issues related to MII may be dealt with by CEA/DoT/MoP as per the Make in India Policy. The JC to finish the work of preparation of DRAFT TS before July 2024.

(iv) Chhattisgarh to send the nomination for the JC within one week.

Meeting ended with a vote of thanks.

Annexure-I

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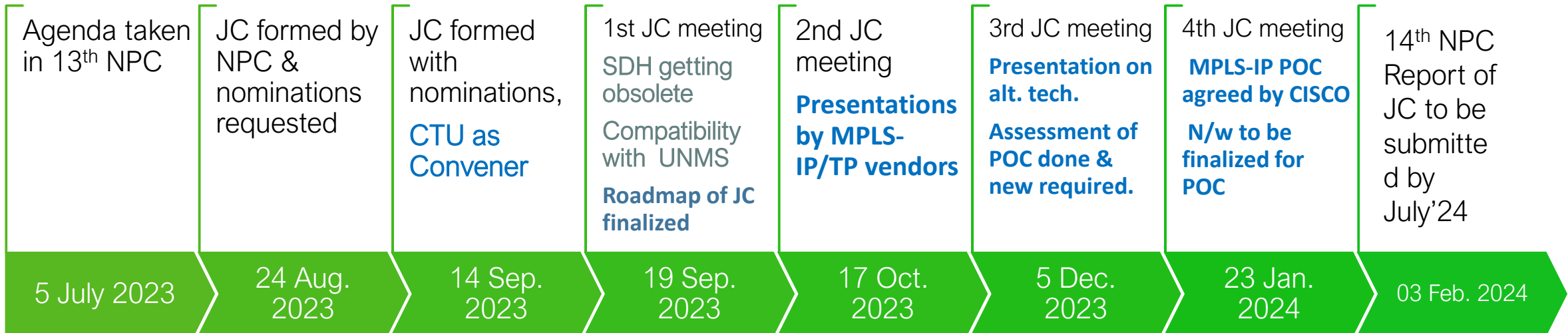


Agenda points for 5th MPLS JC meeting

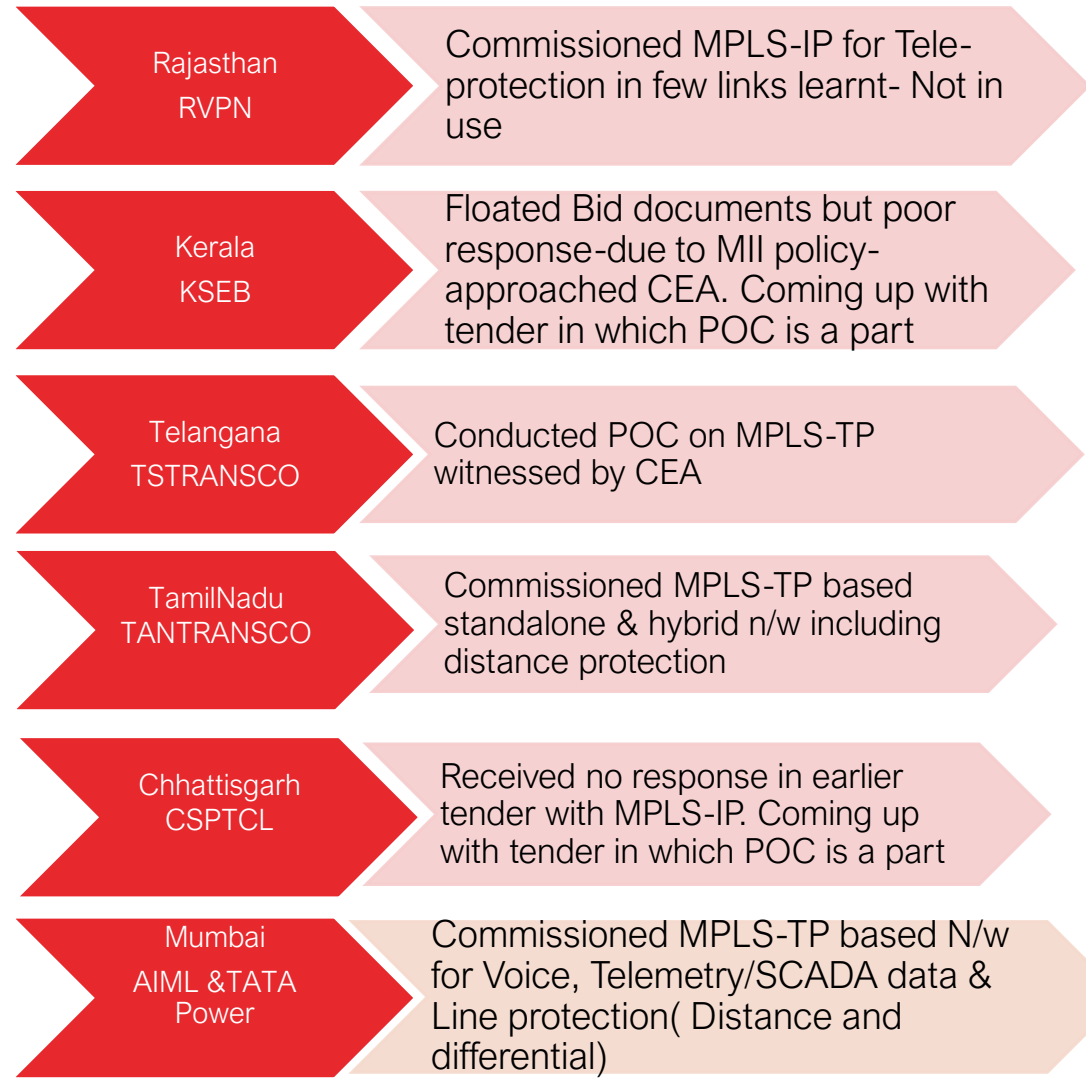
CTU Gurugram

11.03.24

Chronology



Migration status of STUs to MPLS



Constraints & Proposal

S. No	Constraints	Proposal
1	Latency for Tele-protection: Distance:<10ms & Differential:<5ms by main & redundant routes suitability to be checked for Latency of tele-protection by main & redundant routes Redundant route may have multiple nodes (hops) which may increase the latency.	Study of operational network in various similar utilities
2	Actuation of Tele-protection with dissimilar communication equipment at either end of the Tx line	Such combination has not been tested in POC can be envisaged in upcoming POC.
3	Adoption of technology: MPLS-IP or MPLS-TP, to meet ISTS communication requirement	Study of operational network in various similar utilities
	Interoperability :Different makes MPLS-IP/TP & MPLS/SDH equipment	
4	MII Policy constraints	Can be put up to CEA/MoP for relaxation.

Alternative of PoC

- MPLS-TP PoC done by POWERGRID
- MPLS –IP operational in Rajasthan (RRVPNL)
 - RRVPNL-share the operational performance & PoC if any
- MPLS-TP tele-Protection application (TANTRANSCO)
 - TANTRANSCO- share the operational performance
- RRVPNL and TANTRANSCO –confirm about their MPLS networks are with single make or multiple make of MPLS equipment.
- Tele-Protection and other applications- PoC for TP /IP to be reviewed
- MPLS-TP/IP network deployed in STUs to be integrated with ISTS network

Requirement of hybrid MPLS equipment

Hybrid MPLS equipment should be compatible with legacy network.

Technical Specifications of RRVPNL and TANTRANSCO to be reviewed wrt functional requirement.

Integrability with other makes of MPLS-IP/TP and SDH equipment meeting functional requirement.

MPLS OEM/Vendors issues

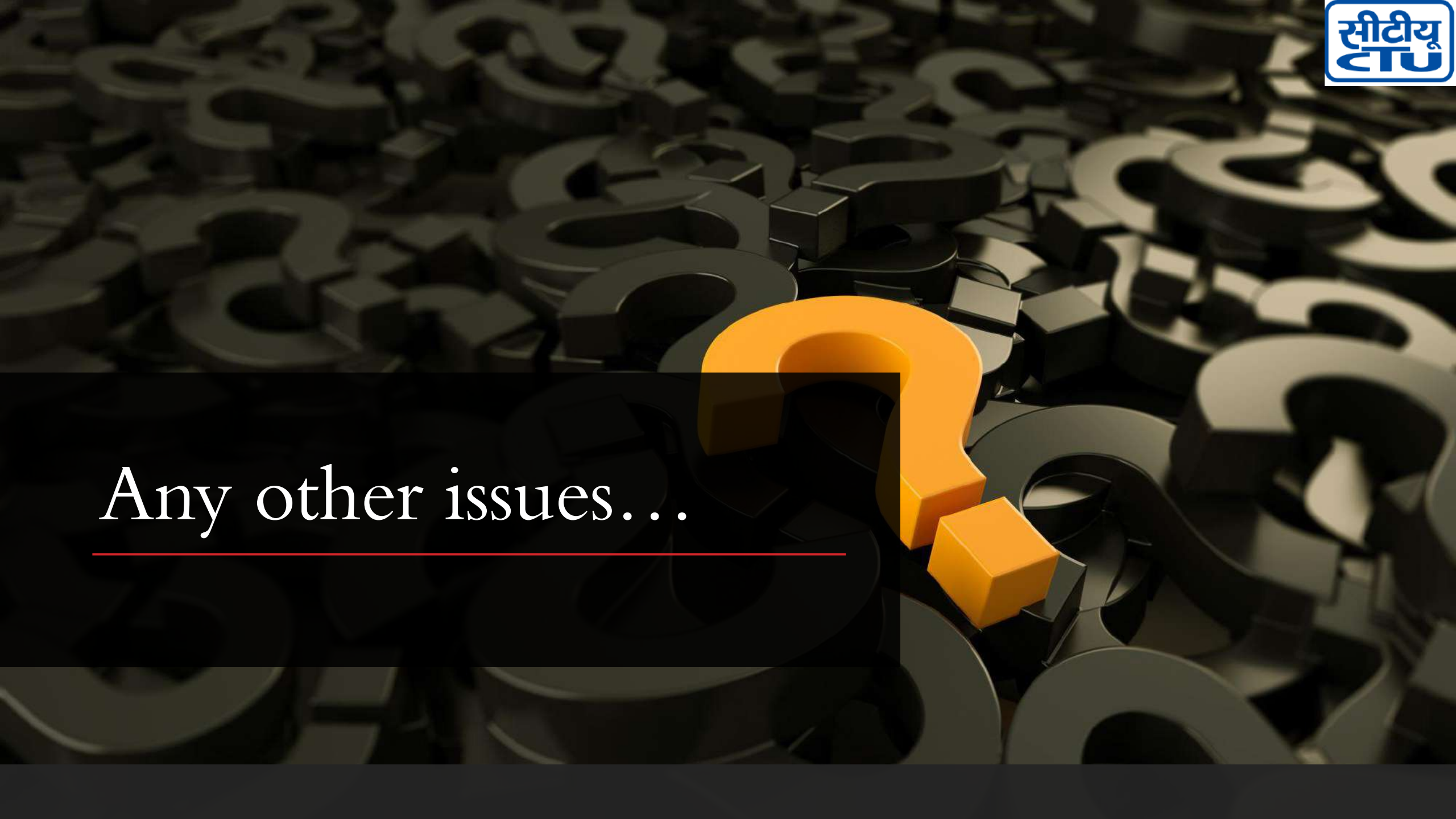
Integration of different make IP or TP equipment.

Integration issues of IP and TP equipment in a single network.

Integration of IP and TP network NMSs and also with UNMS.

MII Related Issues

Description	Constraints	Reference
Eligibility of Class I & Class II local suppliers	Local Content (LC) $\geq 50\%$ → Class I 20% < LC < 50% → Class II	Ministry of Commerce & industry order Dtd: 04.06.2020 Clause-2: Definitions
MPLS-TP MPLS-IP	LC > 65% LC > 60%	Ministry of Communication order Dtd: 29.08.2018 (Not Referred by MoP)
MPLS technology products	Not Mentioned	Ministry of Power order Dtd: 03.07.2023
Services such as Transportation, Insurance, Installation, Commissioning, Training and AMC	Not part of Local content calculation	Ministry of Power order Dtd: 16.11.2021 → Clause: 7 in Appendix
Participation for bidding	Participation is for PSDF or govt. funded/granted projects or any other fundings also.	

The background of the slide features a dense field of 3D-rendered dollar signs (\$). One dollar sign, positioned slightly to the right of the center, is highlighted in a bright orange color, while all the others are dark grey. A semi-transparent dark grey rectangle is overlaid on the left side of the image, containing the text 'Any other issues...'.

Any other issues...



Thank you



Annexure-III

RRVPNL Rajasthan Rajya Vidyut Prasaran Nigam Ltd.

“Design, Supply and Implementation of Information and Communication Technology Infrastructure under Package-B of Smart Transmission Network and Asset Management System (STNAMS)”



**Rajasthan Rajya Vidyut Prasaran Nigam Limited
(RRVPNL)**

SCOPE OF WORK

- Planning, Design
- Methodology

Site Survey



- MCCC at 400kV Heerapura GSS
- Back up and Sub-Control Center at Jodhpur & Ajmer

Establishment of MCC



- Structural cabling with IP-MPLS Node 552 RPF-POP EHV Substations

Establishment of DWDM/IP-MPLS



- **NMS Application Software**
- **NMS Hardware with Accessories**

NMS



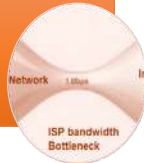
- **IP Surveillance Cameras**
- **POE Switches**

VMS



- **500 Mbps – ISP link for all 552 GSS location**

ISP Bandwidth



- **Voice Gateway**
- IP Phone
- Firewall
- IPS & ATP

UCM & Cyber Security



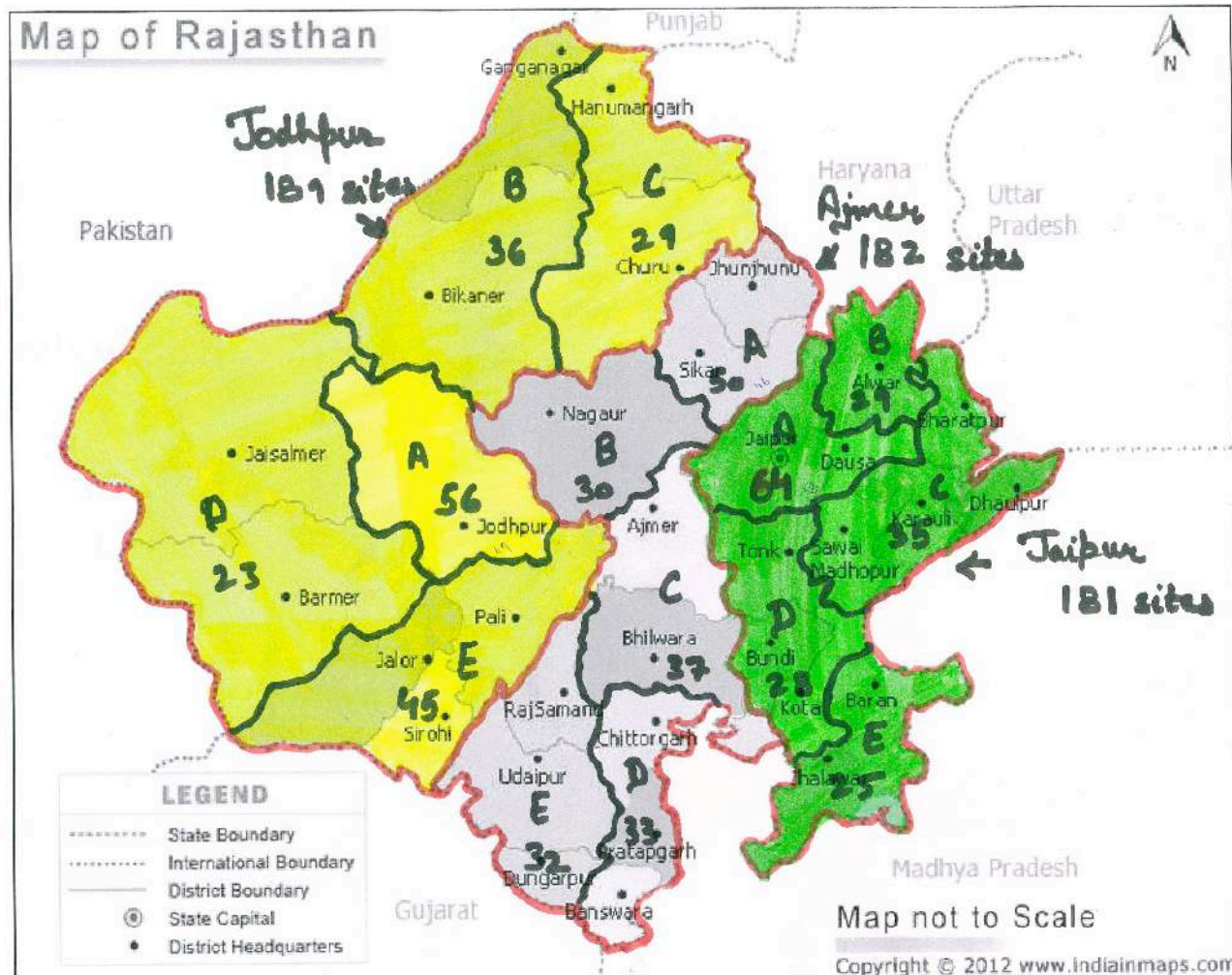
- **Maintenance Training on implementation, customization, utilization and maintenance**

Training



GEOGRAPHICAL FOOT PRINT OF GSS POP LOCATIONS

Geographical representation of all 552 GSS POP locations spread across whole Rajasthan and 3 Command Control Centres



SS Category	No. of sites
765kV	2
400kV	15
220kV	121
132kV	414
Total	552

Zones	No. of sites
UOM	Nos.
Jaipur	181
Jodhpur	189
Ajmer	182
Total	552

LOCATION-WISE INFRASTRUCTURE

Sl.No	Locations	Qty	Remarks
1	Main Control centre at Jaipur	1	
2	Backup Control centre at Jodhpur	1	
3	Sub Control centre at Ajmer	1	
4	Total Substations	552	
4 (a)	Substations with only MPLS router	480	Earlier proposed to be connected on ISP Network, later changed to be connected on OPGW Network
4 (b)	Substations with MPLS router and DWDM	72	To be connected on OPGW network from the beginning
5	Data connectivity to Field Offices	87	Outside building via fiber; remaining connected in Substation's switch
8	UCM with Phones	206	138 GSS Locations + 45 locations in VB+ 23 in Command centres
9	Video Surveillance	261	(138 +3)FC at GSS+ 36 FC at CC + 84 PTZ ; 42 Switches, 84 Poles

Smart Transmission Network and Asset Management System (STNAMS)

Project Objective



Operations management for efficient, safe & stable grid via Wide Area Network.

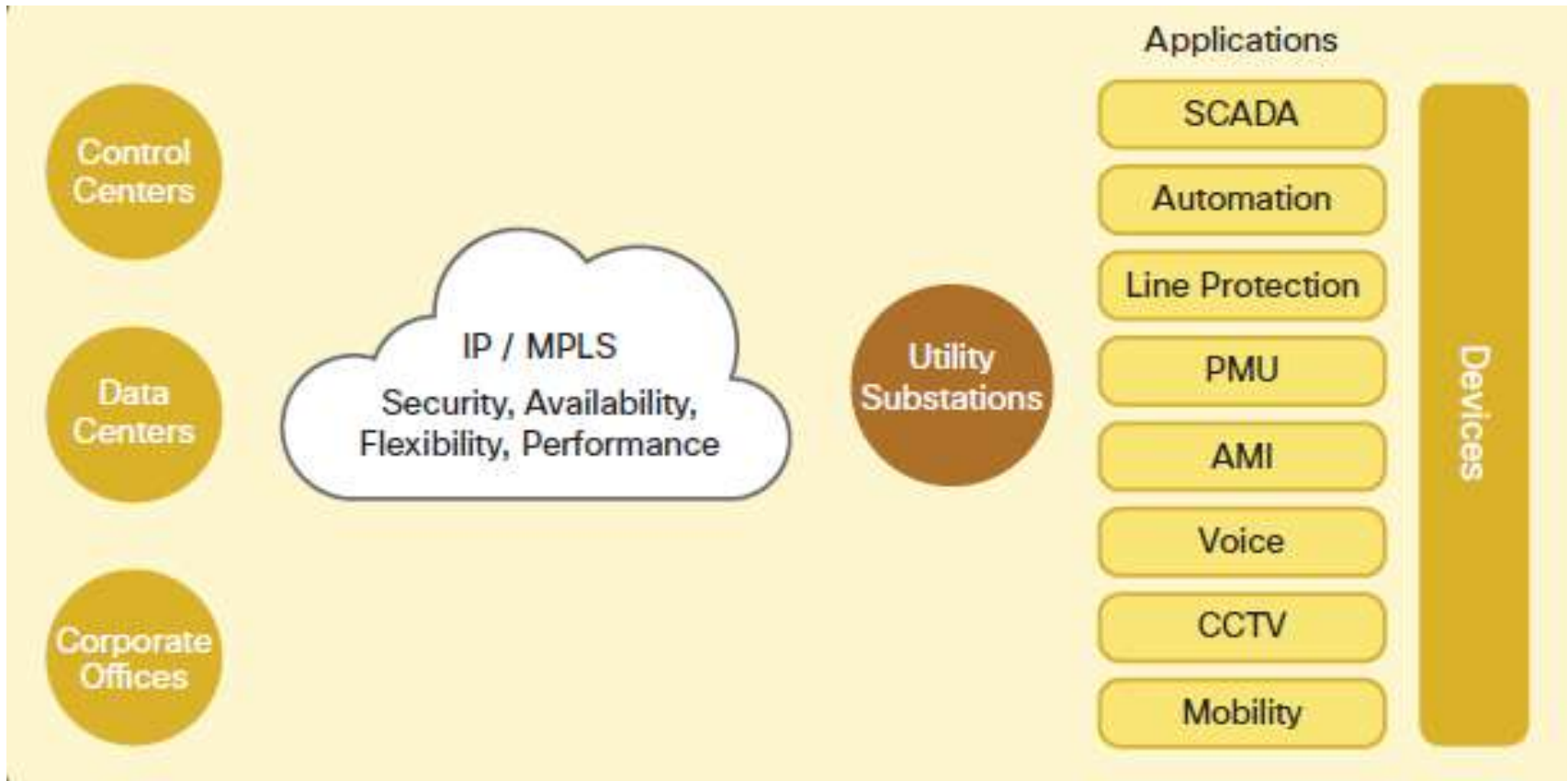
Monitoring, Control of the Transmission Grid and substations from Control centre through real time data transfer with reliability, speed and geo-referenced localization of faults

Quality management of Power flow through maintaining the Voltage and Frequency under prescribed limits by effective monitoring and utilizing the reactive elements.

Asset Management at Substations via Dynamic GIS Maps.

The accurate data and estimations for future **Planning** and studies.

SMART GRID Architecture



Real time monitoring

Better Control

Data Acquisition
for Planning

Integration with
GIS for asset
tracking and
localization of
fault.

INTRODUCTION

- RRVPNL has decided to implement Cisco IP/MPLS (Multi-Protocol Label Switching) WAN (Wide Area Network) solution for its various utility applications and services including Supervisory Control and Data Acquisition (SCADA) systems, Tele-Protection, Phasor measurement unit (PMU) data, IP Voice/Video and IP Camera for Surveillance.
- The RRVPNL IP/MPLS WAN solution is designed to build a common fast convergent IP/MPLS platform for 552 sites.
- The RRVPNL IP/MPLS WAN solution that connects Operational Technology (OT) endpoints over an IP packet-based infrastructure will allow RRVPNL to form the core of an advanced communications solution for implementing intelligent network services that facilitate new business requirements now and into the future.

OBJECTIVES

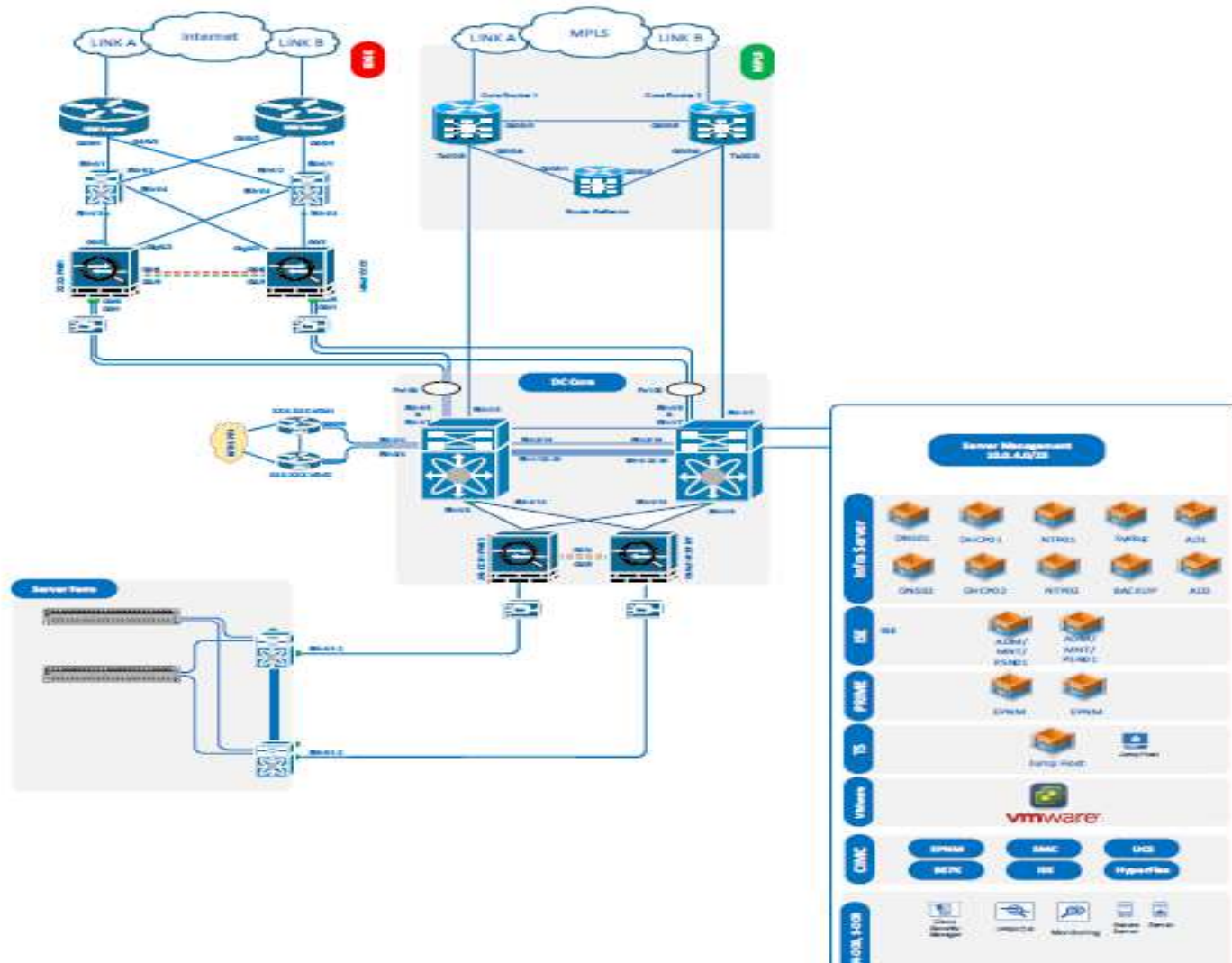
- The objective of project is to provide the Information and Communication Technology Infrastructure for the proposed Smart Transmission Network and Asset Management (STNAMS) system. The reliable, efficient and scalable communication backbone as proposed under this project shall enable the achievement of following wider objectives under proposed STNAMS.
- The IP/MPLS WAN will provide the following functions and capabilities to RRVPNL.
 - Implementation of a network architecture based on IP standards
 - Deployment of a multiservice network
 - Integration of equipment from multiple vendors across a common communications solution.
 - A tailored approach for meeting the requirements of RRVPNL's defined services.

- **DATA CENTER DESIGN**

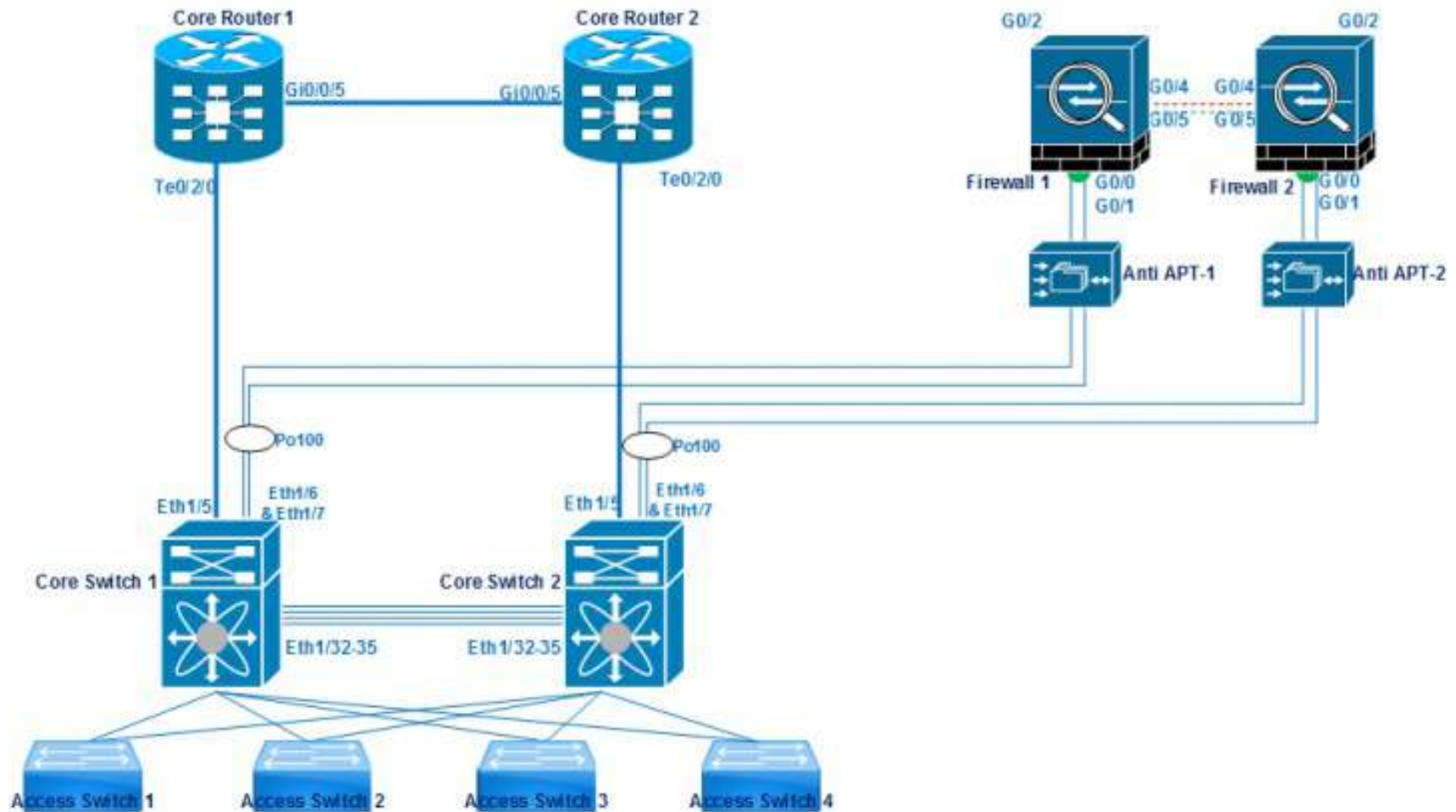
- RRVPNL Campus is based on a 2-level hierarchical design, including the levels of Access and Core.
- The Access level provides end-users connectivity, along with Access Points connectivity.
- The Core level, at the top of the hierarchy, aggregates all traffic coming from Access switches and connects the LAN Campus to the other Campus blocks.

JAIPUR DATA CENTRE ARCHITECTURE

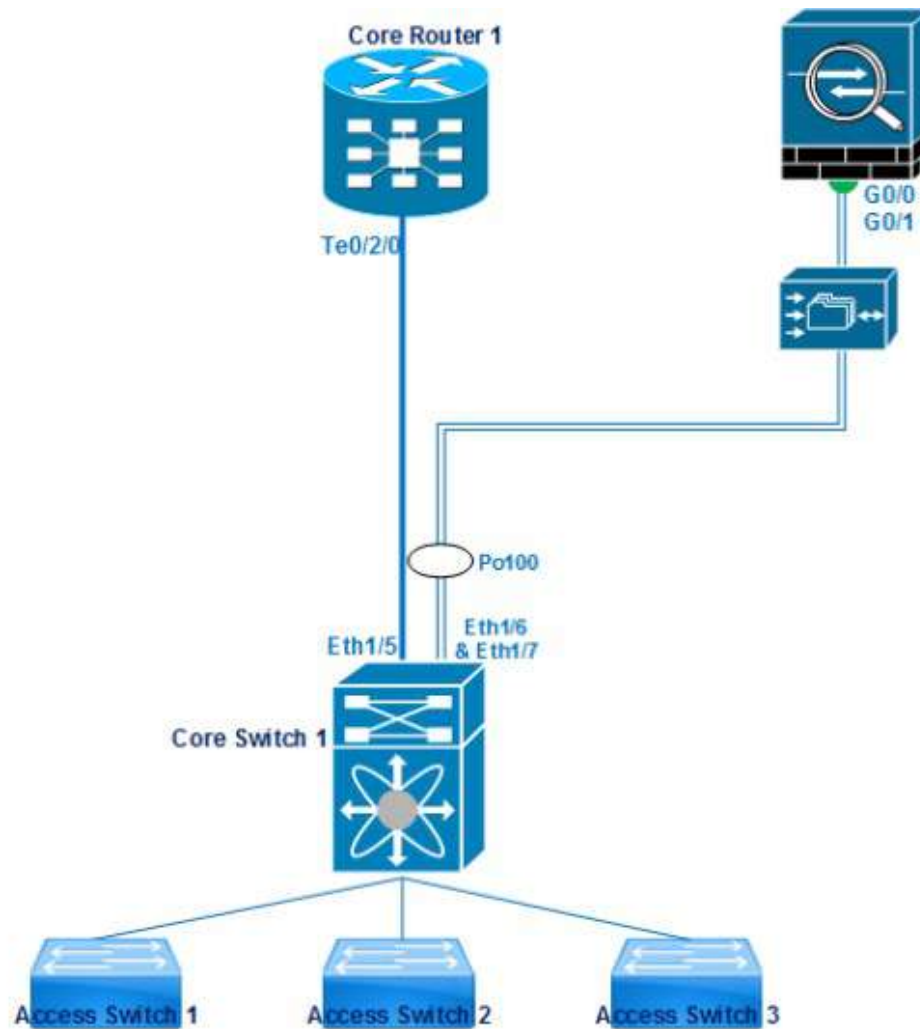
Figure 3-1 Jaipur Datacenter



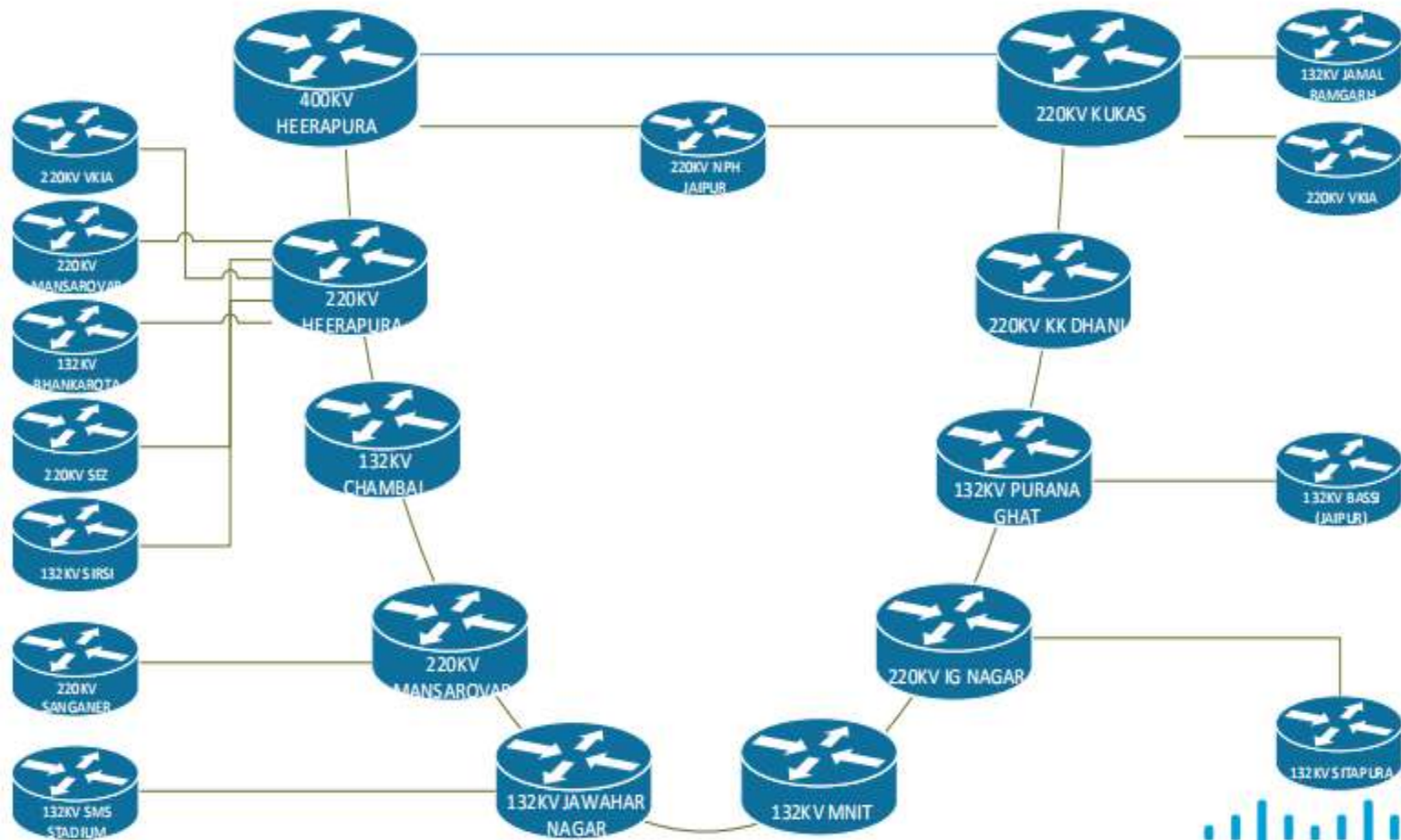
JODHPUR DATA CENTRE ARCHITECTURE



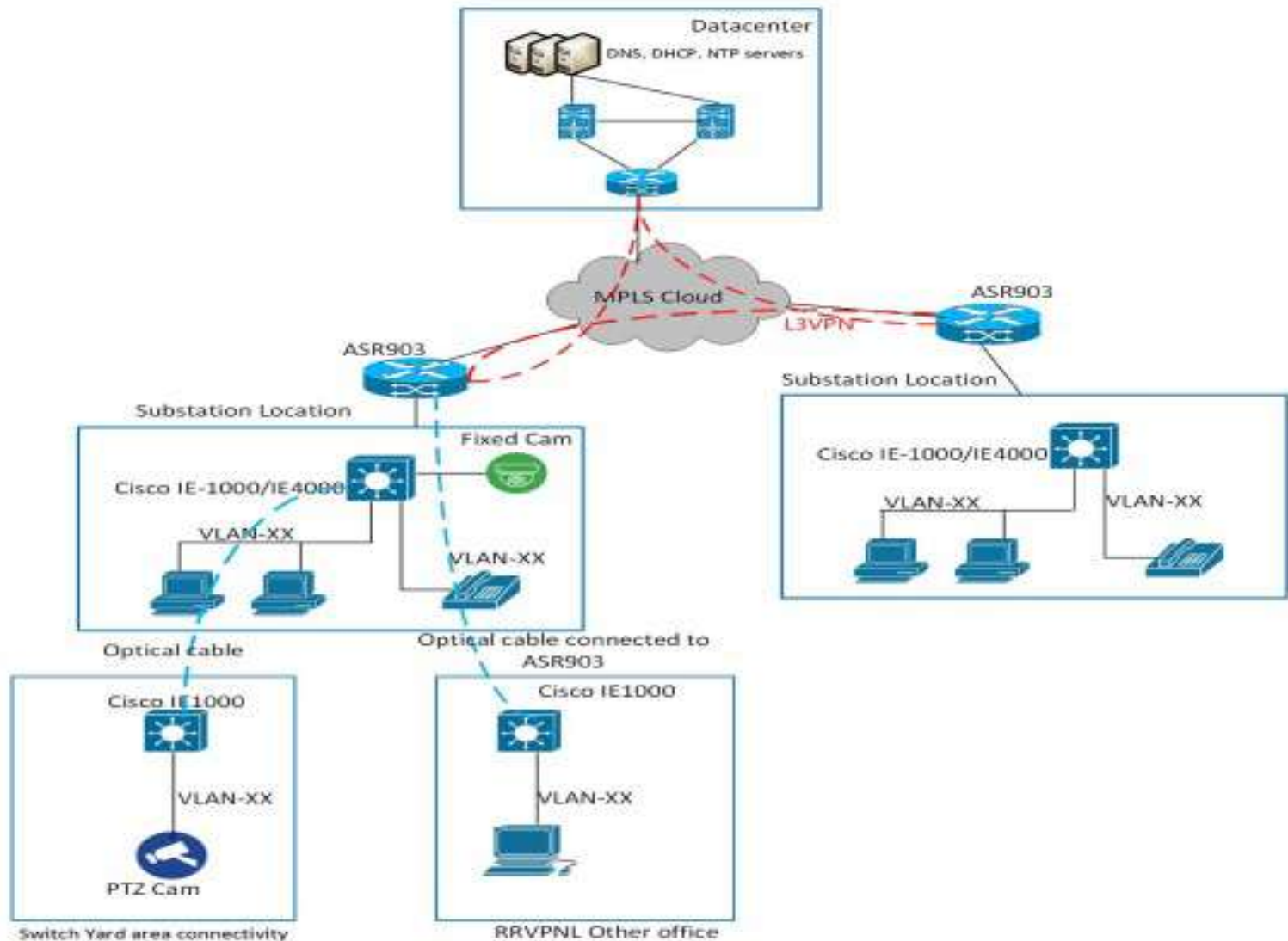
AJMER DATA CENTRE ARCHITECTURE



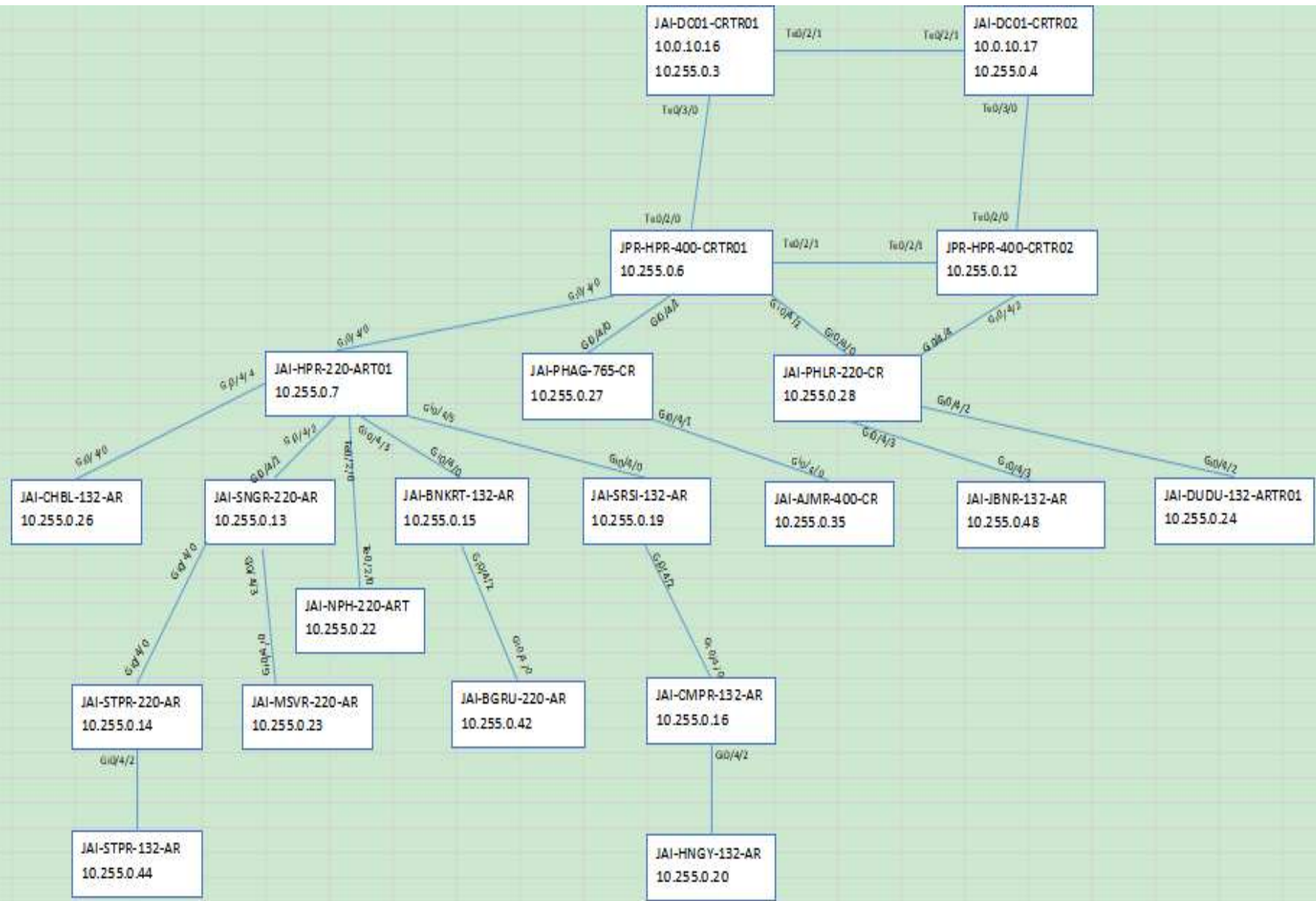
MPLS RING DIAGRAM



RRVPNL IP MPLS network architecture for substation location



MPLS POP CONNECTIVITY



TELE-PROTECTION CONNECTIVITY

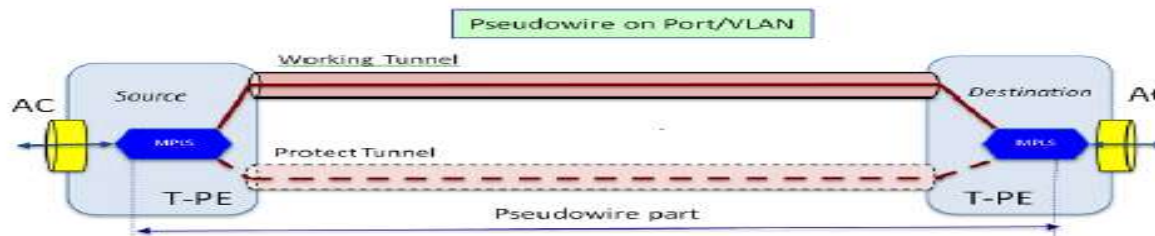
13.2 EoMPLS Terminologies

Pseudowires: Pseudowires(PW) are used to provide end-to-end services across an MPLS network. They are the basic building blocks that can provide a point-to-point service as well as a multipoint service such as VPLS, which is practically a mesh of PWs used to create the bridge domain across which the packets flow.

The end-to-end service is composed of 2 parts. The Attachment Circuit (AC) part and the Pseudowire part. The whole circuit end-to-end is still referred to as Pseudowire in Cisco Transport Controller(CTC), but bear in mind the two part distinction exhibited here for the troubleshooting that follows.

Pseudowire part practically starts and stops at the tunnel end points (if you exclude the MPLS encapsulation block shown here).

Figure 13-3. Pseudowire



Attachment Circuit (AC): The AC carries the customer traffic in its native form, i.e. Ethernet frames with or without VLAN tagging depending on whether we are creating a VLAN based Pseudowire or Ethernet Based Pseudowire (AC Type box in the PW creation wizard). The MPLS labels for the specific PW service as well as for the tunnel over which it is riding are then added. Packets are then sent across the Pseudowire part of the circuit into the MPLS cloud. This process is called Label Imposition in MPLS terminology. On the far end, the reverse process occurs, i.e. the labels are removed or the Label Disposition occurs, and the packets, which are now back to native Ethernet frames, are then delivered to the other end through the far end AC part of the Pseudowire circuit.

13.3 EoMPLS Forwarding

When the ingress PE router receives the Ethernet frame, it strips off the preamble, Start of Frame Delimiter (SFD), and FCS fields, adds a control word, labels the frame, and forwards it across the MPLS network. If the Ethernet frame is tagged with an 802.1Q tag, this tag is kept, too. On the egress PE router, the VC label is stripped off, the control word is removed, the Ethernet FCS is added, and the frame is sent toward the CE router or switch.

13.3.1 VLAN ID Rewrite

VLAN ID Rewrite is the feature whereby the 802.1Q tag might be rewritten in Ethernet VLAN mode if the 802.1Q VLAN ID is different at both sides of the ATM network. You might have VLAN 100 on the ingress PE router and VLAN 200 on the egress PE router, for example. The VLAN ID rewrite happens either on the imposition side or on the disposition side. The VLAN ID Rewrite is an automatically enabled feature, so no configuration is needed to enable it.

13.3.2 EoMPLS carrying one VLAN

In RRVPNL's network, in the scenario of EoMPLS carrying one VLAN, you have an 802.1Q trunk between the CE and the PE routers. Each VLAN is mapped to one pseudowire. The advantage of this scenario compared to non-vlan tagged scenario is that each VLAN has its own pseudowire and can be routed differently through the MPLS network, or the different pseudowires can be between different CE routers.

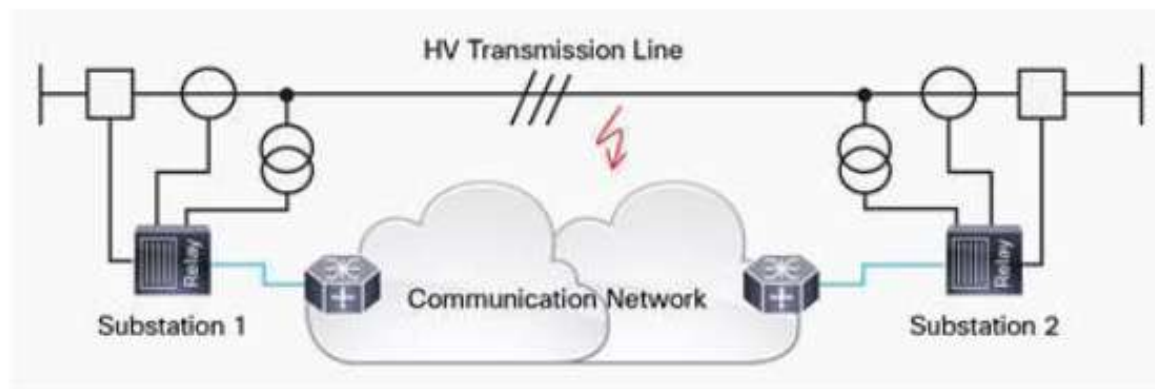
TELE-PROTECTION CONNECTIVITY

14.4 Teleprotection

A secure and uninterrupted supply of electricity is only possible with the help of comprehensive protection and control functions, which ensure the reliable operation of the power system. To prevent the system from failure and damage, the Teleprotection system has to selectively disconnect the faulty part by transferring command signals within the shortest possible time.

Tele-protection schemes employ protection relays that sense anomalies in power line current, phase or voltage, and signal between geographically separate substations to protect grid infrastructure such as transformers and circuit breakers, as depicted in the below Figure.

Figure 14-9: Smart Grid Tele-protection



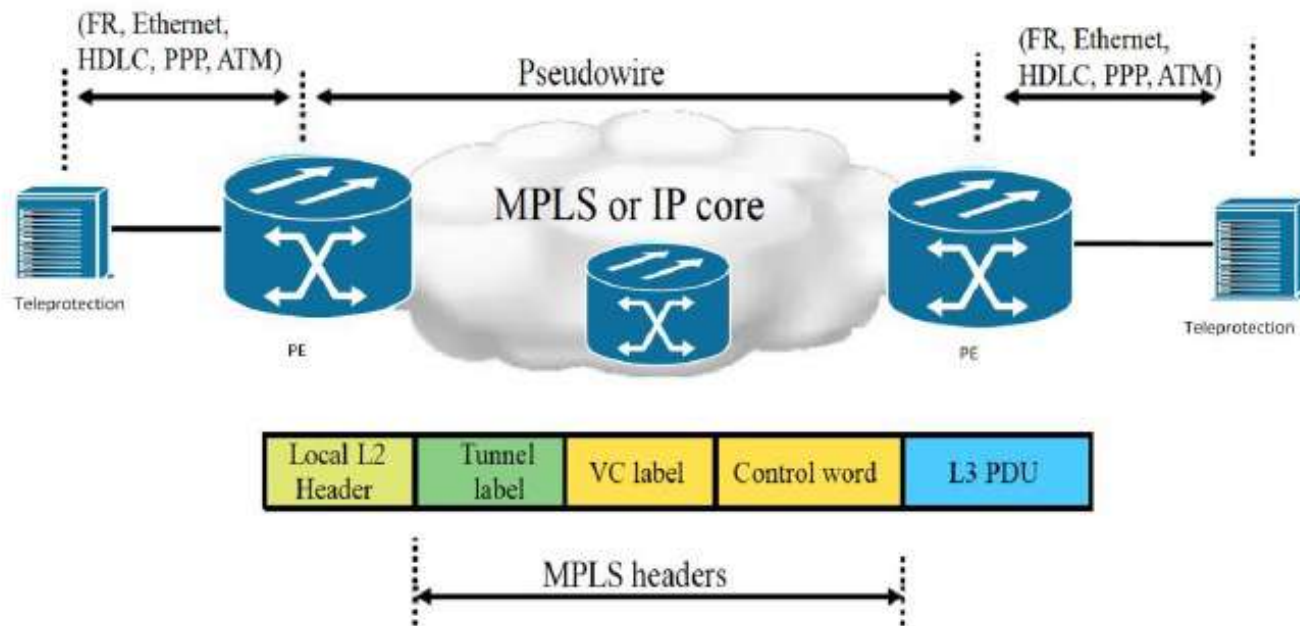
Cisco ASR903 has a interface module that delivers 6 ports of Ear and Mouth (E&M) interfaces. The design emphasizes Smart-Grid and low-latency applications environments. Typical uses cases for this module are Teleprotection and Land Mobile Radio applications. The module supports E&M type I, II, III, and V on 2 or 4 wire modes with selectable 600 or 900 ohm impedances. The physical connectivity

TELE-PROTECTION CONNECTIVITY

on the interface module is using standards based RJ-45 connectors. The E&M signals and voice data can be transported using CESoPSN with and without Channel Attached Signalling (CAS) over MPLS.

Over the IP/MPLS network the Teleprotection data frame will be transported between two Substations with P2P L2VPN. The L2VPN technique we will be using is called EoMPLS as explained L2VPN section. There was a requirement, that if point to point link fails, the L2VPN tunnel should be redirected through alternate path. This will be done by using MPLS targeted LDP sessions. This concept has already been explained in MPLS LDP session protection.

Figure 14-10: L2VPN packet flow



TELE-PROTECTION TEST CASES

16.7 L2VPN config test

Test No:	16.7	Revision:	1.0	Author:	Advanced Services	Date:	
Test Category:	L2VPN			Standard/Optional:	Standard		
Product Chassis ID:	Cisco ASR 903			Product Card ID:	N/A		

Test No:	16.7	Revision:	1.0	Author:	Advanced Services	Date:								
Technology:	MPLS	(Conformance Tests)	Standard:	N/A										
Hostname:														
Elements Managed (NMS Tests):	N/A													
Test Title:	L2VPN													
Test Purpose:	Verify MPLS L2 VPN Config on ASR903													
Test Setup:	Tests will be carried out on fully implemented network topology build out as described in the LLD.													
Procedure:	1. Verify L2VPN and Pseudowire Config show xconnect all													
Checks:														
1. Verify L2VPN configs							Pass: ☒ Fail: ☐							
2. Verify Pseudowire configs.							Pass: ☒ Fail: ☐							
Expected Results:	L2VPN should be configured as per NIP and LLD design.													
mpls ldp neighbor 10.4.32.13 targeted ldp mpls ldp discovery targeted-hello accept JAI-HPR-CRTR01#sh xconnect all Legend: XC ST=Xconnect State S1=Segment1 State S2=Segment2 State UP=Up DN=Down AD=Admin Down IA=Inactive SB=Standby HS=Hot Standby RV=Recovering NH=No Hardware														
XC ST Segment 1 S1 Segment 2 S2 +-----+-----+-----+ UP prl ac CEO/3/0:0(CESoPSN Basic) UP mpls 10.4.32.13:100 UP														
Passed: (Initial)														
Failed: (Initial)														
Reason for Failure:														
Remarks:														

Generally Approved

Generally Approved

TELE-PROTECTION TEST CASES

16.8 L2VPN test

Test Category	Test ID	Applied	Advanced Services	Date
Test Category:	L2VPN		Standard/Optional:	Standard
Product Card ID:	Class ASR 903		Product Card ID:	N/A
Test ID:	MPLS	(Conformance Tests)	Status:	N/A
Storage Manager (NMS tests):		N/A		
Test Case:	L2VPN			
Test Purpose:	Verify MPLS L2 VPN status			
Test Steps:	Tests will be carried out on fully implemented network topology build out as described in the LLD.			
Procedure:	1. Verify L2VPN and Pseudowire status show mpls l2transport vc detail			
Checklist:	FAULT 10.4.32.13: LDP, L2transport vc 100 detail Local interface 10.4.32.13 up, line protocol up, CEsioPSN Basic 0 up Remote interface 10.4.32.13, VC ID: 100, VC status: up Tunnel id 100, proposed label stack (0 20) Port 100 is established Default path cost: Next hop 10.4.32.13 Creation time: 17:11, last status change time: 1d08h Last reset 17:11, change time: 1w2d Signaling protocol LDP, peer 10.4.32.13:0 up Expected local LDP ID (LDP Id) > 10.4.32.13, LDP is UP Generated output configured and enabled Non-stop mode packet configured and not enabled Status P2P support (local remote) : enabled/supported LDP authentication : enabled Label import status mode : established, LruRru Last local link down status rcvd: No fault Last RPD link down status rcvd: Not sent Last RPD link down status rcvd: No fault			

Generaly Approved

TELE-PROTECTION TEST CASES

Test No.	16.8	Revision:	1.0	Author:	Advanced Services	Date:	
Last local AC circuit status sent: No fault Last local PW l/f circ status rcvd: No fault Last local LDP TLV status sent: No fault Last remote LDP TLV status rcvd: No fault Last remote LDP ADJ status rcvd: No fault MPLS VC labels: local 16, remote 20 Group ID: local 39, remote 51 MTU: local 0, remote 0 Remote interface description: Sequencing: receive disabled, send disabled Control Word: On (configured: autosense) SSO Descriptor: 10.4.32.13/100, local label: 16 Dataplane: SSM segment/switch IDs: 8197/4097 (used), PWID: 1 VC statistics: transit packet totals: receive 87397025, send 87397043 transit byte totals: receive 4369851250, send 3670675806							
1. Verify L2VPN configs						Pass: ☒ Fail: ☐	
2. Verify Pseudowire configs						Pass: ☒ Fail: ☐	
Expected Results:	VC(Virtual circuit) status should be "UP"						
Passed: (Initial)							
Failed: (Initial)							
Reason for Failure:							
Remarks:							

LOW LATENCY IN NETWORK

```
Administrator: C:\WINDOWS\system32\cmd.exe
Control-C
^C
C:\Users\administrator>ping 10.255.1.95 -t

Pinging 10.255.1.95 with 32 bytes of data:
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=15ms TTL=249
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=37ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=17ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249

Ping statistics for 10.255.1.95:
    Packets: Sent = 21, Received = 21, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 13ms, Maximum = 37ms, Average = 15ms
Control-C
^C
C:\Users\administrator>_
```

Contd..

LOW LATENCY IN NETWORK

```
Administrator: C:\WINDOWS\system32\cmd.exe
    Minimum = 13ms, Maximum = 37ms, Average = 15ms
Control-C
^C
C:\Users\administrator>ping 10.255.0.7 -t

Pinging 10.255.0.7 with 32 bytes of data:
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=50ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=4ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251

Ping statistics for 10.255.0.7:
    Packets: Sent = 20, Received = 20, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 2ms, Maximum = 50ms, Average = 4ms
Control-C
^C
C:\Users\administrator>
```

JAIPUR DATA CENTRE CONTROL ROOM VIEW



JAIPUR DATA CENTRE EQUIPMENT ROOM VIEW



JAIPUR DATA CENTRE EQUIPMENT ROOM VIEW



JODHPUR DATA CENTRE VIEW

Jodhpur DC
All Zone Wise



AJMER DATA CENTRE VIEW



PTZ CAMERA VIEW-1



PTZ CAMERA VIEW-2



GSS LOCATION CONTROL ROOM FIXED CAMERA VIEW



THANK YOU





TANTRANSCO PRESENTATION OF ITS IMPLEMENTATION OF ITS MPLS-TP BASED OT COMMUNICATION SYSTEM

5th MPLSJC Meeting at Gurugram
Dt : 11-03-2024



Introduction:

* TANTRANSCO has a vast network of grid substations ranging from 110KV , 230KV , 400KV, 765KV quantifying to 200+ nodes of communication equipments.

* Comprises 100+ SDH, PDH and recently 40+ Hybrid and 10+ MPLS-TP FOTE equipments apart from Legacy PLCC equipments for voice,Data and tele-protection applications.

SDH	ABB /HITACHI/TEJAS/COMTEL
HYBRID	ABB /HITACHI (FOX615)
MPLS-TP	ABB/HITACHI (FOX 605)



Adoption of modern tech:

- * Adoption of modern technology is to be exercised with caution and at the same time seamless migration to modern technologies avoiding major risks in migration process.
- * Security, reliability, maintainability of communication network is of importance.
- * Hence the adoption of MPLS-TP technology is by gradual basis by deploying hybrid equipments that support concurrent communications over MPL-TP and SDH network.
- * MPLS-TP is more characteristic of the Transmission utility applications in terms of network design, deterministic communication, N/W management etc.



TANTRANSCO- Key Reasons for Adoption of MPLS-TP

Aspects/ Criteria	SDH	Modern technology (MPLS-TP)
Technology	Obseleteness	Investment protection necessitates to adopt modern technology instead of obsolete technology. At the same time suitable for power utility application.
Bandwidth Efficiency	Not optimised as TDM based	Optimised as packet based
Product and service support	Waning availability of vendors.	Growing availability of vendors.
Inventory	Inventory of hardware is high leading to higher cost of inventory due to various types of legacy interfaces for voice, tele-protection, Data applications.	Inventory of hardware is optimised since most of applications are migrating to ethernet based interface Tele-protection : External / Builtin are ethernet based Data : Ethernet based protocols such as 104, C37.94 etc., Voice comm.: VoIP is ethernet based CCTV : Video (Future) PoE+ based
Other features	-	QoS, Priority tagging of traffic data etc. Retains SDH flavour suited for power utilities in respect of Deterministic time for Tele-prot, User defined network path definition BFD prot switching < 50ms etc.

TANTRANSCO - MIGRATION FROM SDH NETWORK TO MPLS-TP NETWORK USING HYBRID NODES & STANDALONE MPLS-TP NODES

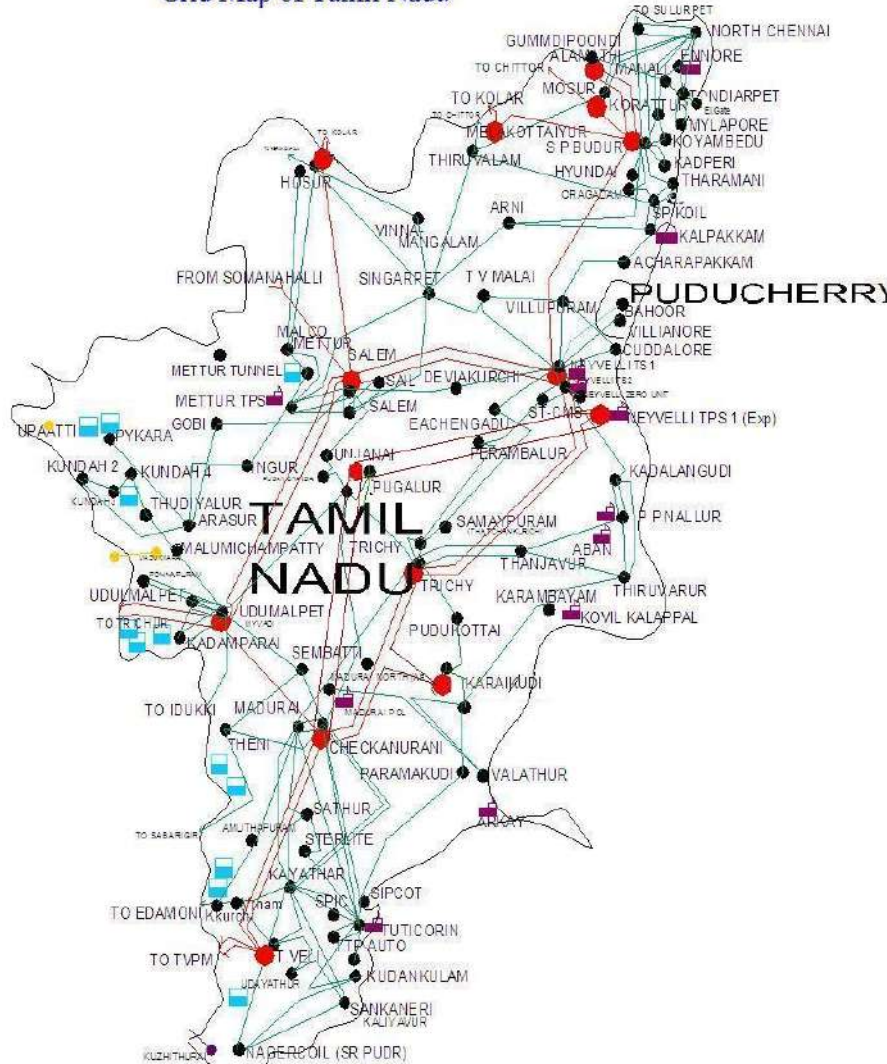


Tantransco, India

Hybrid FOTE solution is implemented in our mission critical communication network migrating the legacy Time-Division Multiplexing (TDM) method of transferring signals like Ethernet (IEC 60870-5-104), RTU/SAS on Serial V.24/V.28, Distance & Differential Protection & to a packet-switched (MPLS-TP) technology at Tamil Nadu Transmission Corporation.



Grid Map of Tamil Nadu



The Project – 400 Kv Ottapidaram

- Migration of TDM based legacy application for OT network with Hybrid FOTE over 230 KV above and MPLS-TP for 110 KV S/S
- Converge multiple applications, Data (IEC 60870-5-104 & 101) Differential & Distance Teleprotection on the same infrastructure
- Simplify management of legacy and packet networks

Proposed solution

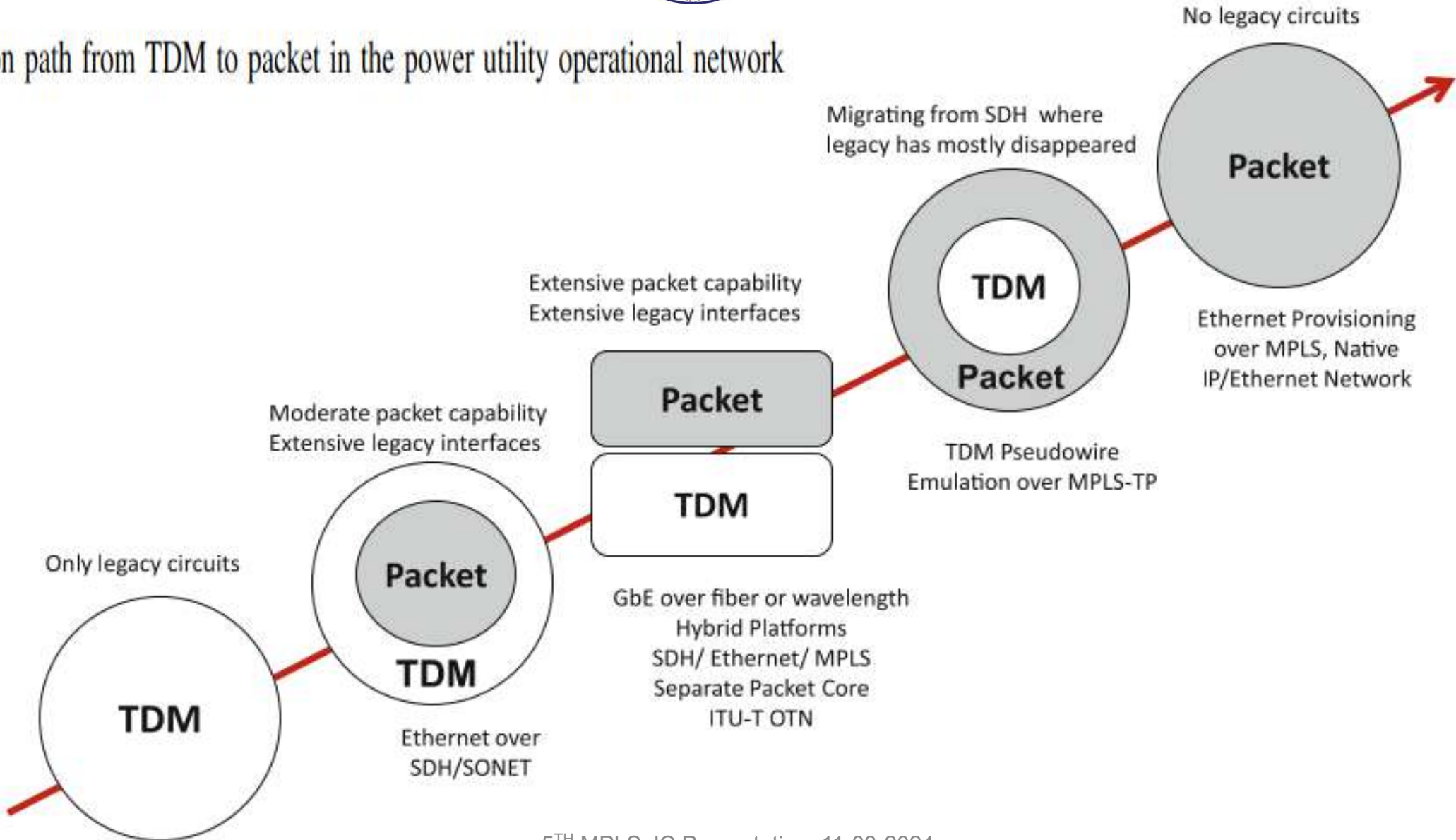
- FOX615 Hybrid Multiservice platform Transport: 1G/10GbE Hybrid & MPLS-TP- capable
- Ethernet IEC 60870-5-104 & IEC 60870-5-101 data.
- Differential & Distance Teleprotection for intertripping application

Benefits

- Increased efficiency with a single packet-switched OT network
- Single NMS for overall network with all application including teleprotection.
- Ensured high availability during a complex migration



Migration path from TDM to packet in the power utility operational network





TANTRANSKO : Product Details for Hybrid Equipments

Hybrid Equipment : (Typical Configuration details)

HITACHI (Formerly ABB) FOX 615 with cross connect multiplexer, dual power supply cards & control cards, 4 port circuit emulation card to support min. 16 E1s, tributary cards & other hardware accessories including subracks, patch cords,DDFetc.,

For SDH Interface:

(i) 4 port STM1/4/16 I/F card- 2nos. (with min.2 STM1/4 & 2 STM4/16 per card)

For MPLS-TP Interface:

- (ii) 4 port x 1G MPLS-TP opt. I/F card-1 no.
- (iii) 4 port x10G MPLS-TP opt.I/F card-1no.

Legacy interfaces:

- (iv) 2/4W, 8 channel E&M card - 1no.
- (v) 8 channel FXO card - 1no.
- (vi) 8 channel FXS card - 1 no.
- (vii) 4 port serial data I/F card -1 no. (V.11,V.24,V.35 etc.,)
- (viii) 8 ch. E1(framed/unframed)card- 2nos.
- (ix) 4 ch. Diff. protn interface card-(C37.94 compatible) (Where ever required)

Ethernet ports:

- 8 port 10/100/1000 Mbps ethernet I/F card with L2 switching capacity- 1no.



TANTRANSCO : Product Details for MPLS-TP Equipments

MPLS-TP Equipment :

HITACHI (Formerly ABB) FOX 605 with redundant supply cards, all cabling, circuit emulation card & other hardware accessories including subracks, patch cords, DDF etc.

- (i) 4 port GE electrical ethernet card (POE/ PoE+ capable) 1 Gb capacity/port- 1 no.
- (ii) 4 port optical SFP interface card ,each port supporting E/FE/GE/STM1 - 1 no.
- (iii) 4 ports interface card for E1 framed/ unframed channels -1no.
- (iv) 4 port interface card for V.11, V.24, RS 485/ RS 232 etc.,) - 1no.

NMS: HITACHI (Formerly ABB) FOX MAN

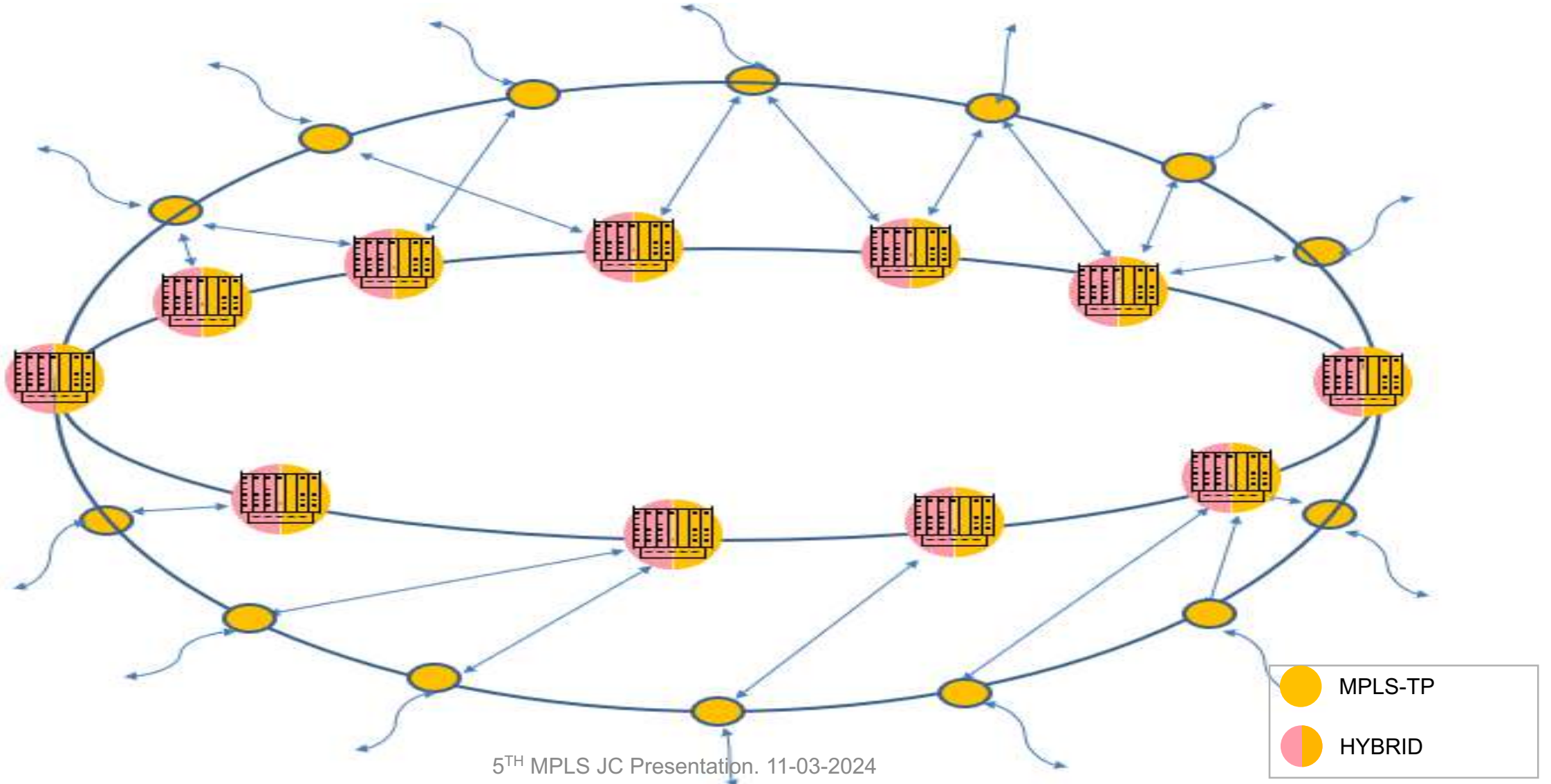
NMS main servers at Chennai LDC,

Client machines at Madurai Backup LDC and at Erode Sub-LDC

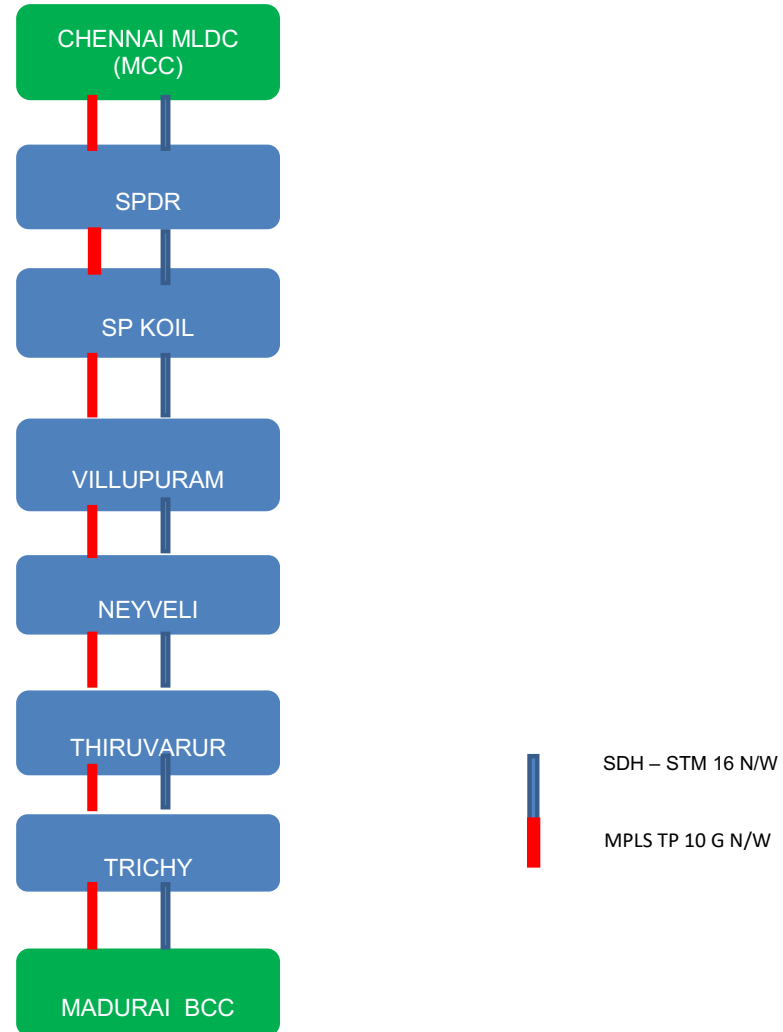
Visualized Archiecture



MPLS_TP Main Ring via Hybrid Nodes & Protection Ring via Standalone MPLS_TP Nodes



TANTRANSCO- BACKBONE NETWORK FORMATION USING MPLS-TP AND SDH LINKS

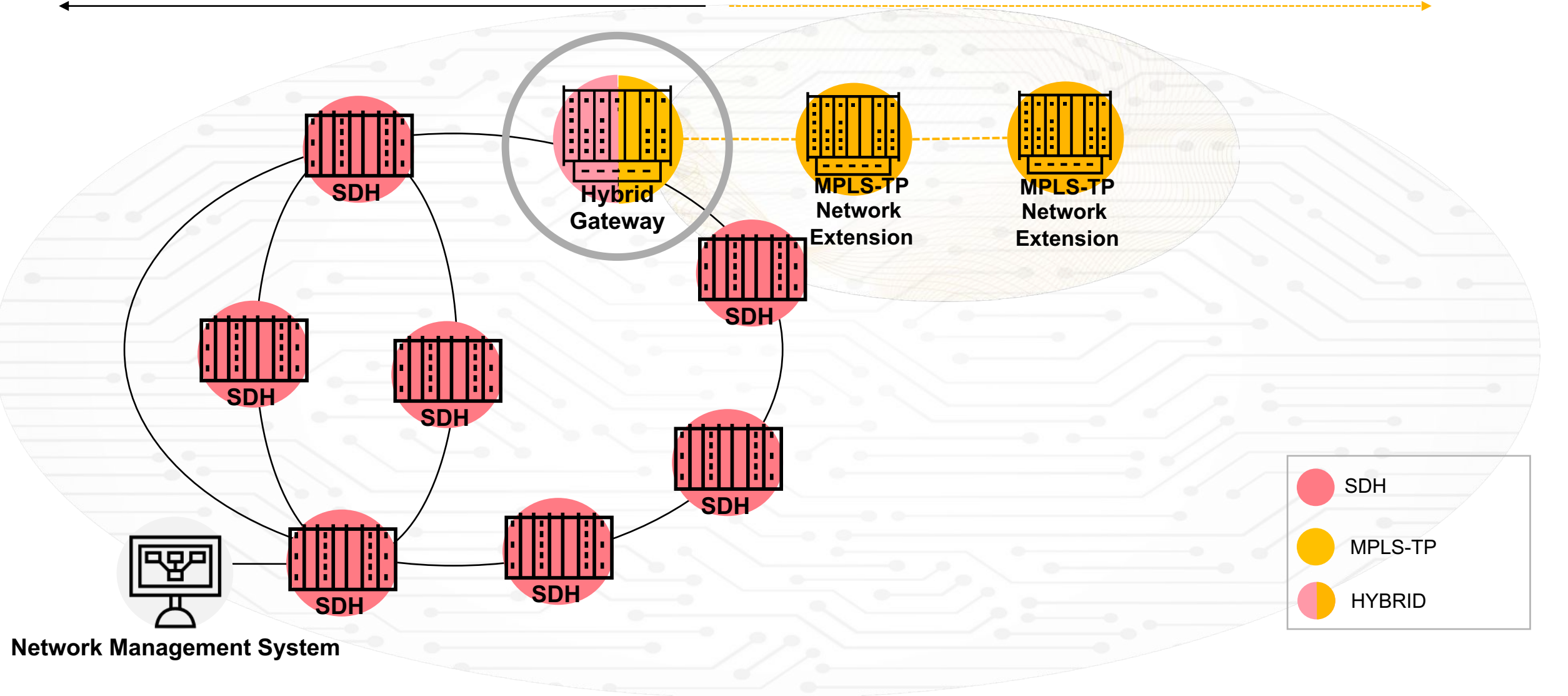




Present Case: MPLS-TP extension via Hybrid gateway node

EXISTING SDH NETWORK

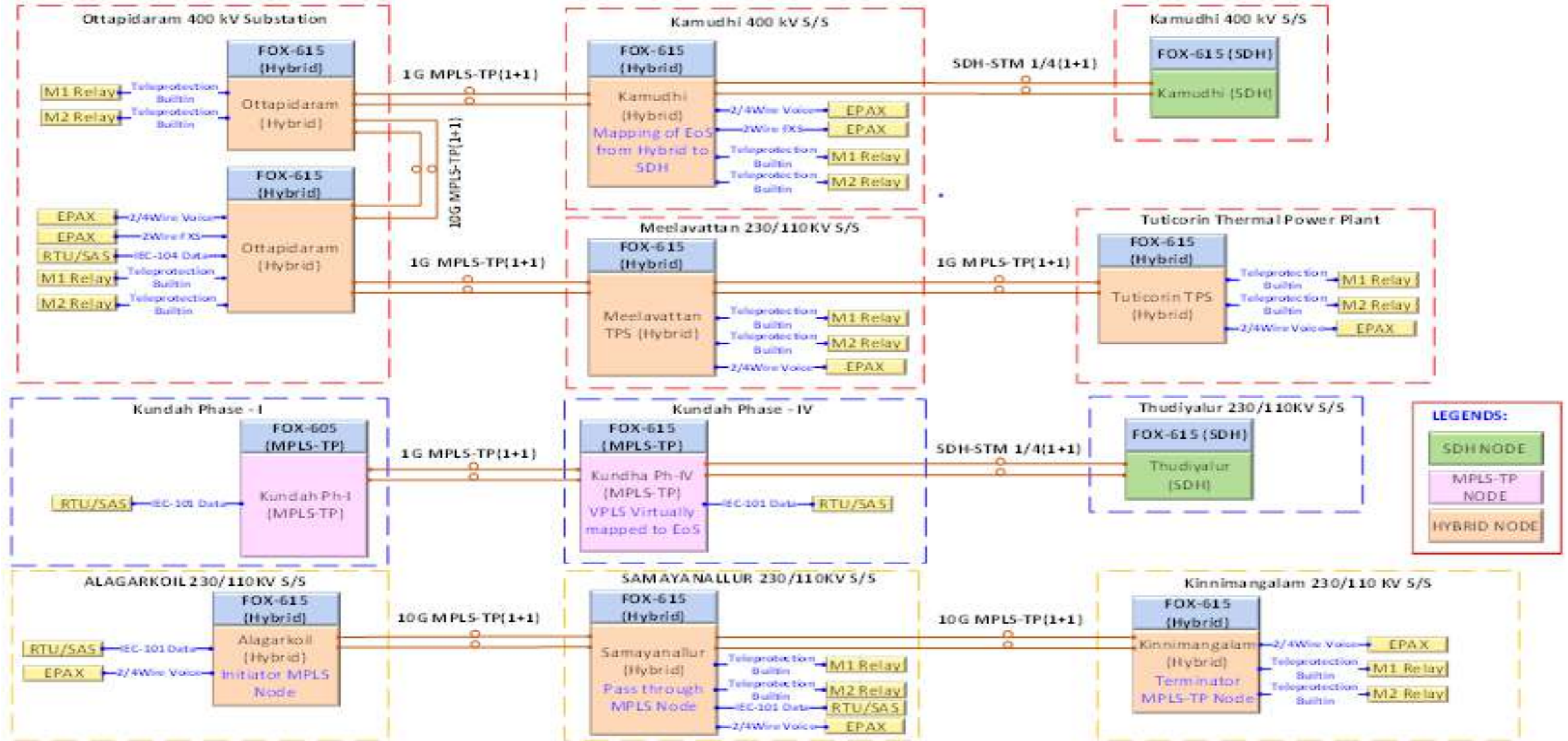
MPLS-TP



Network Management System

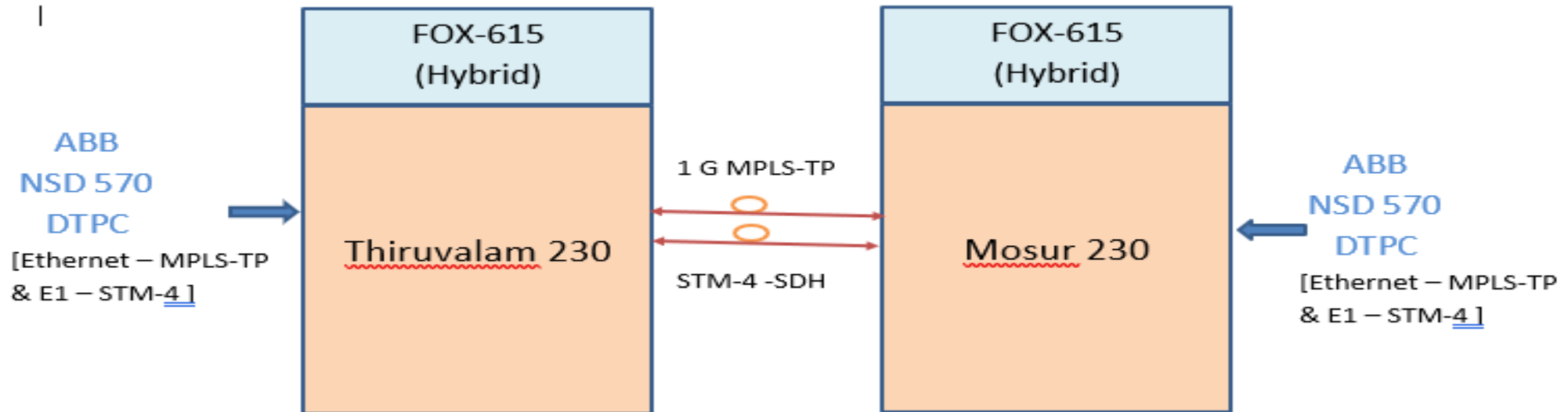


Implementation of Distance Teleprotection Scheme & RTU/SAS Data Communication via MPLS TP of Hybrid Nodes





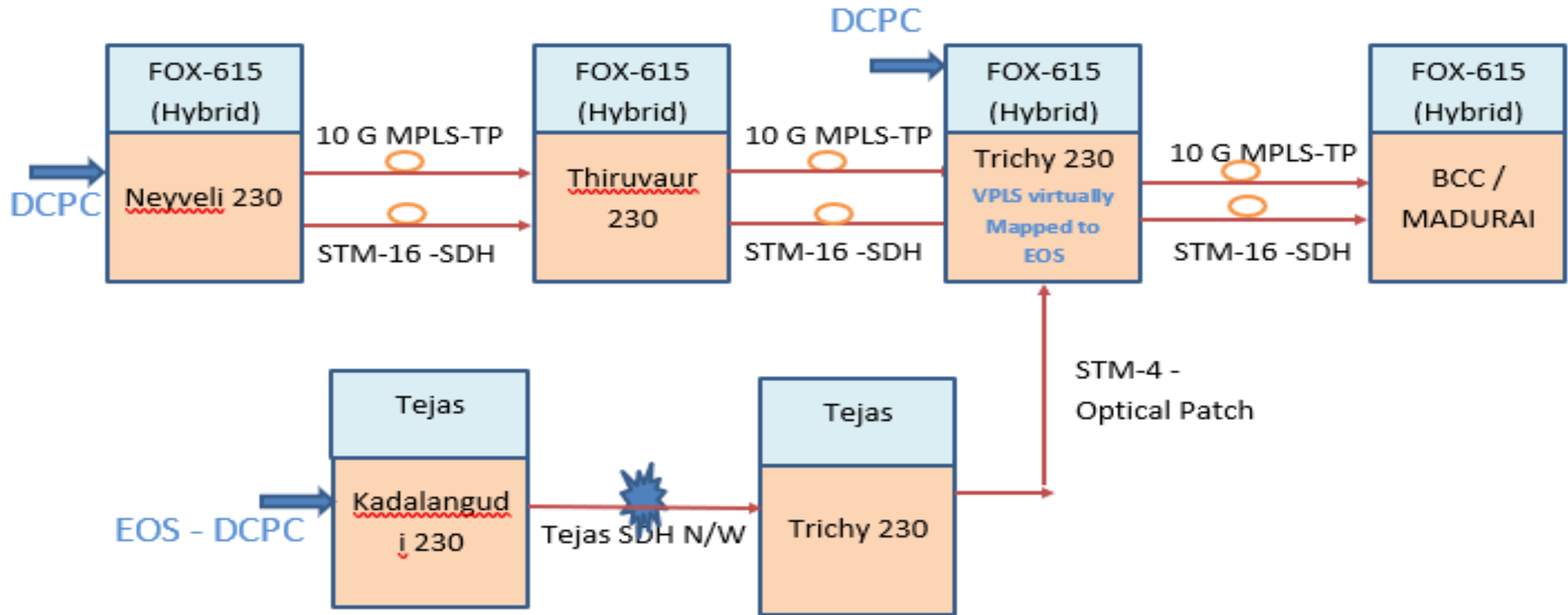
Implementation of Distance Protection Scheme via Standalone DTPC interfaced in Hybrid Node with MPLS_TP Main Channel & SDH Redundant Channel



E1 Channel Loop Test Time is 5.9 ms
Ethernet Channel Loop Test Time is 3.1 ms

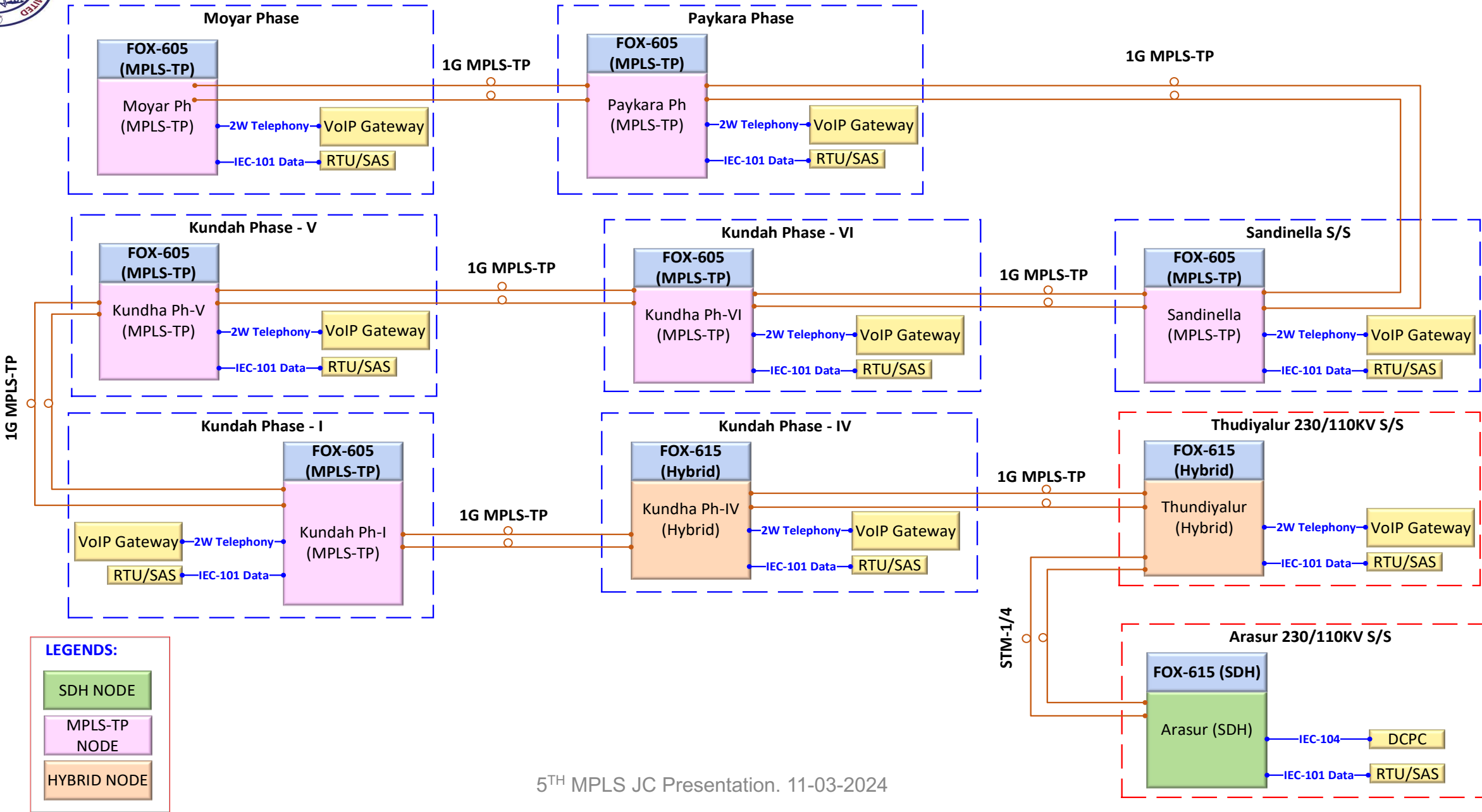


Integrability of Hybrid Node with other SDH Equipment



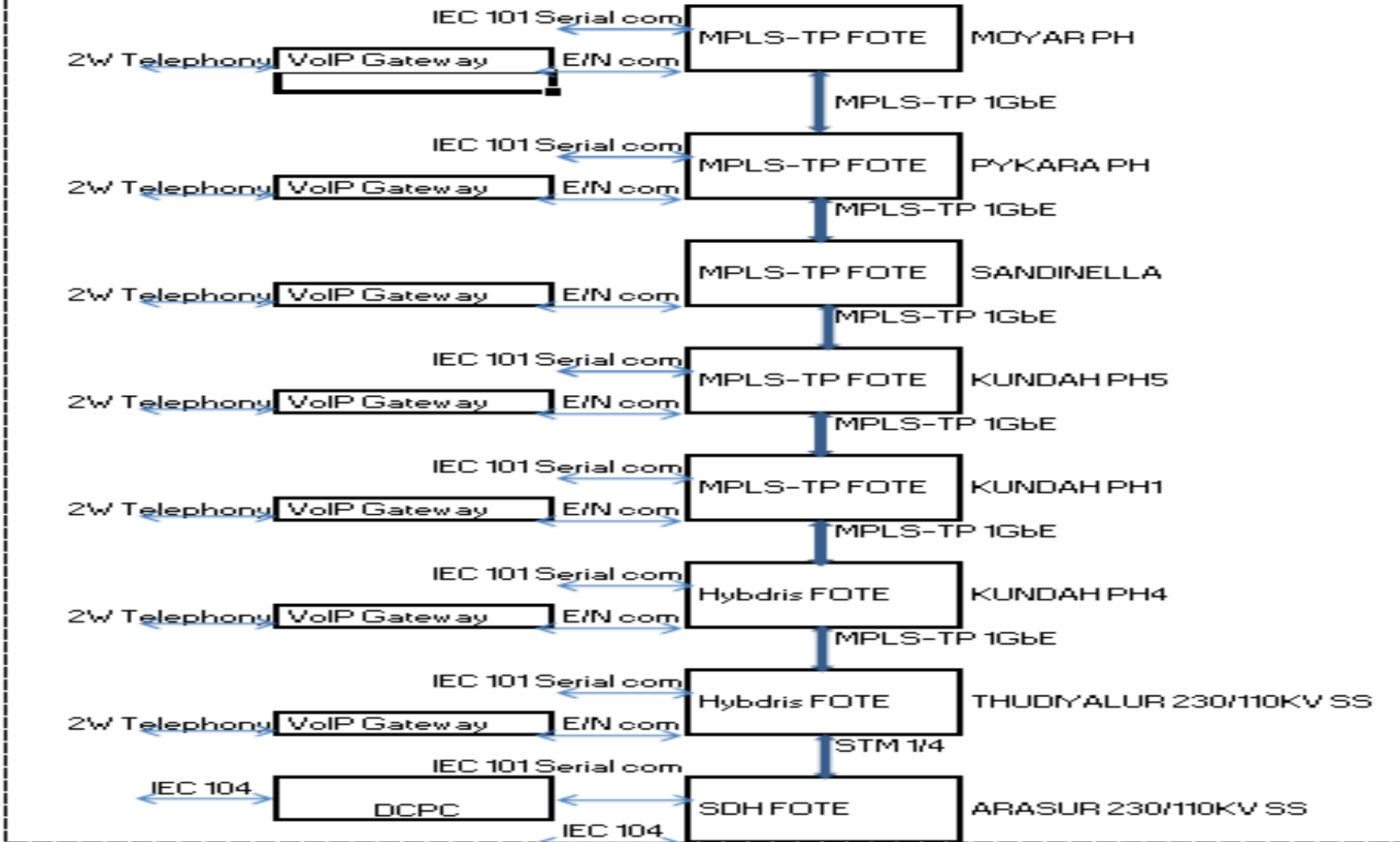


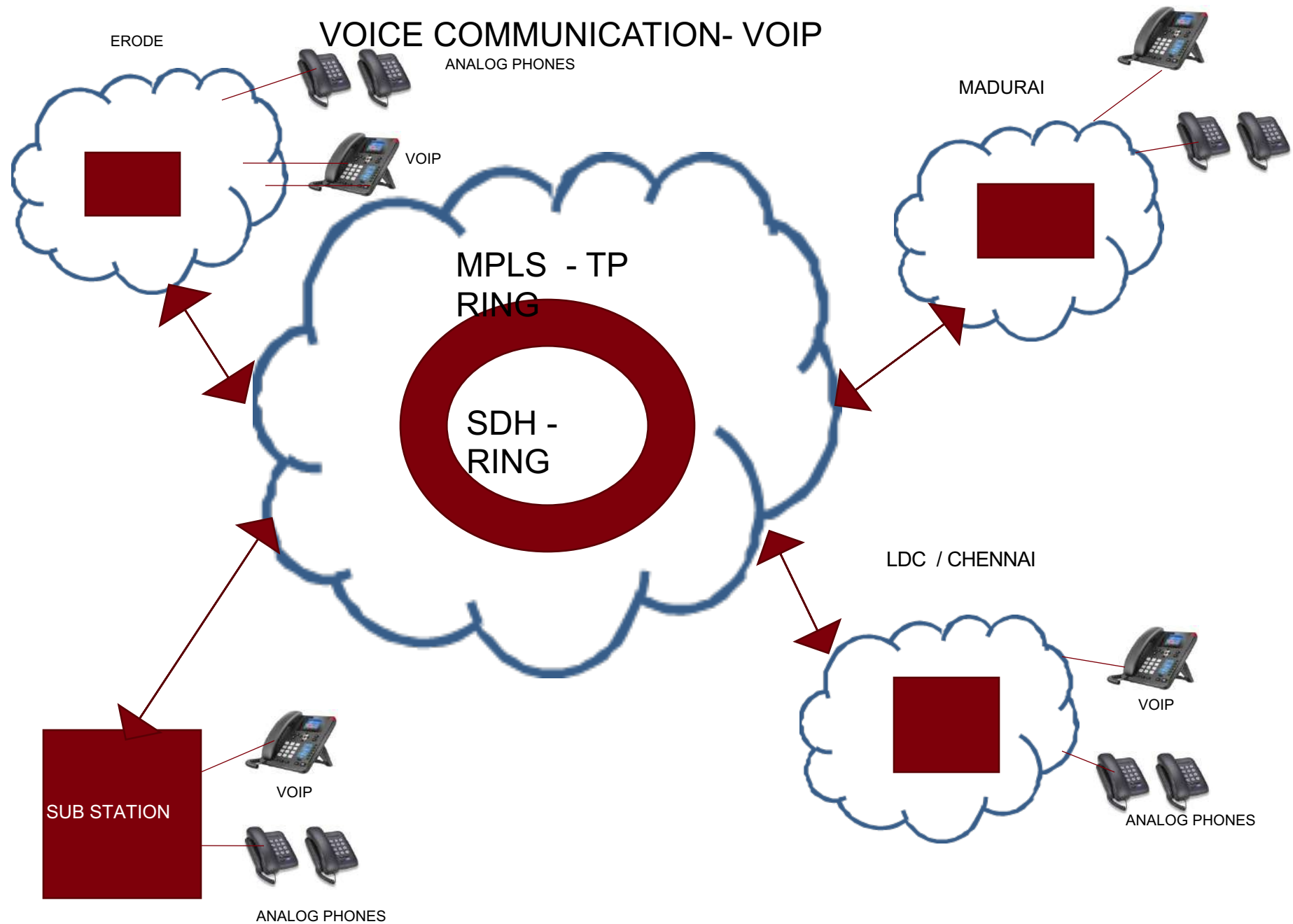
VOICE Communication based on VOIP between
MPLS-TP connected stations





VOICE Communication based on VOIP between MPLS-TP connected stations







Thank you



TANTRANS CO. : EMERGING TRENDS –TECH SPEC -MPLS-TP Equipments

Power utility Applications	MPLS-TP interface
Network management	Ethernet based interface
Tele-protection interface	Ethernet based interface between DTPC and FOTE
Voice communication Interface	Ethernet interface based VoIP supports: - VoIP phone - VoIP gateway for analog phone interface
Data communication:	Ethernet interface based SCADA : IEC 104 protocol PMU Data : IEEE C37.94 Protocols TWFL : Ethernet based exchange of fault data DR & RAS : Ethernet based DR acquisition and File transfer
CCTV System	PoE+ based interface

Significance: The ethernet based power utility applications interface facilitates MPL-TP suitable interface without the need of legacy interfaces / circuit emulation hardware.

E/N based interface facilitates scope for interoperability with other make MPLS-TP subject to POC verification.



TANTRANSCO : EMERGING TRENDS –TECH SPEC –Grid substations

	Hybrid Equipment	MPLS-TP Equipment
Redundancy:	CPU Modules Link : 1G/10G MPLS-TP i/f & STM-4/16 i/f SFP module for 1+1 redundancy Power supply sources nxE1 ports Module and E/N port for Tele-prot signalling	CPU Modules Link : 1G/10G MPLS-TP i/f modules SFP module for 1+1 redundancy Power supply sources Or Device complete replication.
Tele-protection	Main-1 ch through E1-SDH Main-2 ch through E/N MPLS-TP	Main-1,Main-2 ch through E/N MPLS-TP
Voice	Legacy 2W/4W FXS,FXO,E&M interface – SDH/ MPLS-TP. VoIP- MPLS-TP	VoIP- MPLS-TP Including hotline applications.
Data	E/N based protocols – EoS over SDH, E/N – MPLS-TP	E/N based protocols – MPLS-TP
Line diff Prot comm.	E1/C37.94 over SDH C37.94/ E/N - MPLS-TP	C37.94 Ckt emulation module –MPLS-TP
Cyber security	Encryption to support standard algorithm like AES 256	

PI.Note: Hardware to be specified for redundancy and for provision for future expansion, cross connect capacity.



Thank you

Report of Field Visit at RRVPNL Sites by MPLS-JC Team

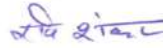
**Jaipur
17.05.2024**

Acknowledgement

The Joint Committee acknowledges the cooperation extended by CEA, NRPC, CTU, POWERGRID, GRID-India, RRVPNL during the field Visit at RRVPNL Site.



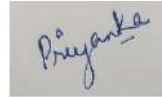
Satyendra Kumar Dotan
Director NPC



Ravi Shankar Singh
Dy. Director NPC



Sushil Kr Suman,
Assistant Director NPC(R&D)



Priyanka Patel
Manager NRPC



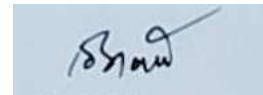
T P Verma
DGM CTUIL



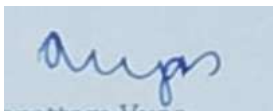
Gaurav Awal
Chief Manager POWERGRID



Paritosh Pathak
Manager NRLDC/GRID-India



V.A Kale
SE RRVPNL



Narottam Vyas
SE Automation RRVPNL

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1. **Background**

5th Meeting of MPLS Joint Committee was held on 11.03.2024 at CTU office, Gurugram. The relevant points of minutes of aforementioned meeting is quoted below:

Quote

- 5(i) *Experience of RRVPNL on interoperability of MPLS-TP, MPLS-IP and SDH to be shared. Field visits to be undertaken by a team of JC members.*
- 5(ii) *PoC to be conducted for different makes of MPLS-TP and MPLS-IP equipment on TANTRANSCO/RRVPNL network within one (1) month to assess/confirm that both the technologies are suitable for functional requirements of power system with respect to data, voice and tele protection.*

Unquote

It was suggested that these visits will help the members of JC for better understanding of MPLS system and interoperability of MPLS-TP, MPLS-IP and SDH.

2. **Purpose of the Visit**

During the 5th Meeting of MPLS Joint Committee, it was requested to RRVPNL to share the experience of their MPLS-IP system and their experience on interoperability of MPLS-TP, MPLS-IP and SDH. RRVPNL agreed for the same. Therefore, a team was constituted from the MPLS JC members/their nominated members to field visit at RRVPNL system for experiencing the MPLS system of RRVPNL. List of members for the RRVPNL visit is attached at **Annexure-I**.

3. **Location of Visit**

Team visited the 400 kV Heerapura substation and witnessed the RVPNL IP/MPLS system at that substation and STNAMS (Smart Transmission Network and Asset Management System) control centre (Heerapura) along with functioning of SCADA/ PMU data over MPLS. Moreover, tele-protection (distance) function was also witnessed during the visit. RVPNL demonstrated features of their STNAMS system under which they have implemented MPLS-IP based communication among 3 control centres and 535 stations. The Power Map of RRVPNL is attached at **Annexure-II**.

4. **Brief Summary of RVPNL STNAMS System:**

a. **PROJECT PROFILE & BACKGROUND INFORMATION**

The RVPN is responsible for efficient, stable and safe operation of the transmission grid in the state. It is mandated to maintain the transmission system availability, Voltage Profile, Frequency profile and other parameters within the limits as prescribed by the Rajasthan Electricity Regulatory Commission (Transmission Licensee's Standards of Performance) Regulations, 2004 and its subsequent amendments. RVPN is also required to comply with Rajasthan Electricity Regulatory Commission (Rajasthan Electricity Grid Code) Regulations 2008 and other relevant regulations and operational codes as prescribed time to time by relevant organisations. With the modern complex smart grids, issues related to Wide Area Monitoring and Control, Integration of renewable energy, Open Access, Congestion management, Asset Management etc. have become predominant which requires system handling on real time basis with visualization, monitoring and data analytic capabilities for faster control and operations.

The project for the Smart Transmission Network and Asset Management System (STNAMS) was got approved in the 247th BOD RVPN meeting held on 16.08.2016 and also got 50% funding from Power System Development Fund (PSDF).

The project consists of following packages:

1.	Package-A	SCADA/EMS System that includes field infrastructure (RTUs, DCUs, PMUs Interfacing/ adaption work at substations) and Main, Back-Up and Regional Control Centres (Servers, Firewall, Printers, Ethernet & associated software's)
2.	Package-B	Information and Communication Technology Infrastructure which includes the data centre (NMS, UCS, VMS, Cyber Security), routers, switches etc.
3.	Package-C	OPGW network which includes OPGW and its associated hardware accessories, approach cable and Fiber Optic Distribution panel.

b. **Broad Objectives of scheme:**

- Visualization and situational awareness of Transmission Grid.
- System for real time monitoring and control of substations and grid.
- Decision support system for maintaining voltage profile and reactive power management.
- Wide area monitoring and protection.
- Accuracy of data for planning studies, forecasting and implementing of required analytics for decision making.
- Grid security and stability management.
- Remote operation of substations.
- Reliable communication backbone.

- c. **Communication backbone package- services/ facilities implemented:** Under above scheme total 14320 Km OPGW cable installed on RVPN transmission line along with

establishment of 3 Nos. Command and Control Centre and installation and commissioning of terminal equipment at 552 Nos. locations.

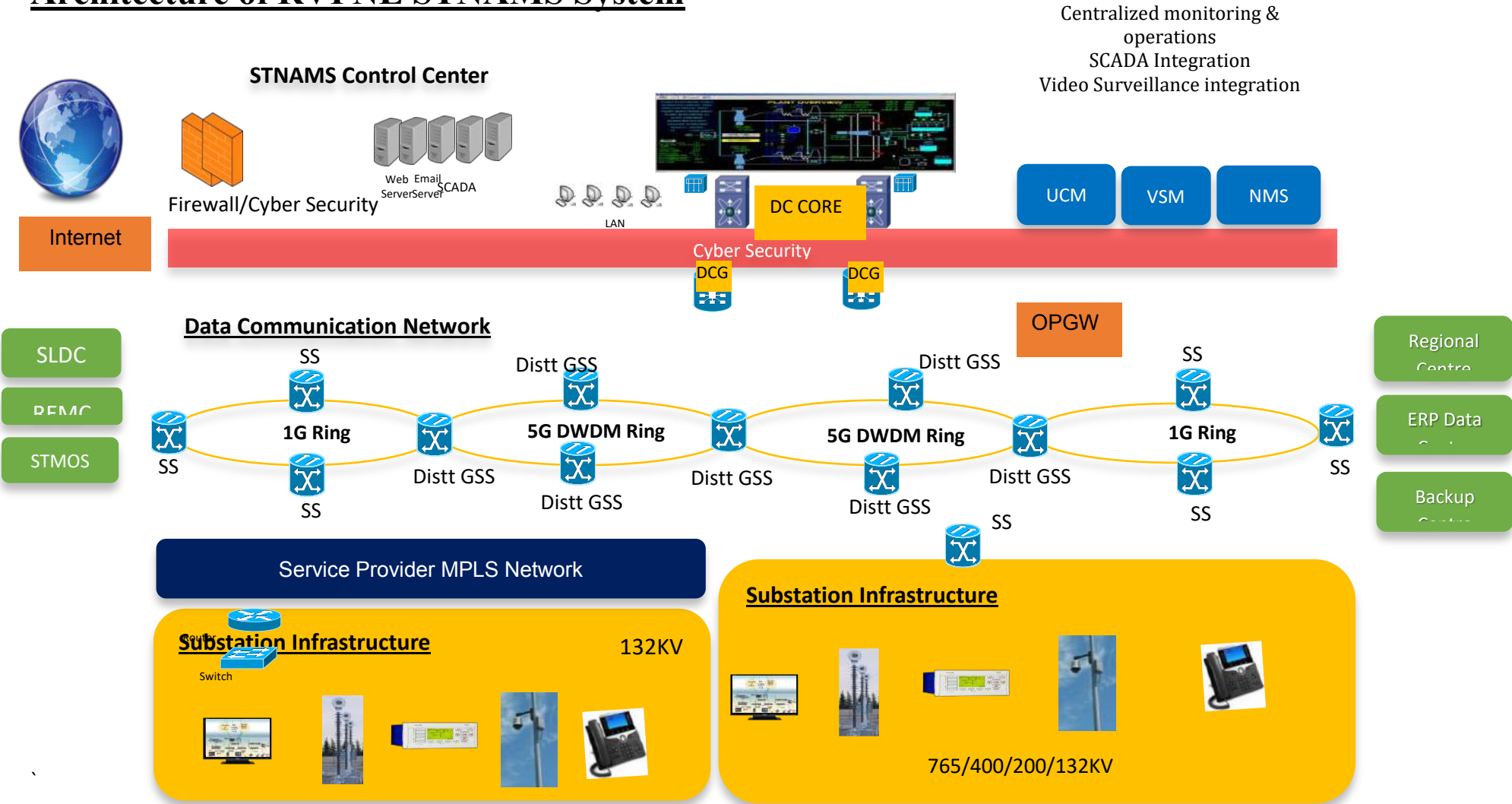
- Monitoring: Internet Protocol Camera installed on 220 kV & 400 kV Substations are operational and Live feed visible at Control Center.
- Network Management System: NMS Implemented and devices and control centers and substations are monitored through it.
- Cyber- Security Layer: It is implemented at Command-and-Control center and web access/ exchange is being done through Cyber Security Layer
- Unified Call Manager (UCM): VOIP Telephony established between substations through Voice & Video IP Phones
- RVPN- IP/MPLS Network and Internet Utilization: Vidyut Bhawan/ Other offices and substations as approved are connected on LAN and using internet bandwidth (500 Mbps available at Main Command and Control Centre).
- Tele-protection Connectivity: The connectivity tested and to be extended as per requirement for carrier communication.
- Video Wall and Physical Infrastructure: The video wall and physical infrastructure as per requirement.

d. **Real Time Data Acquisition System- services/ facilities implemented:** Total No. of substations covered is 535 Nos.

- SCADA/EMS: Installations made at Control Center, presently showing data for 389 Nos. of substations.
- Remote Operation: Remote operation for command output connected for 389 Nos. of substation are tested successfully.
- Geographic Mapping/ Line network: Under Integration- Available transmission line co-ordinates provided.
- DCU/ RAS system: Numerical Relays at 378 Nos. of substations connected to control center and data accessible at Control Center.
- AFAS System: Data accessible for the connected substation and analysis is being carried out by system for generating various reports.
- WAMS: 14/ 25 PMUs integrated & operational. Remaining integration work is in progress.
- Report Module (Web and Mobile App): Dashboard and Mobile App developed, email enabled and tested.
- ADMS (Advanced Demand Side Management): Software functionality implemented but to be made operational based on the logic developed for load shedding and integration of those substations and completion of cyber security audit.
- Asset Management: Module Developed and made operational for 20 s/s.

5. Architecture of RVPNL STNAMS System and MPLS Network of RRVPN:

Architecture of RVPNL STNAMS System



6. Testing of Tele-Protection (Distance):

Details of transmission line for demonstration of tele-protection on MPLS-IP:

a) Line: **220kV Heerapura – SEZ line**

b) Line Length: **17.5 Km**

c) Details of Relays under test:

220kV Heerapura end	220kV SEZ end
MiCOM P-442 (M1)	MiCOM P-442 (M1)
SIEMENS SIPROTEC 7SA52 (M2)	MiCOM P-442 (M2)

d) Tele-protection time (Round Trip): **3 msec.**

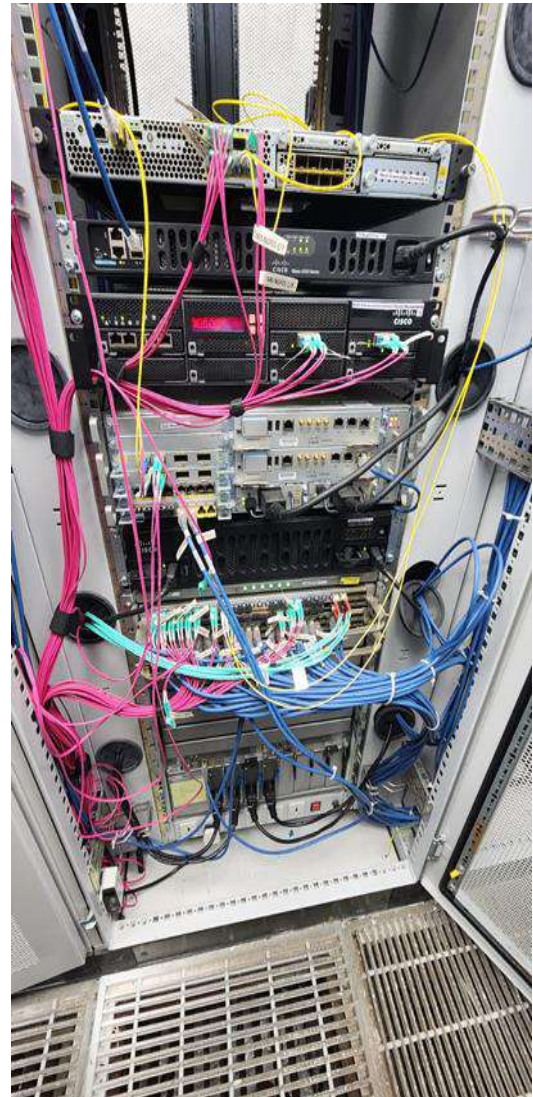
e) Equipment make/ model:

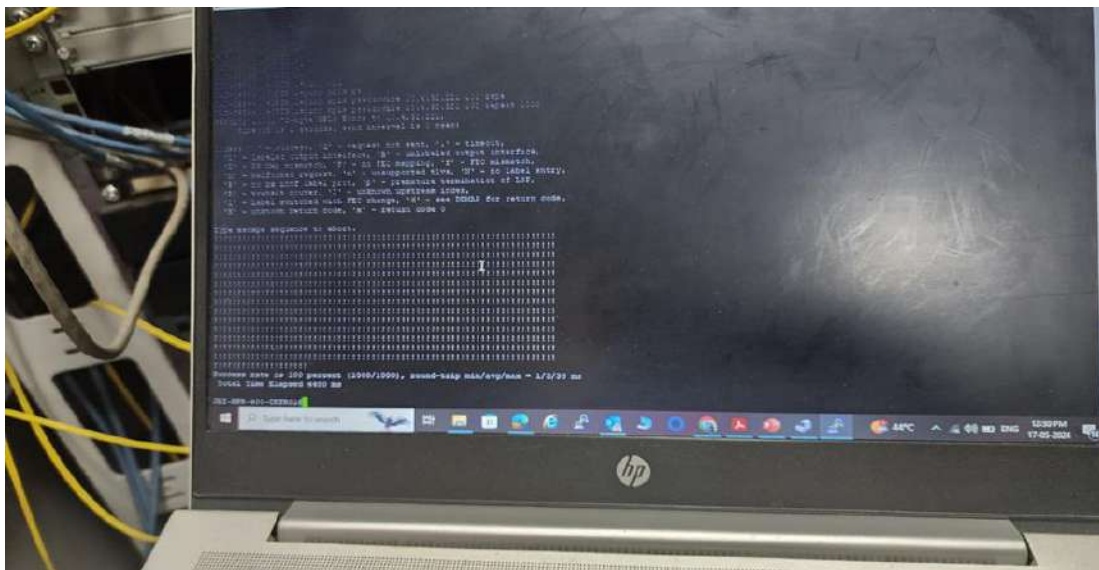
1.	MPLS-I/P	CISCO, ASR-903
2.	DWDM	CISCO, WOM4C10KRC

f) SCADA data latency is also tested by ping test and that shall be half of 3ms which comes to 1.5 ms.

7. Photographs of JC-Team Visit at RVPNL Site:







8. Conformities of the visiting team for RVPNL MPLS-IP network:

Sr.No	Functions witnessed	Observation
1.	Applications to Witness in the MPLS System: (a) SCADA (b) PMU (c) VOIP (d) Protection	Testing of these applications were carried out and witnessed successfully. Data communication between routers was looped back and tested. VOIP was not tested but it was functional. Distance Protection was also witnessed.
2.	Round Trip Delay in the Following Applications: (a) SCADA (b) PMU (c) Distance Protection (d) VOIP	For SCADA, PMU and distance Protection, ping test was carried out and total delay (round trip) was around 3ms. VOIP was not tested but it was functional.
3.	Interoperability between SDH, MPLS, and IP Interfaces	Only MPLS IP network is present and is not connected with SDH.
4.	Maximum Bandwidth supported by the MPLS System	Operational BW – 1Gbps Designed BW – 10Gbps
5.	Tributary Level Study	For Distance Protection, E1 interface is used and for other applications Ethernet ports are used.
6.	Study of Interfacing Equipment at the Junction of SDH and MPLS-IP	Interfacing not available
7.	535 Locations are Installed with MPLS in RVPNL, whether these locations have MPLS or Hybrid of MPLS-SDH	Only MPLS IP.
8.	MPLS Routers: Links, Nodes and locations where they are patched	Main ring is operational on DWDM equipment for long haul links (up to 80 Km) and is interconnected with the STNAMS nodes on 1 Gbps optical interface with MPLS-IP.
9.	Protection Demonstration with information of following: (a) Location (b) Line Length	(a) Location: Heerapura-SEZ line (b) Line Length :17.5 Km

	(c) Voltage Level (d) Latency Measurement	(c) Voltage Level : 220kV (d) Latency Measurement :3ms (round trip)
10.	Protection Implementation Through MPLS-IP/MPLS-TP/SDH	MPLS-IP
11.	Interfaces Used in DWDM (E1 or Any Other)	1 Gbps optical interface.
12.	Remote Control Working Through SDH/IP/TP	Remote control working through MPLS-IP only.
13.	Integration of State Transmission Network with State Distribution Network	Not Applicable
14.	Integration of ISTS and STUs Network is through MPLS-IP/TP or SDH	Only SDH
15.	AGC Command Through MPLS	Not Used

9. **Observations of Visiting Team:**

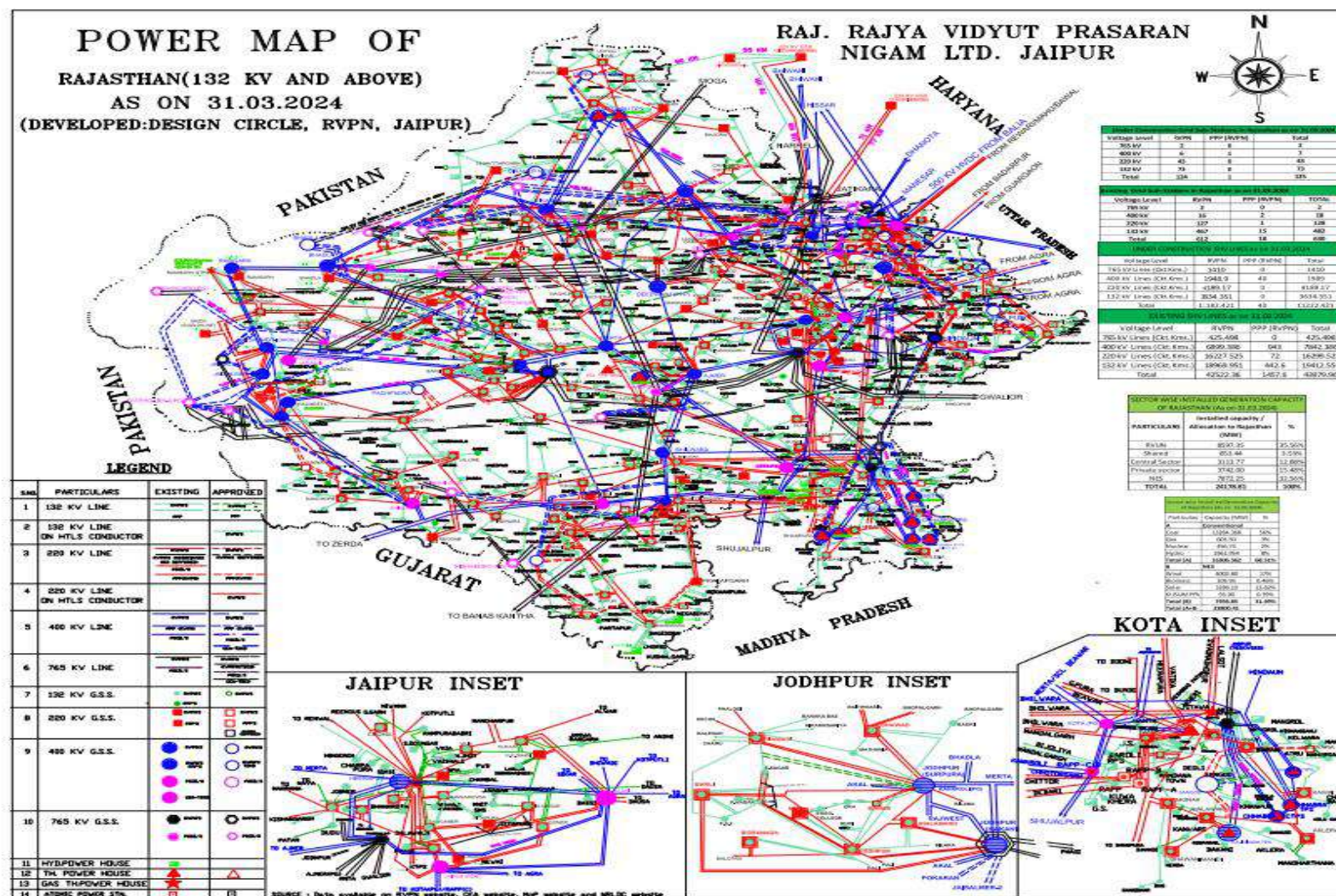
- (i) Main ring is made of DWDM network for the long haul links and short haul links are interconnected between DWDM & IP/MPLS equipment optically.
- (ii) MPLS-IP and SDH Network are on separate fibers. Thus, ULDC network is working separately from STNAMS network.
- (iii) Tele-Protection (distance) is tested successfully through E1 interface of MPLS-IP network with latency figure of 3ms avg. (round trip). However, differential protection testing was not available in stations of MPLS-IP network.
- (iv) SCADA data latency measured by ping test and same is found to be 3 ms avg. (round trip).

Annexure-I

List of Participants witnessed Field at RRVPNL Jaipur Site:

S.No	Officers Name	Designation
CEA-NPC		
1.	Satyendra Kumar	Director (NPC)
2.	Ravi Shankar Singh	Deputy Director (NPC)
3.	Sushil Kr Suman	Assistant Director
NRPC		
4.	Priyanka Patel	Manager
CTU		
5.	T P Verma	DGM
POWERGRID		
6.	Gaurav Awal	Chief Manager
NRLDC/GRID-INDIA		
7.	Paritosh Pathak	Manager
RRVPNL		
8.	V.A Kale	SE
9.	Narottam Vyas	SE Automation

Power Map of RRVPNL



**Report of Field Visit at
TANTRANSCO Sites by
MPLS-JC Team**

CHENNAI

23.05.2024

Acknowledgement

The Joint Committee acknowledges the cooperation extended by CEA, SRPC, CTU, POWERGRID, GRID-India, TANTRANSCO during the field Visit at TANTRANSCO Site.



Himanshu Lal
Dy. Director NPC



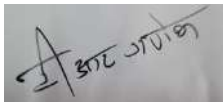
Nikul Rohin,
Asst. Director NPC



T P Verma
DGM CTUIL



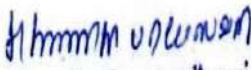
Shyama Kumari
Sr. DGM POWERGRID



T R Ganesh, CGM
SRLDC/GRID-India



Rafeeqe KP
SE KSEB



S. Kannika Parameshwari
CE P&C TANTRANSCO



Sh. K N Srinivasan
EE TANTRANSCO

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 - a) TANTRANSCO communication network
 - b) Current applications
 - c) Digital Communication Technology
 - d) MPLS TP Technology adoption
 - e) Backbone Network
 - f) Voice Communication application
 - g) Tele protection signaling
 - h) Data Communication
 - i) Management of network
 - j) Integration of nodes other than backbone nodes
 - k) Time synchronisation
4. Applications tested at TANTRANSCO Site
5. Snaps of JC-Team Visit at TANTRANSCO Site
6. Conformities of the visiting team for TANTRANSCO MPLS-IP network
7. Observations of Visiting Team
8. Annexures
 - a) Annexure-I: List of participants

1. Purpose of Field Visit

As per the 5th MPLS Joint Committee Meeting held on 11.03.2024 at CTU office, Gurugram, following decisions were taken:

MoM point no. 5 (i) Experience of RRVPNL on interoperability of MPLS-TP, MPLS-IP and SDH to be shared. Field visits to be undertaken by a team of JC members.

& (ii) PoC to be conducted for different makes of MPLS-TP and MPLS-IP equipment on TANTRANSCO/RRVPNL network within one (1) month to assess/confirm that both the technologies are suitable for functional requirements of power system with respect to data, voice and tele protection.

In this regard, a Team of officers from CEA-NPC, CTU, Grid India, POWERGRID and KSEB were formed for TANTRANSCO field visits and witnessing the same.

2. Background

The 5th Meeting of MPLS Joint Committee was held on 11.03.2024 at CTU office, Gurugram. As per MoM of this meeting, Field visits were to be carried out by a team of JC members to get familiarized with the operations, interoperability etc. of the TANTRANSCO MPLS-TP network, which may be provided as an input for the TOR of NPC Joint Committee.

In this regard, NPC formed a team of members from Joint Committee constituting officers from CEA, SRPC, CTU, POWERGRID, SRLDC/GRID India, KSEB for field visit at TANTRANSCO sites. List of officers for the TANTRANSCO visit is attached at **Annexure-I**

During the team visit, TANTRANSCO's MPLS-TP system with a communication link between Pullinathope 400/230KV GIS S/s and Sriperumbudur 400/230/110KV AIS S/s was selected for demonstration of MPLS-TP FOTE with Voice, Data and Tele-protection application.

3. Grid network of TANTRANSCO:

TANTRANSCO has its own independent Operation technology (OT) communication network for Transmission of Substation data to SLDC for Grid control and further to SRPC, Monitoring of Grid network, application of tele-protection in the feeders, implementation of special protection schemes, Interstate transmission network, Data communication towards Load dispatch centres for real time grid monitoring and management, REMC, Voice communication including hotline communication etc. This OT communication network is functioning using the Optical Power grounded wire network (OPGW) along transmission lines and underground Fibre optic cable network of TANTRANSCO (UGFOC) connected between the substations with Fibre Optic Terminal Equipment (FOTEs) to facilitate the independent communication system. Such independent network will provide a robust and reliable communication system during normal times and during natural calamity. All the real time data from Grid Connected substations are communicated to the SLDC through the Optical fibre ground wire /UG FOC and Fibre optical terminal equipment available in the Substations. The OT data from the FOTE is sent through ICCP to SRPC via Ethernet.

A. TANTRANSCO Communication Network:

TANTRANSCO operation technology communication network is made of Fibre optic medium based connectivity with SDH based technology for Voice, Data and Tele-protection applications with Uplink rate of upto STM-1/4. The FO communication network encompasses 230KV, 400KV and upto 765KV substations with currently about 200 nodes.

The FOTE equipment of following make are available in TANTRANSCO network.

Hitachi (Formerly ABB) make FOX series (SDH; Hybrid equipment (SDH & MPLS-TP) TEJAS Make 1400 (SDH) FIBCOM make (SDH) SIEMENS make (Hybrid (SDH & MPLS-TP); MPLS-TP) to be commissioned.

B. Current applications include :

- a) Digital Tele-protection signalling with standalone Tele-protection device of E1 interface as well as Tele-protection interface built in the SDH FOTE.
- b) Voice communication based on Analog communication exchanges networked through SDH FOTEs.
- c) Data communication for SCADA based on serial based IEC 101 protocol and Ethernet based IEC 104 protocol communicating to LDC through SDH FOTEs.

Apart from the FO based digital communication, significant number of substations and transmission lines from 230kv and above voltage level are provided with PLCC based carrier communication scheme for data transmission to LDC through DCPC, Tele-protection using analog protection couplers and PLCC based voice communication system with associated analog EPAX.

C. Digital Communication Technology:

Taking into account of the market trend of available OEMs of FOTE equipment and the seminars/ conference participated by OEMs of FOTE equipment, it is noticed that SDH technology is going to become obsolete and that MPLS based technologies are going to prevail for FOTE communications equipment for power utility applications.

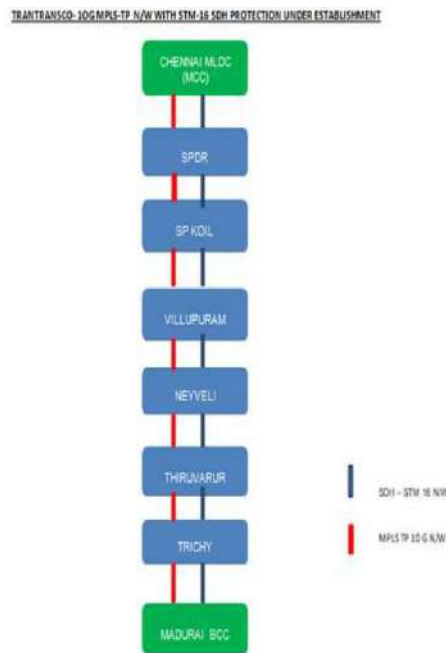
The recent CIGRE green book (D2 working group edition), states that the next level transformation of fibre optic end terminal equipment in power utilities will be from SDH technology to MPLS-TP technology.

In this regard, TANTRANSCO has planned for smooth migration of the FO based communication network for TANTRANSCO Grid Operation from SDH based technology to MPLS-TP based technology by adopting combination of hybrid technology FOTE equipment and MPLS-TP FOTE equipment for integrating the SDH FOTE devices with the MPLS-TP based devices.

D. MPLS-TP Technology adoption :

An ongoing project awarded to M/s. Hitachi Energy India Ltd (Formerly M/s ABB Power Products and Systems India Ltd) for supply, erection and commissioning of 34 nos. of Hybrid FOTE equipment (SDH and MPLS-TP) and 9 nos. of MPLS-TP equipment is under execution with progressively commissioning of FOTE equipment in nodes.

E. Backbone network:



The FO Communication network is being organised in a ring network formation for backbone communication across the state interconnecting the main LDC, Chennai and the Backup LDC, Madurai through a chain of nodes of substations. Hybrid equipment are being positioned in the nodes of the backbone network to form a double ring network for redundancy with one ring on STM-16 SDH protocol and another ring on 10G MPLS-TP protocol. The nodes are being progressively commissioned in SDH link and on the MPLS-TP link is being initiated. The nodes are of 230 kV and above voltage level grid substations with applications comprising Voice, Data and Tele-protection applications.

F. Voice communication application:

VoIP based communication is being deployed in this project wherein the VoIP phones that are SIP compatible type in 34 substations connected through Hybrid FOTEs. Hybrid type voice communication exchanges are provided in certain locations to establish routing of calls. Hybrid exchange support both analog and VoIP based voice communication wherein the Analog telephone user can be connected to VoIP telephone user across the state with the exchange to exchange trunk connectivity. SIP server is provided in the Hybrid exchange. In certain stations VoIP gateways are installed for connectivity of legacy 2wire/4wire telephone users to VoIP communication network. In this scheme the analog telephone subscriber can be communicating with VoIP telephone subscribers through the Hybrid Exchange.

G. Tele-protection signalling:

Tele-protection signalling is being implemented with DTPC to Hybrid interface using E1 and Ethernet ports wherein E1 signalling transmitted through the STM link and Ethernet signalling transmitted through the MPLS-TP link of the Hybrid FOTE equipment. The signalling delay is within satisfactory limit in SDH and MPLS-TP link.

H. Data communication:

SCADA Data of IEC 101/ IEC 104 protocols from substations to the main control centre/ back up control centre is transmitted through Hybrid FOTEs with suitable serial/Ethernet interface.

I. Management of network:

NMS is being provided by Hitachi to manage and monitor the Hybrid FOTEs and MPLS-TP FOTEs being installed in the ongoing project. The Hitachi FOXMAN NMS also facilitates to establish management channel access from the NMS to the Hitachi make MPLS-TP device through the Hitachi make Hybrid FOTEs.

J. Integration of nodes other than backbone nodes:

Substations that are on SDH FOTE are being integrated to the backbone network through the SDH interface of the Hybrid equipment as and when the OPGW connectivity is established. Substations that are on MPLS-TP FOTE are being integrated to the backbone network through the MPLS-TP interface of the Hybrid equipment as and when the OPGW connectivity is established. This approach facilitates gradual and smooth integration of the SDH and MPLS-TP FOTEs into the existing communication network of TANTRANSCO.

K. Time synchronisation:

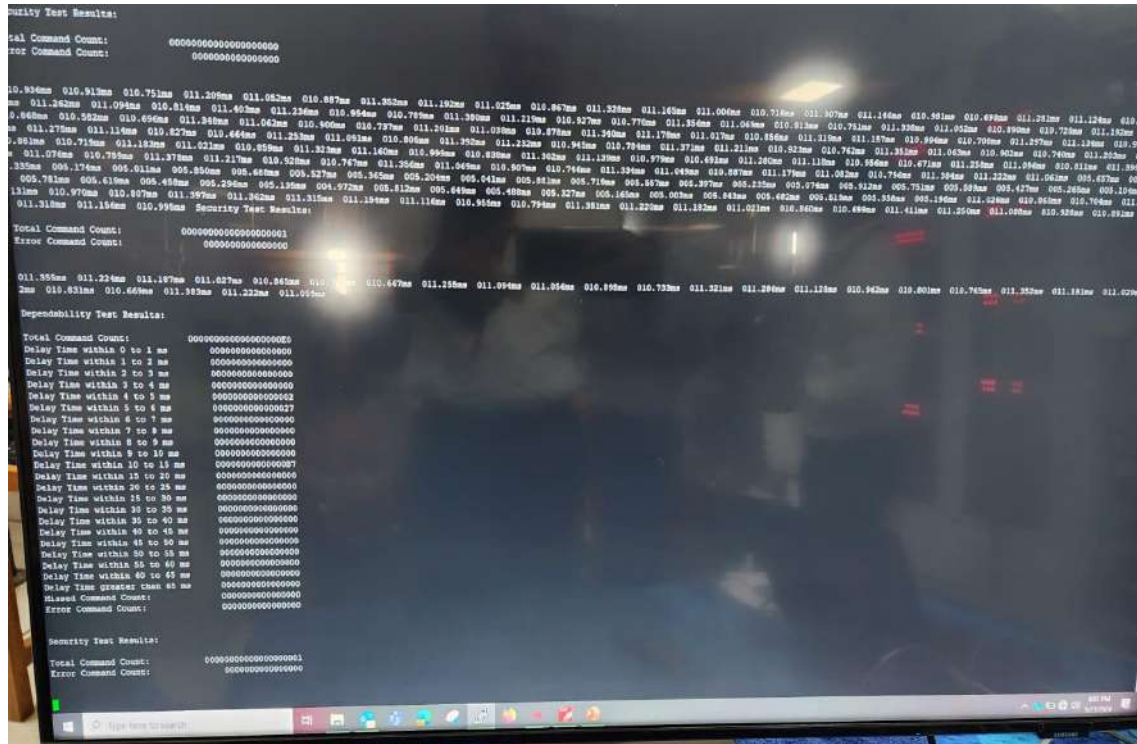
GPS with SNTP and PTP time synchronisation signalling is being installed in the LDC, Chennai for communication network time synchronisation.

4. Applications tested at TANTRANSCO Site:

Equipment	Pullinathope 400/230KV GIS SS	Sriperumbudur 400/230/110 KV AIS	Communication Link
FOTE Equipment	Hybrid FOTE FOX615	Hybrid FOTE FOX615	SDH : STM-4 MPLS-TP:10G
Telephone	VoIP Phone	VoIP Phone	Configured for 2Mbps port speed
Tele-protection	NSD570 EI (2Mbps) interface and Ethernet (10Mbps) interface	NSD570 EI (2Mbps) interface and Ethernet (10Mbps) interface	Command transmission time between DTPC to DTPC- 5.6 ms over SDH Link and 3.24 ms over MPLS-TP link
SCADA Data	IEC 104 to LDC over MPLS-TP link		
Ethernet data			Ethernet frames @ 100 Mbs were sent using Ethernet Test device. Through put, Latency and Frame loss were tested as mentioned below: Through put : 100% successful. Frame loss: 0% Latency : 1.3 ms
• SNTP was used for time synchronisation.			

5. Photographs of Visiting Team at TANTRANSCO Site:







6. Conformities of the visiting team for TANTRANSCO MPLS-TP network:

Sr. No.	Functions witnessed	Observation
1.	Applications to witness in the MPLS System: (a) Tele-Protection (b) SCADA (c) VOIP	Testing of these application were carried out and the same were witnessed successfully. <u>For Tele-protection:</u> Transmission time between DTPC to DTPC- 5.6 ms over SDH Link and 3.24 ms over MPLS-TP link. <u>For SCADA Data :</u> Ethernet frames @ 100 Mbs were sent using Ethernet Test device. Throughput, Latency and Frame

		loss were tested as mentioned below: Throughput: 100% successful. Latency : 1.3 ms Frame loss: 0% <u>For VOIP Connectivity :</u> VOIP connectivity tested by calling different stations over MPLS-TP and the same was working satisfactory.
2.	Interoperability between SDH, MPLS, and IP Interfaces	Hybrid equipment are used in the nodes of the backbone network to form a double ring network for redundancy with one ring on STM-16 SDH protocol and another ring on 10G MPLS-TP protocol.
3.	Maximum Bandwidth supported by the MPLS System	10Gbps
4.	Tributary Level Study	For Distance Protection, E1 and Ethernet interfaces are used; and for other applications, Ethernet ports are used.
5.	Protection Demonstration with information of following: (a) Location and Substation Name: (b) Line Length (c) Voltage Level (d) Latency Measurement	(a) Location: Pullinathope 400/230KV GIS S/s and Sriperumbudur 400/230/110 KV AIS S/s. (b) Line Length between substations : 75 Km (fiber length) (c) Voltage Level : 230 kV (d) Latency Measurement : 3.24ms over MPLS-TP link
6.	Protection Implementation Through MPLS-IP/MPLS-TP/SDH	E1 over SDH network and backup protection over MPLS-TP with Ethernet interface.
7.	Integration of ISTS and STUs Network is through MPLS-IP/TP or SDH	Through SDH

7. Observations of Visiting Team

- (i) Hybrid equipment are used in the nodes of the backbone network to form a double ring network for redundancy with one ring on STM-16 SDH protocol and another ring on 10G MPLS-TP protocol.
- (ii) Tele-Protection (distance) is tested successfully through MPLS-TP over Ethernet interface of MPLS-TP network with latency figure of 3.24ms. However, differential protection testing was not available over IEEE C37.94 interface.
- (iii) SCADA data latency was measured by Ethernet frames ping test and the same was found to be 1.3 ms.

Annexure-I

8. List of Participants: Field Visit at TANTRANSCO Chennai Site:

S. No.	Name of the Officials	Designation
NPC, CEA		
1.	Shri Himanshu Lal	Dy. Director NPC
2.	Shri Nikul Rohin	Asst. Director NPC
CTU		
3.	Shri T P Verma	DGM
POWERGRID		
4.	Smt. Shyama Kumari	Sr. DGM
SRLDC/GRID-INDIA		
5.	Shri T R Ganesh	CGM
KSEB		
6.	Shri Rafeeqe KP	SE
TANTRANSCO		
7.	Shri S. Kannika Parameshwari	CE P&C
8.	Shri K N Srinivasan	EE
9.	Smt. C DEEPA	AEE

Annexure-XI

Minutes of Meeting Regarding POC details finalization at TANTRANSCO held on 27th May 2024 in Virtual Mode

The Meeting Regarding POC details finalization on MPLS network of TANTRANSCO held on 27.05.2024 through virtual mode (MS-Teams). The list of participants is attached at *Annexure-I*.

Sr.GM (CTU) welcomed all the participants at the meeting and thanked TANTRANSCO for their supportive gesture during field visit of NPC-JC Team at their sites. CTU proceeded with the agenda items as mentioned below.

Agenda of the Meeting

1. Finalization of POC network by integrating TANTRANSCO operational network with the different make/technology equipment of the prospect vendors.
2. POC implementation and witnessing schedule.

Deliberations:

CTU stated that POC regarding interoperability and witnessing of POC shall be planned accordingly subsequent to the field visit at TANTRANSCO. CTU shared a proposed POC network diagram (attached at *Annexure-II*). TANTRANSCO stated that their MPLS -TP ring is under construction and point to point integration of nodes shall be taken up for POC. Same was demonstrated during the TANTRANSCO MPLS-TP network. CTU agreed that only spare (dark) fiber shall be utilised for POC.

In the said diagram TANTRANSCO MPLS-TP ring is shown, which is proposed to be connected from a suitable node of TANTRANSCO MPLS-TP (make HITACHI) with MPLS-TP equipment (makes GE/BELDEN) placed at another node of the said ring. Finally MPLS-IP equipment (makes CISCO & NOKIA) shall also be integrated with the above mentioned node as shown in diagram. TANTRANSCO suggested that since their MPLS-TP ring is also connected with the SDH ring, so that the data communication can be demonstrated through SDH -TP(1)-TP(2/3)-IP(1/2). TANTRANSCO informed about the data applications to be tested in the POC shall be applications like Data (SCADA), Voice (VOIP), Tele-Protection(C37.94 / E1/Ethernet). CTU further clarified that Tele protection shall be demonstrated for both Distance as well as Differential.

CTU requested TANTRANSCO that for establishing above network 3 nodes of their operational network shall be required for the proposed POC for the interoperability of data communication. CTU further stated that spare ports alongwith spare fiber pair/s shall be required for this purpose which shall be coordinated by TANTRANSCO alongwith the 3 nodes required as above.

CTU asked the prospective bidders participating the proposed POC about the provision of MPLS equipment & protection equipment including desired interfaces for the same.

BELDEN replied that their equipment has 1G interface and they have already tested interoperability with Hitachi FOX system. They also stated that their equipment supports more

than 100 Km distance between two successive nodes. BELDEN agreed to conduct interoperability test on TANTRANSCO network.

NOKIA stated that 1G interface connections can be established with MPLS-TP at other node with their MPLS -IP equipment. CISCO also agreed for proposed POC.

GE could not attend the meeting due to unavoidable circumstances. However, they have confirmed integration of their equipment as desired for the proposed POC during the visit of NPC-JC Team at TANTRANSCO.

TANTRANSCO further stated that they will check and inform the distances between the nodes of the MPLS-TP network after the finalization of the three nodes for POC. However, they informed that these distance are in the order of 30-40 Kms.

HITACHI stated that based on the information of link distances, power budget calculation shall be done, once the nodes are finalised.

POWERGRID suggested that SDH equipment shall be integrated with 2 MPLS-TP equipment, one at either side of SDH equipment. TANTRANSCO clarified that SDH cannot Communicate with MPLS-TP due to protocol mismatch, data of SDH needs to be extracted and provided to MPLS-TP for communication. CTU advised that TANTRANSCO shall provide the application data at the input of SDH equipment which shall be connected optically with their MPLS-TP equipment.

TANTRANSCO requested vendors to come along with all the required equipment including interfaces and main test equipment. CTU stated that for tele-protection C37.94/E1/ethernet interfaces shall be used. TANTRANSCO replied that for their ongoing project they have to check for C37.94 interface otherwise OEMs have to bring their own tele-protection equipment. BELDEN stated that their equipment has card which have both C37.94 and E1 interface. CTU stated that to make POC successful all the bidders participating in the POC shall be coordinating with TANTRANSCO and HITACHI for all the equipment/interfaces/test equipment etc. and shall deploy their teams to integrate the POC network.

CTU stated that for VoIP testing purpose 3 VoIP phones at station nodes 1,2&3 are required and for tele protection testing tele-protection equipment with C37.94 and ethernet interface are required at station 2&3 and SCADA data may be tested at station 1. TANTRANSCO stated that they shall provide the VoIP phones as required and for remaining items shall share the details.

TANTRANSCO stated that they are using master node from control centre for time synchronisation TANTRANSCO enquired the OEMs, how the time synchronisation of different make IP/TP equipment shall be achieved. CTU stated that all OEMs shall mention this aspect in their test plans.

CTU clarified that all the POC expenses shall be borne by the OEMs.

CTU asked vendors to prepare a base test plan beforehand so that same shall be modified in accordance with test plan shared by TANTRANSCO.

Following points are agreed in the meeting for the said POC:

1. TANTRANSCO to provide suitable 3 node of their MPLS-TP network alongwith technical details within a week.
2. Subsequent to information received from TANTRANSCO , all OEMs shall submit their Test Plans accordingly within 3 days .
3. Detail logistics plan for all the requirement at TANTRANSCO sites to be provided by each OEM for the POC.
4. CTU/TANTRANSCO shall prepare the schedule of witnessing the POC by JC Team.
5. All the POC expenses shall be borne by the OEMs.

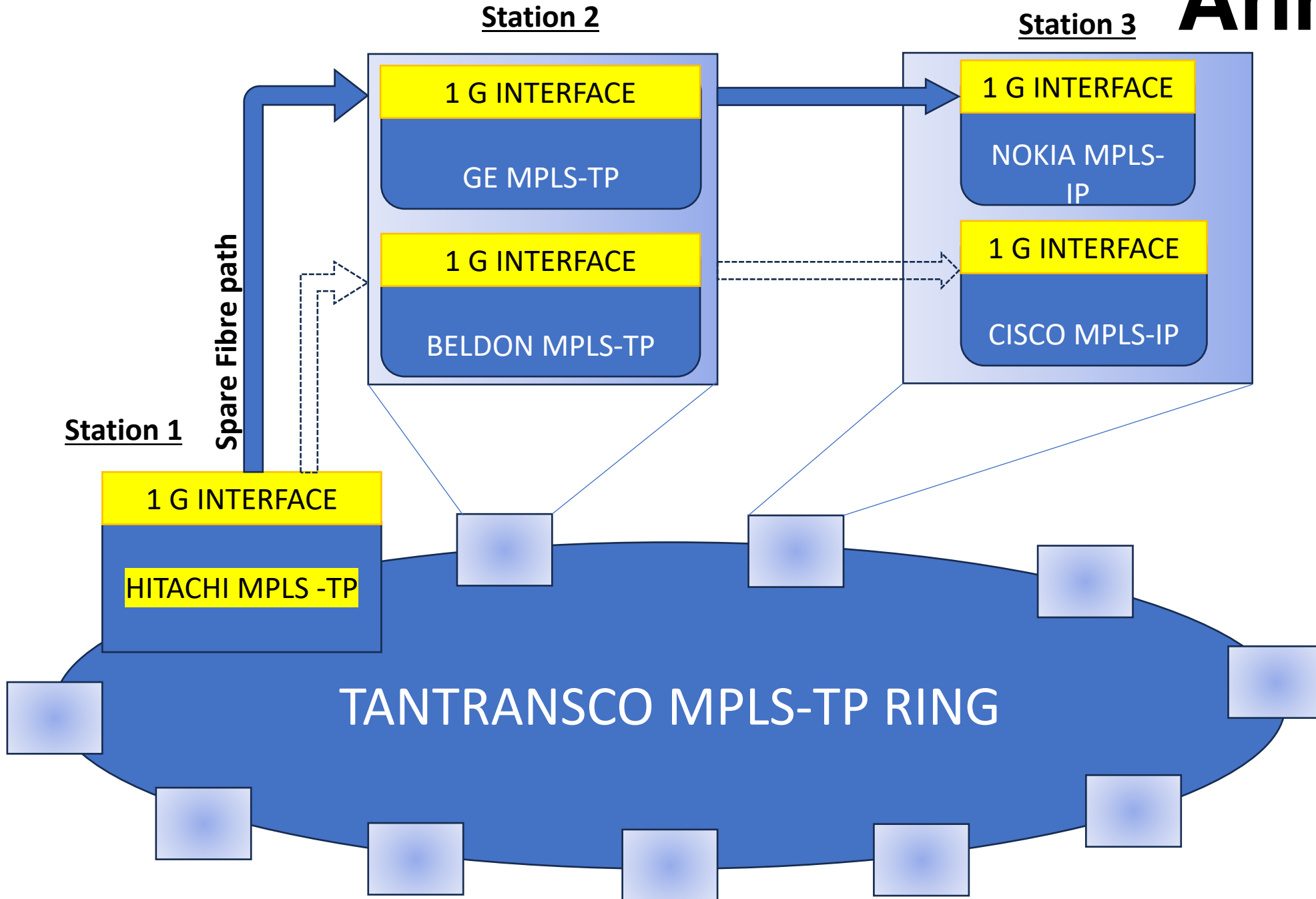
Annexure-I

List of Participants

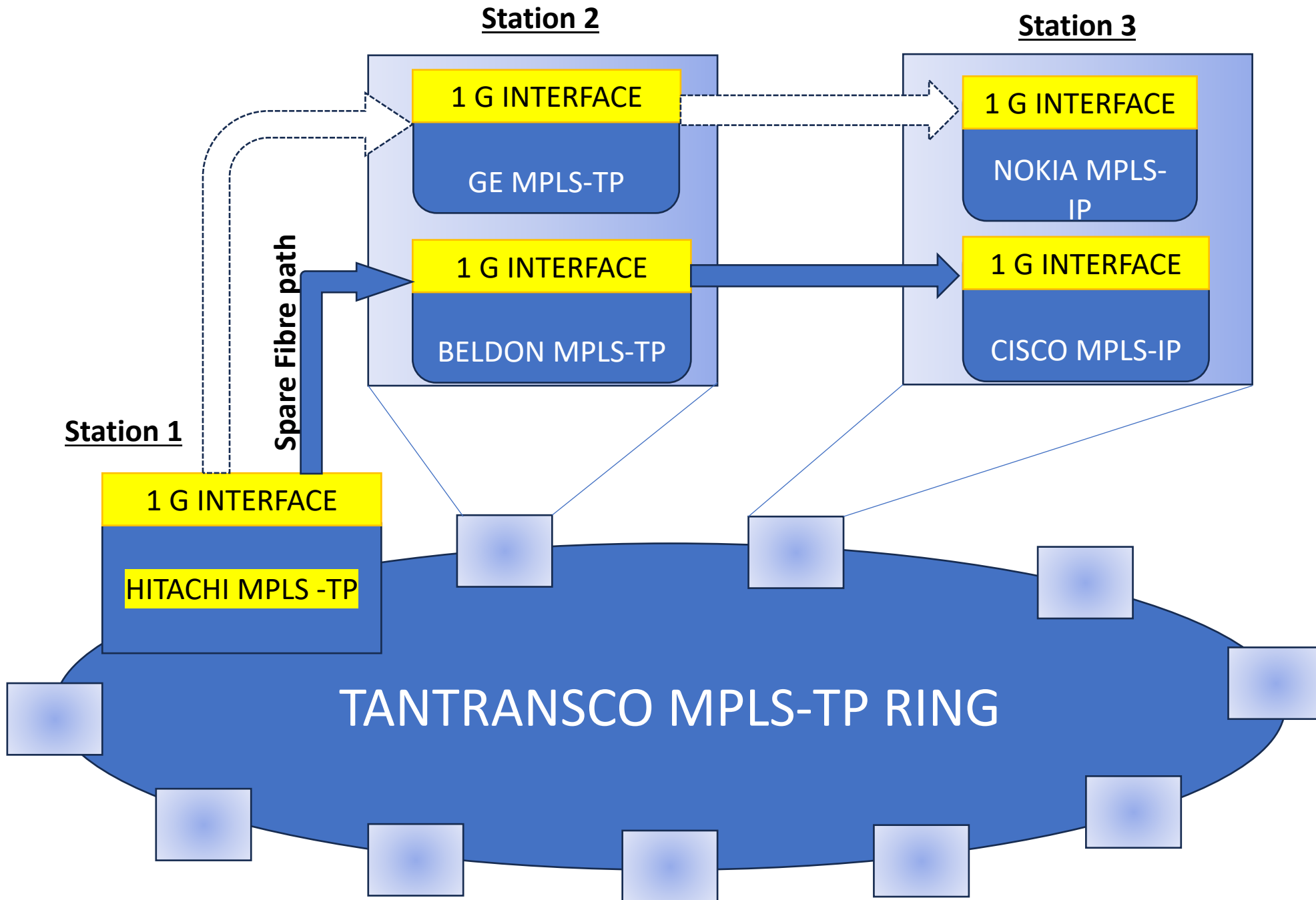
Sr.No	Participant	Designation	Mobile No.	Email-Id
CTU				
1.	Sh. H.S. Kaushal	Sr.GM	9599291535	hsk@powergrid.in
2.	Sh. Tej Prakash Verma	DGM	9650598191	tejprakash@powergrid.in
3.	Sh. Prakhar Pathak	Engineer	8953109167	prakharpathak321@powergrid.in
POWERGRID				
4.	Ms. Shyama Kumari	Sr. DGM	9873918459	Shyama@powergrid.in
TANTRANSCO				
5.	Sh. K N Srinivasan	EE	9445396708	eeepc3@tnebnet.org
6.	C DEEPA	AEE	9445867862	aec2scadamdu@tnebnet.org
HITACHI				
7.	Sh. Yogendra Patwardhan	Associate Sales Director	9987615561	yogendra.v.patwardhan@hitachienergy.com
BELDEN				
8.	Sh. Pavan Kumar Yadav	Sr Manager	8826796214	pavan.yadav@belden.com
9.	Sh. Gaurav Shanbhag	Sr. Solutions Consultant	8097885286	gaurav.shanbhag@belden.com
NOKIA				
10.	Sh. Sameer Deo	Regional Sales Lead West & South	9833310249	sameer.deo@nokia.com
CISCO				
11.	Sh. Saurabh Kr. Srivastava	Head Utilities	9899278039	ssrivasa@cisco.com

Annexure-II

Proposed Connections for POC



Proposed Connections for POC



Salient points of online meeting held on 21.06.2024 regarding Vendors MPLS POC Plan

1. The topology was again explained as linear constituting 3 nodes of TANTRANSCO n/w as already communicated. Termination point can be the last Node -3 or it may be looped back at Node-3 and tested at Node-1. Further at Node-2, MPLS TP equipment of BELDEN and GE can be connected together followed by MPLS IP equipment of NOKIA and CISCO at Node-3.
2. There is no existing ring of TANTRANSCO available for POC.
3. PoC shall be like a test bench setup in real field conditions, equipment shall be placed on the tabletop and connected with dark fibers/wires and no space in the existing racks of TANTRANSCO is required.
4. At Station-1 TANTRANSCO shall provide Hybrid equipment which shall support both SDH and MPLS-TP and fiber length between Station-1 & Station-2 is 30 Km between Station-2 & Station-3 fiber length is 50 Km and Two sets of dark fiber shall be provided by TANTRANSCO for redundancy testing.
5. DC source shall be provided by TANTRANSCO.
6. Vendors coordinate among each other to make the equipment of different OEMs to communicate with each other.
7. Amplifiers are not required for the above-mentioned fiber lengths. However, if required shall be arranged by the Vendors.
8. Site survey (if required) for accessing the BoQ and other items associating the POC shall be arranged by vendors.
9. Testing shall be done in two main categories
 - a. Ethernet based testing for all type of data (SCADA, PMU, VOIP & Ethernet based protection) applications.
 - b. Non ethernet based testing i.e. Teleprotection with E1 and C37.94.
10. TANTRANSCO to provide the DPC (Digital Tele-protection Coupler) for PoC at all the 3 nodes alongwith relays. However, differential Tele protection equipment shall be provided by vendors and cards for Tele-protection using C37.94 shall be provided by M/s Hitachi at all the 3 nodes. Line Differential relays shall be provided by GE/BELDEN at all the 3 nodes
11. VOIP phones at all three nodes will be provided TANTRANSCO for testing, patch cords to be provided by vendors for integration.
12. Data communication (SCADA, PMU etc.) shall be tested emanating from Node-1 onwards.
13. Formal letter shall be given to all vendors for logistics by TANTRANSCO/CTU (if required). Site permission shall be given by TANTRANSCO for vendor's equipment for POC and testing on returnable basis.
14. Local transportation and technicians shall be arranged by respective vendors.

15. Interconnection block diagram and wiring diagram to be provided by vendors to TANTRANSCO and CTU. TANTRANSCO shall help in wiring if required by the vendors.
16. Revised Test Plan to be provided by MPLS Vendors at the earliest.

::TAMILNADU TRANSMISSION CORPORATION LIMITED::



(By email)

From:
Er. S. Kannika Parameswari, M.E.,
Chief Engineer /Protection and
Communication,
IInd Floor, TANTRANSCO building,
144, Anna Salai, Chennai -2

To:
M/s.GE T&D India Limited,Noida.
M/s.BELDEN India Pvt Ltd,Bengaluru.
M/s.Nokia Solutions and Networks India
Private Limited. Gurgaon.
M/s.CISCO Systems,Newdelhi.
M/s.Hitachi Energy India Limited, Bengaluru.

Lr.No: CE/P&C/SE/D/COMMN/EE/EPC-3/F.ISTS/D.3029/24 DT 04.07.2024

Sir,

Sub: TANTRANSCO-ISTS - JC for MPLS – PoC-MPLS interoperability Testing
between different make (OEM) equipment's at TANTRANSCO's Substations
– Regarding.

Ref: 1. MOM redarding POC details finalization at TANTRANSCO held on 27th
May 2024 in Virtual Mode
2. Lr.No: CE/P&C/SE/D/COM/EPC-3/F.ISTS/D.2673/24 Dt 07.06.2024
3.MoM of MPLS JC VC meeting on 21.06.2024.
4. CTUIL Email dt 26.06.2024 and 01.07.2024

With reference to the above, the joint committee on MPLS formed by NPC has invited OEMs of different make MPLS FOTE for carrying out the Proof of Concept test for interoperability of MPLS FOTE between different make OEMs for Power utility application as per latest MoM dt 21.06.2024.

As per the MOM cited first above, TANTRANSCO has to provide the sites for conducting the POC test for which the following Substations are allocated by TANTRANSCO:

1. Korattur 230/110 kV Substation.
2. Sriperumbuthur 400/230/100 kV Substation.
3. Kanchipuram 230/110 kV Substation.

The OEMs of Fiber optic terminal equipment have to provide their MPLS FOTE equipments at Sriperumbuthur 400/230/100 kV Substation and Kanchipuram 230/110 kV Substation as per the scheme drawing proposed in ref.1 cited above in order to conduct the POC. At Korattur 230/110 kV Substation TANTRANSCO's FOX 615 Hybrid FOTE is available for MPLS –TP for establishing communication for PoC test with equipments at other two sites.

In this regard the shipping address for shipment of equipments for POC is as follows:

Sl.No	Name of the SS	Shipment address
1.	Korattur 230/110 kV SS	Executive Engineer Operation/ 230 KV Korattur SS, TANTRANSCO / TNEB, Korattur, Chennai - 600 080 Cell: 9445850404 Email: eeoktr@tnebnet.org
2.	Sriperumbuthur 400/230/100 kV SS	Executive Engineer/Operation, Sriperumbuthur 400/230/100 kV SS /TANTRANSCO NH 48 Bangalore Highway, Pennalulr, Sriperumbuthur -602105 Cell: 9445850470 Email: eeospr@tnebnet.org
3.	230KV Kanchipuram SS	Executive Engineer/Operation, 230KV Kanchipuram SS/ TANTRANSCO LTD 18, Ariyaperumbakkam Village, Krishnapuram Post(Via Baluchettychatram) Kanchipuram-631 551 Cell: 9499050181 Email: eeoarpkm@tnebnet.org

The concerned OEM of FOTE equipments shall arrange for unloading and shifting of materials to Communication equipment room at TANTRANSCO site. The shipping

address is provided for facilitating shipping of materials for PoC testing purpose only and shall not be billed to TANTRANSCO as this letter is not for procurement of materials by TANTRANSCO to the addresses of this letter.

It is hereby intimated that TANTRANSCO shall not bear any financial liability for the materials brought by the OEM at TANTRANSCO's sites for the subject POC.

The OEM of FOTE equipment who are participating in the subject POC shall ensure to avoid damages to men and materials of TANTRANSCO and ensure safety precautions and practices at TANTRANSCO's sites as per prevailing rules and regulations.

The materials brought for PoC testing shall be arranged to be removed from site by respective OEM after completion of PoC testing.

This office shall be intimated on shipping of materials and on removal from site of OEM for subject PoC testing.

Site activity by OEM team shall be carried out with intimation to the concerned EE/Operation and EE/P&C of TANTRANSCO.

Handwritten signature
5/9/2024
Chief Engineer /P&C.

Copy submitted to the Managing Director, TANTRANSCO. For information please.

Copy to the Chief Engineer/System operation, Chennai. For information please.

Copy communicated to M/s.CTUIL

Copy to the Superintending Engineers/Operation/ Sriperumbudur, Chennai-North.

Copy to Superintending Engineer /P&C/Chennai. The site activity of OEM shall be supervised by concerned P&C engineer during installation and testing of PoC.

Copy to the Executive Engineers/Operation, Korattur, Sriperumbudur, Kanchipuram.

Copy to the Executive Engineers/P&C/Korattur and Sriperumbudur.

Proposed POC details at TANTRANSCO

This is with reference to visit of JC – NPC at Chennai for witnessing TANTRANSCO MPLS network and the MoM of online meeting dtd.27.05.24 wherein it was decided that TANTRANSCO to provide the nodes details for POC purpose and MPLS OEMs to provide their TEST plan thereafter. The TEST plan shall include data communication of the following applications:

1. SCADA
2. PMU
3. VOIP
4. Protection
 - a. Distance Protection using DTPC (with E1 and Ethernet interface)
 - b. Differential Protection using C37.94

CTUIL has received the inputs from TANTRANSCO for the 3 nodes offered for POC which is as under:

Digital Tele-protection communication equipment (DTPC) (Hitachi NSD570) with E1 and Ethernet interfaces shall be provided by TANTRANSCO at three stations for PoC testing purpose only.

Station-1: Korattur230KV SS / Korattur 400/230-110KV SS in the premises of Korattur 230KV Ss in Chennai. TANTRANSCO Hybrid Hitachi make FOX615 Equipment will be available for PoC testing towards station-2.

TANTRANSCO Hybrid FOTE Equipment (Hitachi make FOX615) will be available at Station-1 for PoC testing towards Station-2. Site engineer of M/s. HEIL for carrying out PoC testing and all necessary accessories, cards, cables etc. for PoC testing is to be provided by M/s. Hitachi Energy India Ltd (M/s HEIL). Besides above C37.94 interface and Differential Relay shall also be provided by HEIL for POC at Station-1.

TANTRANSCO concerned P&C Officer will supervise the operation at Station-1 end.

Station-2: Sriperumbudur 400/230-1 10KV SS in Kanchipuram district approximately 35km from Chennai. MPLS-TP Equipment of GE/BELDEN OEMS are envisaged to be placed for PoC testing. Besides above C37.94 interface and suitable Differential Relay shall also be provided by GE/BELDEN for POC at Station-2.

Station-3: Kanchipuram 230-110KV SS in Kanchipuram district approximately 74km from Chennai. IP/MPLS Equipment of Nokia/CISCO OEMS are envisaged to be placed for PoC testing. Besides above C37.94 interface and suitable Differential Relay shall also be provided by NOKIA/CISCO for POC at Station-3.

Between station-2 and station-3 OPGW dark fiber connectivity till FODP will be provided by TANTRANSCO, all other necessary arrangements, materials, patch cables, SFPs etc., test equipment and instruments shall be provided by OEMS /Suppliers participating in PoC.).

Minutes of the 7th MPLS Joint Committee Meeting held in virtual mode on 20.12.2024

The 7th Meeting of Joint Committee (JC) constituted by NPC was held on 20.12.2024 through virtual mode to discuss and recommend the “Introduction of MPLS technology in ISTS Communication System”.

The list of participants is attached at *Annexure-I*.

Sr. General Manager (CTU) welcomed all the participants at the meeting and proceeded with the agenda items. The summary of discussions is mentioned below:

CTU explained briefly about the agenda points for the 7th meeting to the JC as under:

- Proposed recommendation for migration methodology for new/upcoming ISTS nodes into MPLS TP/IP.
- Discussion on the Draft Report circulated by CTU.

Presentation shared by CTU is attached at *Annexure-II*.

CTU explained that as proposed in the draft report MPLS TP/IP network can be integrated with legacy SDH network with hybrid or any intermediate interface supporting SDH technology. CTU proposed a MPLS TP isolated network connecting all the control centres that runs on separate fiber pairs alongside with the existing SDH network for connecting the backup channels initially. Every upcoming node to be connected to the ISTS network shall have to connect the main channel to the SDH ring and backup channel with the MPLS TP ring. The traffic migration on regional basis from SDH to MPLS shall be done gradually by shifting the main channels of the connected nodes to the MPLS TP ring as and when they are required to be replaced.

CTU further gave a presentation for the various scenarios that may arise when a new ISTS node with either MPLS TP or MPLS IP is to be connected with the existing network. The scenarios are mentioned as under:

New ISTS Node type	Existing Node/CC for integration	Comment
MPLS IP	SDH	New MPLS to legacy network link
MPLS TP	SDH	New MPLS to legacy network link
MPLS IP	MPLS TP	New MPLS to MPLS network link
MPLS TP	MPLS IP	New MPLS to MPLS network link
MPLS IP	Control Centre (CC)	Radial connectivity
MPLS TP	Control Centre (CC)	Radial connectivity

Deliberation

1. TANTRANSCO stated that the methodology shown by CTU is not 1+1 protection configuration and it is independent parallel communication instead. To bring MPLS ring in function, we shall require 4 fibres because within MPLS we must enable 1+1 protection channel. CTU replied that the ISTS communication network is already designed in 2+2 channel philosophy i.e. all nodes are reporting to their control centres 2 main and 2 backup channels. In view of this the further redundancy shall not be required.
2. ERLDC expressed their concerns regarding cyber security requirement with NCIIPC consent. CTU explained that security for both MPLS TP and MPLS IP shall be ensured as per CEA Cyber Security Guidelines 2021. CTU also explained that equipment like MPLS TP and MPLS IP are communication equipment and Cyber Security regulations for communication equipment already exist. Moreover, draft cyber security regulations are also shared by CEA which shall be complied by the MPLS IP/TP vendors.

CTU requested CEA to explain their Cyber Security regulations. CEA stated that their Cyber Security regulations draft is already published. At present the draft has stakeholders comments which are being deliberated and after deliberation the draft shall be notified to the JC. CEA also stated that the roles are very clearly defined in the draft and there is no equipment wise differentiation, and it is technology agnostic. CTU further stated that whatever equipment shall be used it must comply the CEA cyber security guidelines.

CEA asked CTU/implementing agency to ensure that OEMs have their equipment complied with certification specified in CEA cyber security regulations. In case the OEMs are not able to comply the requirement fully, they may approach the CEA Cyber Security division.

TANTRANSCO also stated that various provisions are available for the OEMs in IEC 62443 standard.

3. CSPTCL raised their concern for the lack of competition for MPLS tender bidding. CEA asked CSPTCL to write to PCD division or to R&D division of CEA as they are the nodal agencies responsible to ensure that there is sufficient competition in bidding. CEA also asked CSPTCL to make a representation and mail the specifications of tenders and their participation to CEA and seek necessary directions.
4. POWERGRID stated that at present they have only 6 useable fibres for ULDC purposes and only 2 of them are spare for contingency situations. So the formation of backup MPLS ring with separate fibers may not be feasible. CEA stated that in the ongoing committee of the fiber sharing policy provision is already there for the spare fiber for the purpose of technology migration. CTU requested CEA to assign 6 fibres as spare for MPLS in their policy and stated that there is no need to approach CERC as this is for technology upgradation work. CTU explained that the number of fibres is now increased to 48 fiber against present 24 fiber requirement and same is also

communicated by CEA to all the utilities by letter dated 22.11.2024. Therefore, in the upcoming lines there shall be no issue for sparing additional fibers for MPLS technology migration.

5. NRLDC asked for detailed explanation regarding migration from SDH to MPLS e.g. how many nodes to be covered at first, where will the implementation happen and how the data will transfer from SDH to MPLS after the implementation of MPLS ring. NRLDC also mentioned that their system is made up of small regional links and even in those regional links they have small SLDCs connected, they have a cluster of networks in contrast to the singular ring network shown by CTU. CEA also added that the present methodology shown by CTU is very broad and asked for a node specific migration plan.

CTU clarified that the methodology presented is just a representation of migration on a broader level for the discussion of JC and their suggestions. Planning at node level shall require significant time. CTU also requested Grid India and POWERGRID to provide their comments/views on proposed migration plan to CTU. CEA suggested that proposed migration shall be done in phased manner starting from a smaller/regional network.

6. NRLDC stated that a seamless network is not possible when combining both MPLS TP and IP and enquired whether single technology can be selected to have a seamless network. CTU agreed with NRLDC and added concerns regarding implementing a mixed MPLS TP and IP network with problems like extraction of MPLS TP/IP channels from the main payload while going from MPLS TP to IP and vice-versa.

CEA requested KSEBL and TANTRANSOCO to share their inputs in respect of the migration with MPLS as they already have gone ahead with state specific MPLS networks/tenders.

KSEBL stated that MPLS TP and MPLS IP has already been implemented in some European countries. KSEBL further stated that both the technology has their limitations and in some cases even for TP-TP and IP-IP ethernet shall be needed for cross vendor compatibility. KSEBL gave their view, that MPLS TP and MPLS IP both technologies are suitable provided it satisfies the functional requirements of the users. KSEBL suggested in a broader sense that we should not restrict our self with any specific technology, we should be open to both MPLS TP and MPLS IP and wherever there are technical constraints based on the issues we can give some preference to some technology otherwise it should be open to both IP and TP.

ERLDC shared their concerns regarding having a mix of MPLS TP and MPLS IP and stated that how conversion at every node will be done within ISTS network. With a test scenario CTU explained, if the main ring is MPLS TP and the new node has IP technology, then the new node implanter must bear the cost of an additional node to convert its IP payload to TP payload and then connect that TP node to the main TP ring.

Same methodology can be applied if the main network happens to be MPLS IP and the new ISTS node is TP.

CTU further stated that the draft report prepared by them suggests an information highway on MPLS TP as it is more deterministic compared to MPLS IP, however the new nodes on IP/TP can be connected to this highway suitably. CTU requested the JC members to give their suggestions in this regard.

7. CEA NPC suggested that the report shall be equipped with broad technical specifications for the proposed MPLS system. CTU replied that MPLS system on the whole shall be considered for migration, however the broad specifications shall constitute and conform to the functional requirements for the applications being run on the legacy network.

Conclusion:

1. POWERGRID and Grid India to provide their comments/views/suggestions as discussed.
2. In the next meeting report shall be reviewed in view of the above comments/views/suggestions.

Annexure-I**List of Participants**

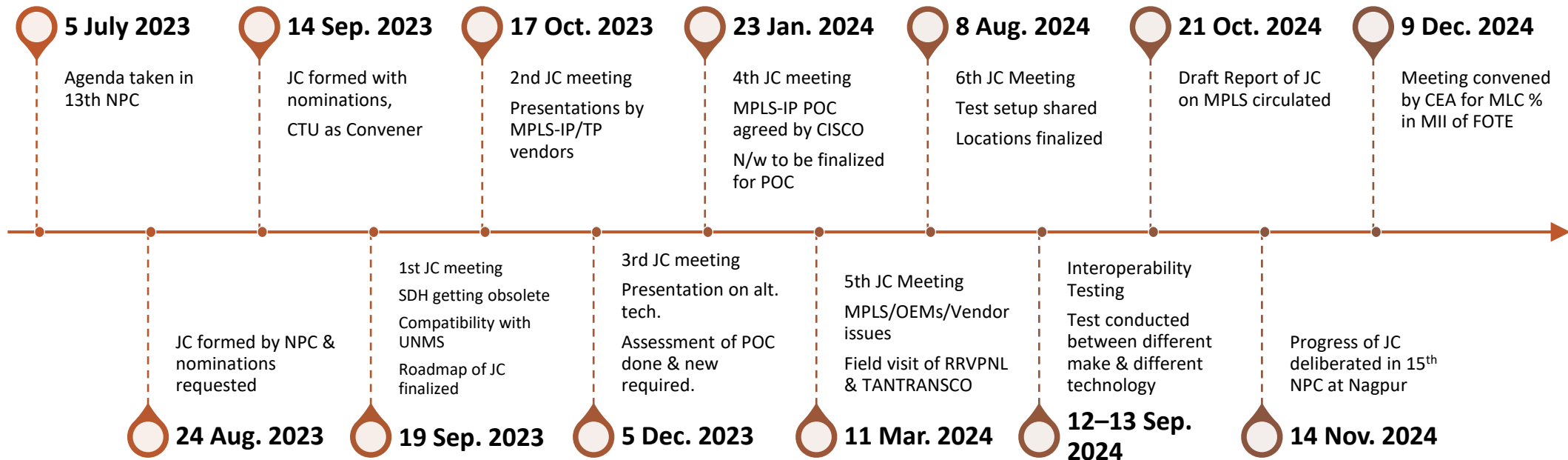
Sr. No.	Name	Designation
CEA NPC		
1	Sh. Satyendra Kumar Dotan	Director
CEA PCD		
2	Ms. Priyam Srivastava	Dy Director
NRLDC		
3	Sh. Ankur Gulati	DGM
ERLDC		
4	Sh. L Muralikrishna	DGM
KSEBL		
5	Sh. K P Rafeeqe	
TANTRANSCO		
6	Sh. K N Srinivasan	EE
POWERGRID		
7	Sh. Gaurav Awal	Ch Manager
WBSETCL		
8	Sh. Biswajit Madhu	Add. CE
CSPTCL		
9	Sh. Jitendra Jha	
CTUIL		
10	Sh. H S Kaushal	Sr GM
11	Sh. S K Gupta	Sr DGM
12	Sh. T P Verma	DGM
13	Ms. Kalpana Shukla	DGM
14	Sh. Kaushal Suman	Ch Manager
15	Sh. Prakhar Pathak	Engineer
16	Sh. Anshul Mahawar	Engineer (T)



Agenda for 7th JC Meeting

20.12.2024

Chronology



Grid Application	Cross OEMs (OEMs of same technology IP or TP) On MPLS	Cross Technology (TP & IP)	Same OEM & Same Technology IP/TP On MPLS
SCADA		On ethernet only 	
VOIP		On ethernet only 	
AMR		On ethernet only 	
*Tele Protection (Distance over Ethernet)			
Tele Protection (Distance over E1)			
Tele Protection (Differential C37.94)			 Tested only for MPLS TP

*This was tested for DTPC with TP (GE)/(BELDEN) to TP (HITACHI). Remaining test were done by pinging on Laptop

Proposed Recommendations (under Draft Report)

MPLS TP/IP network can be integrated with legacy SDH networks with hybrid or any intermediate interfaces supporting SDH technology.

By adopting a hybrid approach, the transition to packet based MPLS technology can be achieved without disrupting existing services while maintaining compatibility with existing infrastructure.

The integration of MPLS with SDH legacy system should also provide full feature support for adding and dropping SDH tributaries (STM, E1, Ethernet service) on the node.

Focus on OEM Collaboration to resolve the remaining interoperability issues

Proposed Recommendations (under Draft Report)



Training and Skill Gap	Personnel Training, Knowledge Transfer, Training and Expertise
OAM Integration	UNMS shall be used to integrate the legacy SDH and MPLS TP/IP environments efficiently.
Redundancy Measures	New channels shall be configured in the legacy network to mitigate the disruption in channel redundancies while migrating from SDH to MPLS environment.
Repeaters optimization	An optimization for repeaters is also required to collocate the repeaterless distances of MPLS environment with the legacy network.
Security	Protect both MPLS-TP and MPLS-IP traffic in line with the CEA cyber security Guidelines 2021

For existing ISTS Nodes

Proposed Recommendations (under Draft Report)

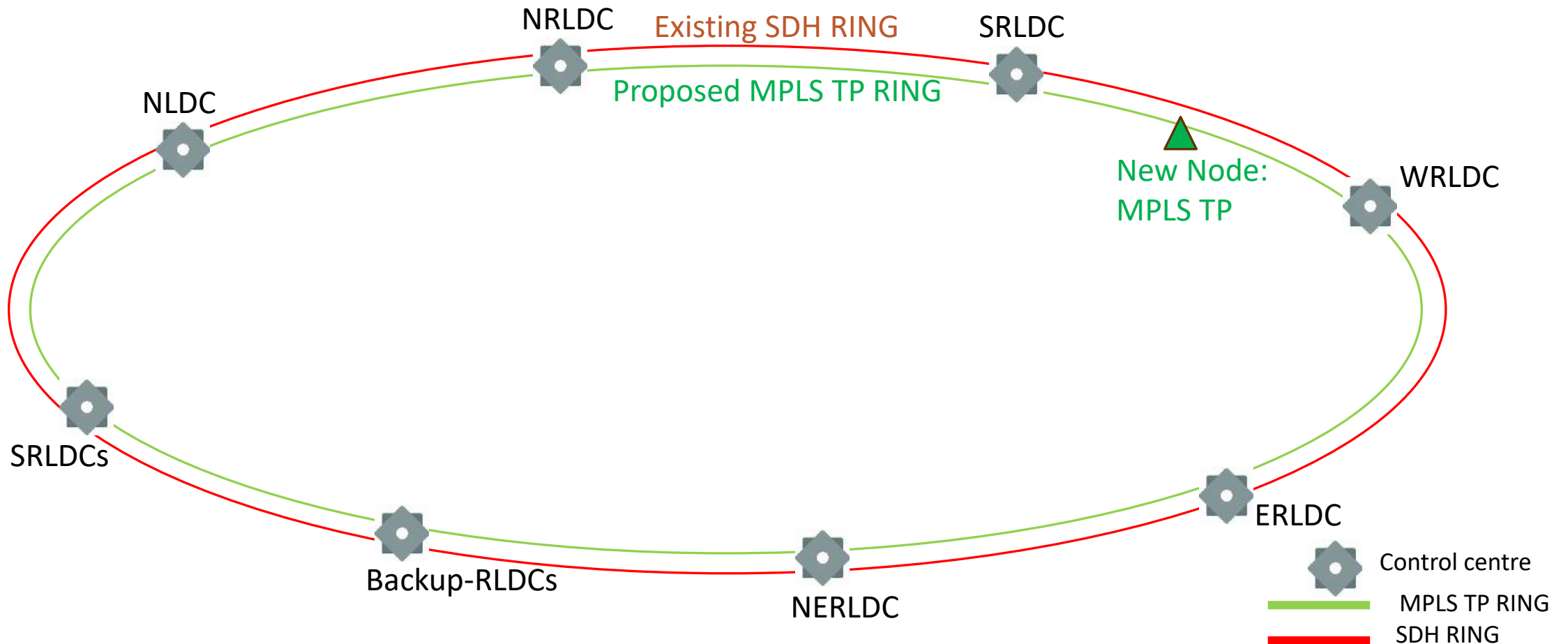
- It is proposed to have a connectivity of all the Control Centers in ring topology with the more deterministic MPLS TP network alongwith the existing SDH network.
- Link budget requirements to route the existing data efficiently.
- MPLS equipment deployment:
 - To substitute the SDH equipment if it has lived the depreciated life (eg 7 years).
 - At SDH nodes which are not to be replaced, for add/drop of channels MPLS TP equipment may be required.
 - At all new nodes.

For upcoming ISTS nodes

Proposed Recommendations (under Draft Report)

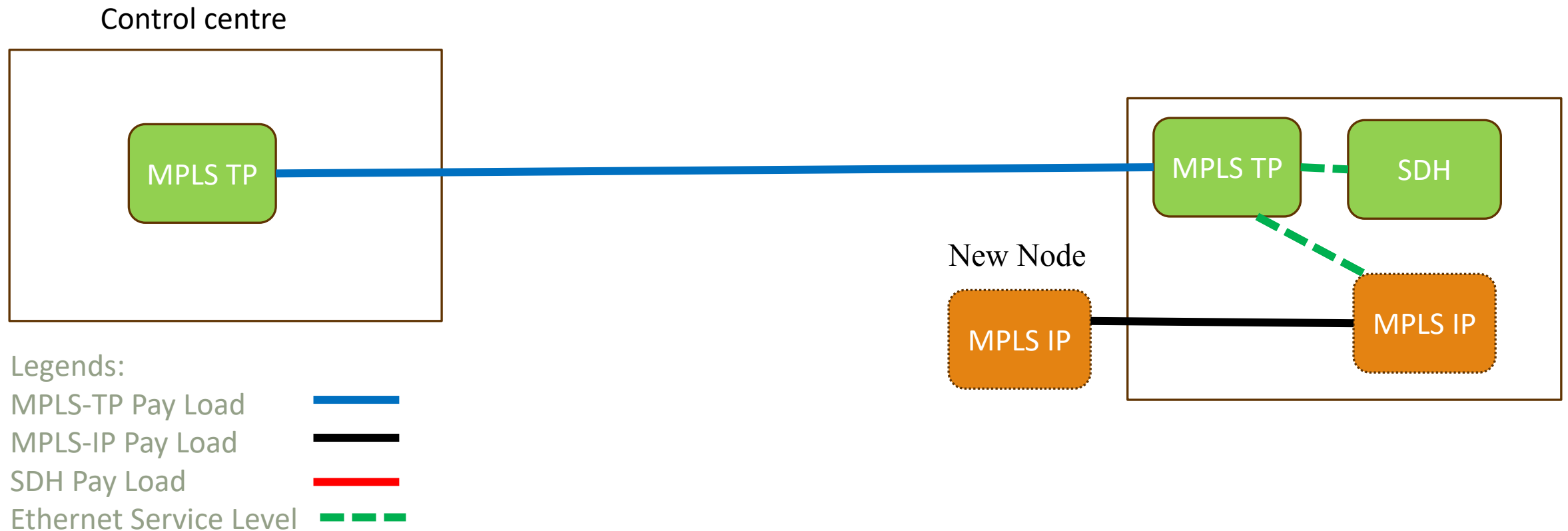
- Besides nodes covered above, all the existing and new SDH nodes is proposed to be reviewed and engineered for either MPLS IP or MPLS TP equipment.
- New node with MPLS IP getting terminated to an intermediate MPLS TP node to reach the control center. In this case MPLS IP traffic shall be fed in the MPLS TP node via ethernet and further transmitted.
- New node with MPLS IP getting terminated directly to control center. In this case an MPLS IP equipment needs to be provided at the control center.

Migration Methodology for Existing ISTS nodes



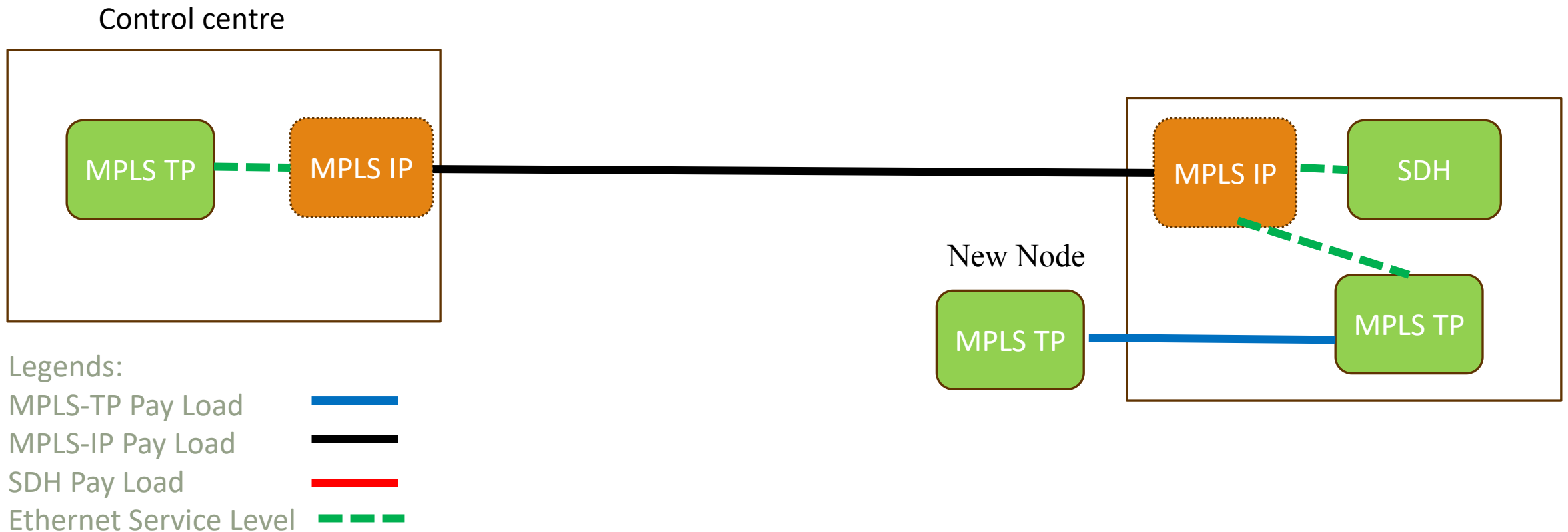
Migration Methodology for new/upcoming ISTS nodes

New node with MPLS IP getting terminated to an intermediate SDH node to reach the control centre



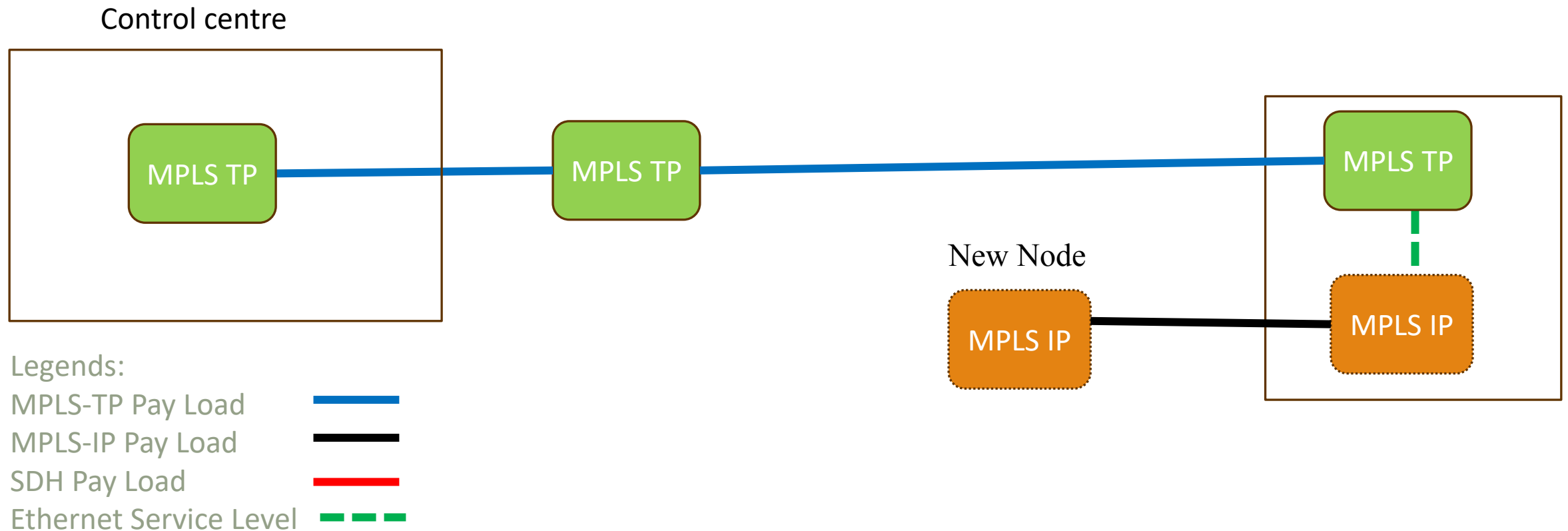
Migration Methodology for new/upcoming ISTS nodes

New node with MPLS TP getting terminated to an intermediate SDH node to reach the control centre



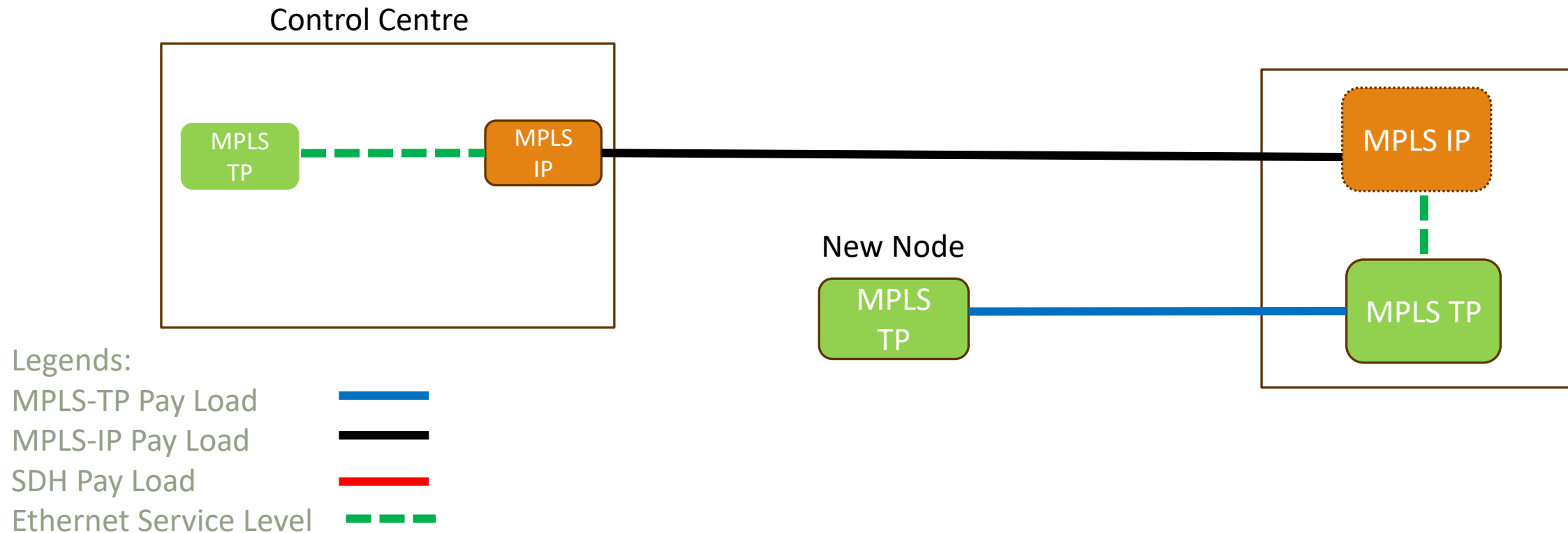
Migration Methodology for new/upcoming ISTS nodes

New node with MPLS IP getting terminated to an intermediate MPLS TP node to reach the control centre



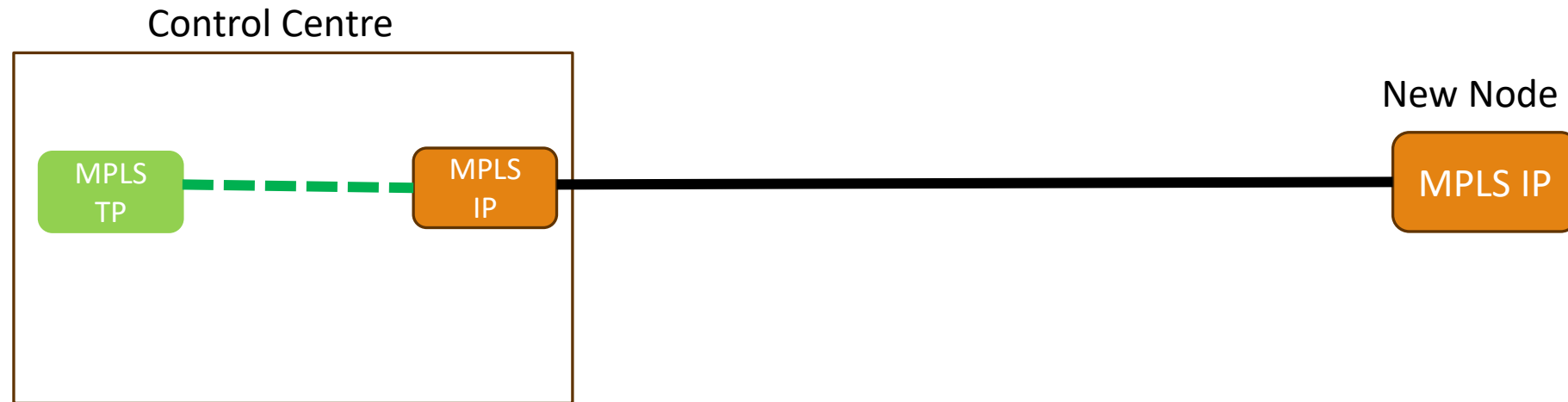
Migration Methodology for new/upcoming ISTS nodes

New node with MPLS TP getting terminated to an intermediate MPLS IP node to reach the control centre



Migration Methodology for new/upcoming ISTS nodes

New node with MPLS IP getting terminated radially to control centre



Legends:

- MPLS-TP Pay Load ————
- MPLS-IP Pay Load ————
- SDH Pay Load ————
- Ethernet Service Level - - - -

Migration Methodology for new/upcoming ISTS nodes

New node with MPLS TP getting terminated radially to control centre



Legends:

- MPLS-TP Pay Load ———— (solid blue line)
- MPLS-IP Pay Load ———— (solid black line)
- SDH Pay Load ———— (solid red line)
- Ethernet Service Level - - - - (dashed green line)

Deliberation in 15th NPC at Nagpur held on 14.11.2024

OEM/Vendor shall plan based on the required market volume to increase the Local Content.

CEA shall also take up with MoP to optimize the LC/MII year on year basis to make a wider participation of OEMs.



Thank you

पावर ग्रिड कारपोरेशन ऑफ इंडिया लिमिटेड

पूर्वी क्षेत्र पारेषण प्रणाली - II

(क्षेत्रीय प्रचालन सेवार्य)

अंतर कार्यालय ज्ञापन

प्रेषक: महाप्रबंधक (यू.एल.डी.सी.),
पूर्वी क्षेत्र -II/कोलकाता

सेवा मे: महाप्रबंधक (जी. ए. एंड. सी),
केंद्रीय कार्यालय/गुरुग्राम

दिनांक: 18.04.2023

सन्दर्भ: ई.आर-II/कोल/यू ल डी सी/F-77

LOA संख्या: ER-II/KOL/CS/I-3008/P-2927/4924 31.12.2021, एस.ए.पी. पी.ओ. न.4800011082

विषय: - Proof of Concept (PoC) for Multiprotocol Level switching -Transport Profile (MPLS-TP) Technology for transmission of data and voice in the existing communication networks of ULDC- Completion of Testing Regarding.

1. This has reference to the demonstration of PoC for MPLS-TP technology for transmission of data and voice in ULDC network which was approved to be carried out in ER-II ULDC network on pilot basis vide e-Office * File No. CC-LDC-41-20/0006/2021/LDandC Grp2 (Computer No. 409643)
2. In this regard, this is to inform that the objectives of testing of said PoC have been tested successfully as per the approved network diagram. The summary of the tests conducted is tabulated below.

Summary of Testing for POC of MPLS Network in ULDC network

Sr. No.	Service Hooked in MPLS System	Link Name		Date Of Integration/Testing
		From	To	
1	Farakka RTU Data-Main	Farakka	ERLDC	22-Jun-22
2	VOIP Data-Main	Farakka	ERLDC	23-Jun-22
3	PMU Data-Main	Farakka	ERLDC	30-Jun-22
4	SLDC ICCP Data-Main	SLDC	ERLDC	29-Jun-22
5	Long Haul Link Testing along with Switching time test between main and Back up Path	Farakka	Gokarna	06-Jul-22
6	DTPC Link	Rajarhat	Subhasgram	16-Mar-23

3. The detailed test reports are enclosed as **Annexure-I** for perusal and record.
यह आपके जानकारी और आवश्यक कार्रवाई हेतु प्रेषित है। This is for your kind information and necessary action please.

अंजन कुमार दास
18/04/23
(अंजन कुमार दास)

संलग्न : यथोक्त

प्रतिलिपि: विनम्र सूचनार्थ हेतु

(i). मुख्य महाप्रबंधक (संपदा प्रबंधन) पूर्वी क्षेत्र- II)



पावरग्रिड
POWERGRID

पावर ग्रिड कॉर्पोरेशन ऑफ इंडिया लिमिटेड
(भारत सरकार का उद्यम)
POWER GRID CORPORATION OF INDIA LIMITED
(A Government of India Enterprise)

Ref No- ER-II/ULDC/PoC/MPLS-TP/F-77/2128

Dated: 31.03.2023

To,
M/S Tejas Networks Ltd.
Plot No. 25 JP Software Park
Electronic City Phase-I
Hosur Road, Bengaluru 560 100

Subject: Work Completion Certificate

Ref.: (i). Your Letter Dated 23/03/2023
(ii). LOA No. ER-II/KOL/CS/I-3a008/P-2927/4924 Dated 31-12-2021
(iii). ER-II/KOL/CS/I-3008/P-2927/FTE Dated 14-11-2022 (Final Time Extension)

Dear Sir,

1. This has reference to your above-mentioned letter regarding the work "Proof of Concept for Multiprotocol Level switching –Transport Profile (MPLS-TP) Technology for transmission of data and voice in the existing communication networks of ULDC" Which was awarded to you vide above mentioned LOA.
2. The Objective(s) of the said testing had been completed successfully in all respect within 30/09/2022.

This completion certificate does not relieve you of your obligation to complete the balance execution of facilities in accordance with contract.

Thanking you,

Yours Faithfully,

अंजन कुमार
31/03/2023

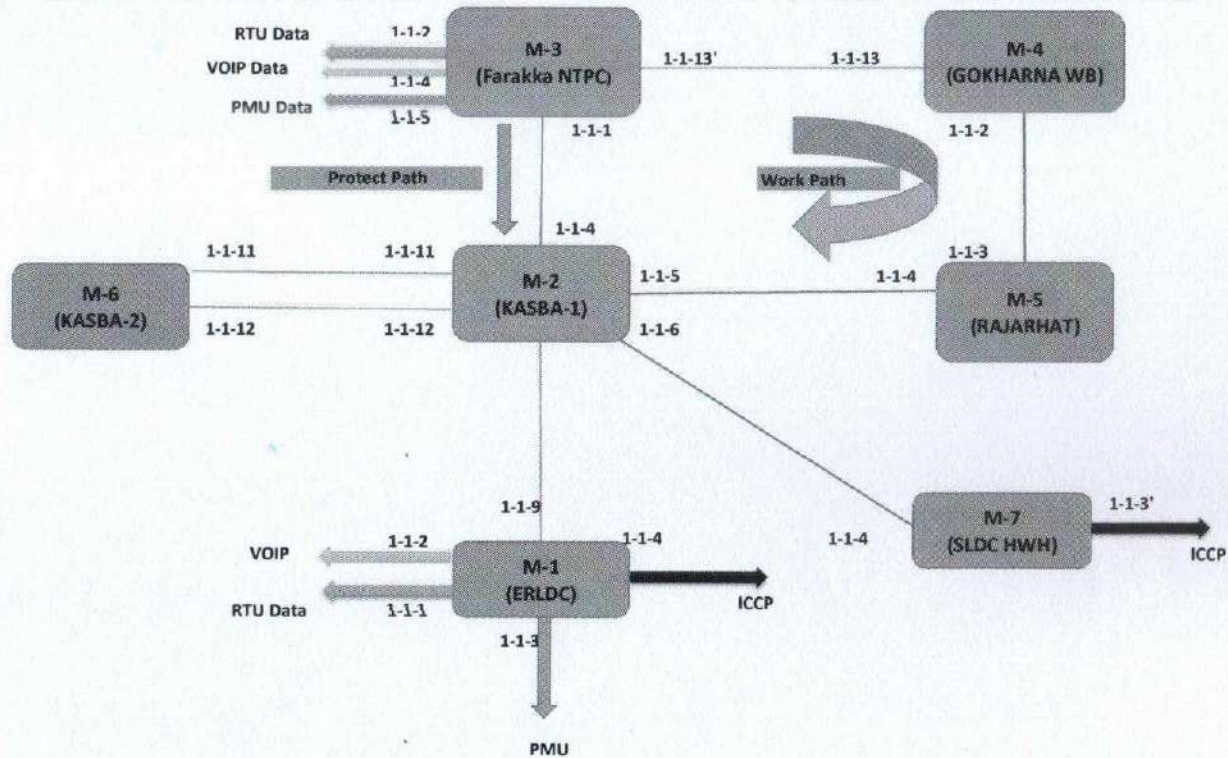
(Anjan Kr. Das)
General Manager, ULDC

Enclosure: As stated above

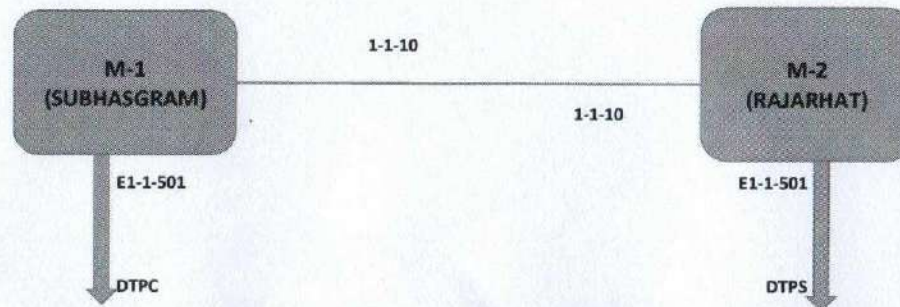
Copy: for kind information, please

1. CGM (AM), POWERGRID, ER-II

MPLS Network Diagram for POC PGCIL ULDC Test Setup-1 for RTU, VOIP, PMU and ICCP Data Testing



MPLS Network Diagram for POC PGCIL ULDC Test Setup-2 For E1 Testing



K.B. Nabli
 Dy. Manager (U.L.O.C.)
 POWERGRID, ER-II, BHQ, KOLKATA



MPLS-TP Test Reports Data.

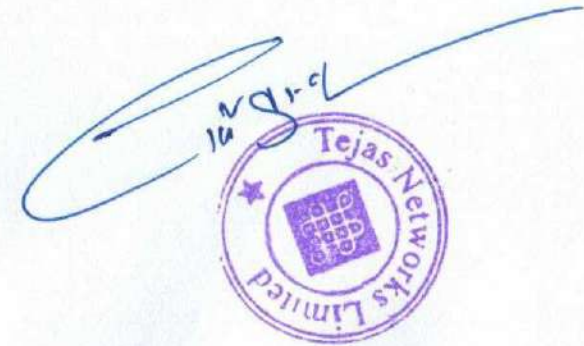
S.No.	Parameter under Test	Station Name A	Station Name B	Test Start Date	Test End Date	Result & Report	Remarks and observation
1	PMU Data*	ERLDC	Farakka NTPC	22-Jun-22	10-Oct-22	Performance Report Shared	OK
2	Voice and VOIP Data*	ERLDC	Farakka NTPC	23-Jun-22	10-Oct-22	Performance Report Shared	OK
3	RTU Data*	ERLDC	Farakka NTPC	30-Jun-22	10-Oct-22	Performance Report Shared	OK
4	ICCP Data*	ERLDC	SLDC HWH	29-Jun-22	10-Oct-22	Performance Report Shared	OK

S. No.	Parameter under Test	Station A	Station B	Total Link loss with Attenuators	Total Link Budget Supported by Amplifier	Result and Report	Remarks
1	Long Haul Link Test	Farakka NTPC (Tx)	Gokharna (Rx)	41.23 dB	150Km	Performance Report Shared	15dB Attenuation at Gokharna
2	Long Haul Link Test	Gokharna (Tx)	Farakka NTPC (Rx)	36.98 dB	140Km	Performance Report Shared	10dB Attenuation at Farakka

S.No.	Parameter under Test	Service Tested	Main Path Route	backup Path Route	Switching Time From	Result and Report	Remarks
1	Switchng time test between main and Back up Path	PMU	Farakka-Gokharna-Rajarhat-Kasba-ERLDC	Farakka-Kasba-ERLDC	27.04	Shared	OK
		Voice and VOIP			27.45	Shared	
		RTU Data			28.27	Shared	
		ICCP Data	SLDC-Kasba-ERLDC	NA	NA	NA	OK

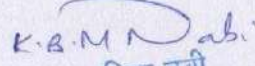
S.No.	Parameter under Test	Station Name A	Station Name B	Test Start Date	Test End Date	Result & Report	Remarks and observation
1	E1 Testing	DTPS	Rajarhat-Subhashgram	16-Mar-23	Still Running	Performance Report Shared	OK

K.B.N. Nabi.
 काशिफ नबी
 Kashif Nabi
 उप प्रबंधक (यू.एल.डी.सी.)
 Dy. Manager (U.L.D.C)
 पावरग्रिड, यूई सेक्टर-II, संशोधन मुख्यालय, कोलकाता
 POWERGRID, ER-II, RHQ, KOLKATA



Long Haul Link Test (Span Loss Calculation Details)

S/N	Location	Port and Slot Details		Optical Input & Output Power at port (dBm)	BA/PA (in dBm)	TX/RX Power (in dBm) in Amplifier	Span Losses (in dB)
1	Farakka NTPC to Gokharna	Farakka NTPC	1-1-13 TX	2.50	BA-13dBm	13.00	41.54
		Gokharna	1-1-13 RX	-28.54	NA	-28.54	
		Gokharna	1-1-13 TX	2.51	BA-13dBm	13.00	37.09
		Farakka NTPC	1-1-13 RX	-24.09	NA	-24.09	


 काशिफ नबी
 Kashif Nabi
 उप प्रबंधक (यू.एल.डी.सी.)
 Dy. Manager (U.L.D.C.)
 पावरग्रिड, पूर्वी क्षेत्र-II, क्षेत्रीय मुख्यालय, कोलकाता
 POWERGRID, ER-II, RHQ, KOLKATA

Comparison of PMU Latency at ERLD C pre and Post implementation of MPLS-TP

Farakka PMU Latency

2022 May

01-05-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	329	147.5845404
FARAKKA PMU02	144	329	147.0995822
FARAKKA PMU03	144	330	147.5557103
FARAKKA PMU04	144	329	147.8224234
FARAKKA PMU05	144	329	147.9616992

2022 June

01-06-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	146	189	149.393454
FARAKKA PMU02	146	190	148.974234
FARAKKA PMU03	146	181	149.2228412
FARAKKA PMU04	146	189	149.2987465
FARAKKA PMU05	146	184	149.0947075

2022 July

01-07-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	1147	147.505571
FARAKKA PMU02	144	1147	147.1727019
FARAKKA PMU03	144	1149	147.4749304
FARAKKA PMU04	144	1149	147.8238162
FARAKKA PMU05	144	1148	147.9491643

2022 August

01-08-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	9068	148.5995822
FARAKKA PMU02	144	9068	148.2019499
FARAKKA PMU03	145	9067	148.4860724
FARAKKA PMU04	145	9067	148.6664345
FARAKKA PMU05	145	9068	148.4408078

2022 September

01-09-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	1108	148.0995129
FARAKKA PMU02	144	1109	147.3569947
FARAKKA PMU03	145	1107	147.6617954
FARAKKA PMU04	145	1109	147.8427279
FARAKKA PMU05	145	1108	147.4154489

06-05-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	339	148.8154596
FARAKKA PMU02	145	339	148.0480501
FARAKKA PMU03	145	340	148.4582173
FARAKKA PMU04	145	340	148.8231198
FARAKKA PMU05	145	339	148.6956825

06-06-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	549	147.7674095
FARAKKA PMU02	144	549	147.2764624
FARAKKA PMU03	144	547	147.7200557
FARAKKA PMU04	144	548	147.887883
FARAKKA PMU05	144	548	147.5424791

06-07-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	268	148.020195
FARAKKA PMU02	144	268	147.7200557
FARAKKA PMU03	144	267	148.0181058
FARAKKA PMU04	145	269	148.2346797
FARAKKA PMU05	145	269	148.1288301

07-08-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	1149	147.9268802
FARAKKA PMU02	144	1149	147.4422006
FARAKKA PMU03	144	1148	147.7458217
FARAKKA PMU04	144	1149	148.1218663
FARAKKA PMU05	144	1147	147.7729805

07-09-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	336	147.6281337
FARAKKA PMU02	144	336	147.0800836
FARAKKA PMU03	144	336	147.3871866
FARAKKA PMU04	145	336	147.6274373
FARAKKA PMU05	144	337	147.4707521

14-05-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	387	148.2200557
FARAKKA PMU02	144	388	147.7026462
FARAKKA PMU03	144	389	148.1073423
FARAKKA PMU04	144	388	148.3962396
FARAKKA PMU05	144	389	148.0090529

14-06-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	314	147.9059889
FARAKKA PMU02	144	309	147.2005571
FARAKKA PMU03	144	315	147.6991643
FARAKKA PMU04	144	315	148.0048747
FARAKKA PMU05	144	315	148.0696379

14-07-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	323	147.948468
FARAKKA PMU02	144	333	147.7423398
FARAKKA PMU03	144	337	148.0626741
FARAKKA PMU04	144	337	148.4066852
FARAKKA PMU05	144	337	148.3147632

14-08-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	1148	147.9596942
FARAKKA PMU02	144	1148	147.2182071
FARAKKA PMU03	144	1148	147.5225851
FARAKKA PMU04	145	1148	147.8596247
FARAKKA PMU05	144	1148	147.9610841

14-09-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	1148	147.9415042
FARAKKA PMU02	144	1146	147.143454
FARAKKA PMU03	144	1148	147.4380223
FARAKKA PMU04	144	1146	147.6615599
FARAKKA PMU05	144	1147	147.6058496

20-05-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	144	494	147.6441504
FARAKKA PMU02	144	495	147.1302228
FARAKKA PMU03	144	455	147.5926184
FARAKKA PMU04	144	495	147.8488858
FARAKKA PMU05	144	494	148.0139276

20-06-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	468	148.6532033
FARAKKA PMU02	144	466	148.0369081
FARAKKA PMU03	144	469	148.2841226
FARAKKA PMU04	145	469	148.6344011
FARAKKA PMU05	144	467	148.6692201

20-07-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	356	148.3774373
FARAKKA PMU02	144	356	147.7235376
FARAKKA PMU03	144	356	148.0083565
FARAKKA PMU04	144	356	148.2841226
FARAKKA PMU05	145	356	148.1023677

20-08-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	306	148.2407794
FARAKKA PMU02	144	306	147.6743215
FARAKKA PMU03	145	307	147.9638135
FARAKKA PMU04	145	306	148.3235908
FARAKKA PMU05	0	307	148.1329158

20-09-2022

PMU Name	Min Ingres (ms)	Max Ingres (ms)	Avg Ingres(ms)
FARAKKA PMU01	145	1146	147.8530641
FARAKKA PMU02	144	1148	147.1204735
FARAKKA PMU03	144	1148	147.4247911
FARAKKA PMU04	144	1148	147.5341226
FARAKKA PMU05	144	1146	147.5967967

FARAKKA PMU DATA RUNNING ONSDH

FARAKKA PMU DATA RUNNING ON MPLS-TP

FARAKKA PMU DATA SHIFTED
TO MPLS-TP ON
30-06-2022

K.B.M. Nabi

काशिफ नबी
Kashif Nabi

उप प्रबंधक (यु.एल.डी.सी.)
Dy. Manager (U.L.D.C.)

पावरग्रिड, एनई क्षेत्र-II, क्षेत्रीय मुख्यालय, कोलकाता
POWERGRID, ER-II, RHQ, KOLKATA

Switching Time Test Calculation sheet

Ethernet Protection Switching Time Calculation					
Test Scenario	Tx Frames	Rx Frames	Drop frames	Frame per second.	Switching time in milliseconds
Scenario-1	732,379	732,313	66	2441.04	27.037656
	732,379	732,312	67	2441.04	27.447318
	732,378	732,309	69	2441.03	28.266756

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WERGRD, ER-II, RHQ, KOLKATA

Port 1: 1GigE Layer 2 Traffic Term Test Report

Generated by JDSU 5800 MSAM

General Info: Device Under Test	
Owner	---
Device Under Test	---
Software Revision	---
Serial Number	---
Comment	---

General Info: Tester Comments	
Test Results	---
Tester	---

General Info: Test Instrument	
Model	JDSU 5800v2
SW Revision	1.1
BERT Serial Number	0120

Results: Summary / Status	
Lost Frames	66
Bit Errors	504

Results: Summary / SLA / KPI	
Rx Mbps, L1	10.39
Tx Mbps, L1	10.39
Rx Mbps, L2	10.00
Tx Mbps, L2	10.00
Frame Loss - FLR, Lost Frames	66
Frame Loss - FLR, Frame Loss Ratio	9.01E-05
Round Trip Delay - FD (us), Average	48.48
Round Trip Delay - FD (us), Current	48.41
Round Trip Delay - FD (us), Maximum	50.86
Packet Jitter - FDV (us), Average	0

Port 1: 1GigE Layer 2 Traffic Term Test Report

Packet Jitter - FDV (us), Max Average	0
Packet Jitter - FDV (us), Peak	4.10
Packet Jitter - FDV (us), Instantaneous	0

Results: Summary / Time	
Current Date	09/27/2022
Current Time	4:13:16 PM AST
Test Elapsed Time	5m:00s
Test Time Remaining	0s

Results: Interface / Signal	
Signal Losses	0
Signal Loss Seconds	0
Sync Loss Seconds	0
Link Loss Seconds	0
Optical Rx Overload	OFF
Optical Rx Level (dBm)	-9.0
Rx Frequency (Hz)	1,250,000,969
Rx Freq Deviation (ppm)	0.8
Rx Freq Max Deviation (ppm)	0.8
Tx Clock Source	Internal
Tx Frequency (Hz)	1,250,000,000
Tx Freq Deviation (ppm)	0.0
Tx Freq Max Deviation (ppm)	0.0

Results: Ethernet / L2 Link Stats	
Total Util %, Average	1.039
Total Util %, Current	1.039
Total Util %, Minimum	1.011
Total Util %, Peak	1.039
Current Util %, Unicast	1.039
Current Util %, Multicast	0.000

Port 1: IGigE Layer 2 Traffic Term Test Report

Current Util %, Broadcast	0.000
Rx Pause Length (ms), Current	Unavailable
Rx Pause Length (ms), Minimum	Unavailable
Rx Pause Length (ms), Maximum	Unavailable
Frame Rate, Average	2,441.04
Frame Rate, Current	2,441
Frame Rate, Minimum	2,375
Frame Rate, Peak	2,442
Frame Size, Average	512
Frame Size, Minimum	512
Frame Size, Maximum	512
Rx Mbps, Cur L1	10.39
Rx Mbps, Cur L2	10.00
Tx Mbps, Cur L1	10.39
Tx Mbps, Cur L2	10.00
Round Trip Delay (us), Average	48.48
Round Trip Delay (us), Current	48.41
Round Trip Delay (us), Minimum	46.76
Round Trip Delay (us), Maximum	50.86
Packet Jitter (us), Average	0
Packet Jitter (us), Max Average	0
Packet Jitter (us), Peak	4.10
Packet Jitter (us), Instantaneous	0
VLAN ID	Unavailable
VLAN User Priority	Unavailable
SVLAN ID	Unavailable
SVLAN User Pri	Unavailable
SVLAN Frame DEI	Unavailable
SVLAN1 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN2 ID	Unavailable

Port 1: 1GigE Layer 2 Traffic Term Test Report

Preceding SVLANs, SVLAN2 User Priority	Unavailable
Preceding SVLANs, SVLAN2 Frame DEI	Unavailable
Preceding SVLANs, SVLAN2 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN3 ID	Unavailable
Preceding SVLANs, SVLAN3 User Priority	Unavailable
Preceding SVLANs, SVLAN3 Frame DEI	Unavailable
Preceding SVLANs, SVLAN3 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN4 ID	Unavailable
Preceding SVLANs, SVLAN4 User Priority	Unavailable
Preceding SVLANs, SVLAN4 Frame DEI	Unavailable
Preceding SVLANs, SVLAN4 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN5 ID	Unavailable
Preceding SVLANs, SVLAN5 User Priority	Unavailable
Preceding SVLANs, SVLAN5 Frame DEI	Unavailable
Preceding SVLANs, SVLAN5 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN6 ID	Unavailable
Preceding SVLANs, SVLAN6 User Priority	Unavailable
Preceding SVLANs, SVLAN6 Frame DEI	Unavailable
Preceding SVLANs, SVLAN6 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN7 ID	Unavailable
Preceding SVLANs, SVLAN7 User Priority	Unavailable
Preceding SVLANs, SVLAN7 Frame DEI	Unavailable
Preceding SVLANs, SVLAN7 ID, PRI, DEI	Unavailable
Svc Disruption (us)	17793793.97

Results: Ethernet / L2 Link Counts	
Received Frames	732,313
Transmitted Frames	732,379
Rx Acterna Frames	732,313
Tx Acterna Frames	732,379
Pause Frames	0

Port 1: 1GigE Layer 2 Traffic Term Test Report

Rx VLAN Frames	0
Rx Q-in-Q Frames	0
Rx Stacked VLAN Frames	0
Unicast Frames	732,313
Multicast Frames	0
Broadcast Frames	0
Rx Frame Bytes	374,944,256
Tx Frame Bytes	374,978,048
Span Tree Frames	0
64 Byte Frames	0
65-127 Byte Frames	0
128-255 Byte Frames	0
256-511 Byte Frames	0
512-1023 Byte Frames	732,313
1024-<Jumbo Frames	0
Jumbo Frames	0

Results: Ethernet / L2 Filter Stats	
Total Util %, Average	1.039
Total Util %, Current	1.039
Total Util %, Minimum	1.011
Total Util %, Peak	1.039
Frame Rate, Average	2,441.04
Frame Rate, Current	2,441
Frame Rate, Minimum	2,375
Frame Rate, Peak	2,442
Frame Size, Average	512
Frame Size, Minimum	512
Frame Size, Maximum	512
Rx Mbps, Cur L1	10.39
Rx Mbps, Cur L2	10.00

Port 1: 1GigE Layer 2 Traffic Term Test Report

Round Trip Delay (us), Average	48.48
Round Trip Delay (us), Current	48.41
Round Trip Delay (us), Minimum	46.76
Round Trip Delay (us), Maximum	50.86
Packet Jitter (us), Average	0
Packet Jitter (us), Max Average	0
Packet Jitter (us), Peak	4.10
Packet Jitter (us), Instantaneous	0
VLAN ID	Unavailable
VLAN User Priority	Unavailable
SVLAN1 ID	Unavailable
SVLAN1 User Priority	Unavailable
SVLAN1 Frame DEI	Unavailable
SVLAN1 ID, PRI, DEI	Unavailable
SVLAN2 ID	Unavailable
SVLAN2 User Priority	Unavailable
SVLAN2 Frame DEI	Unavailable
SVLAN2 ID, PRI, DEI	Unavailable
SVLAN3 ID	Unavailable
SVLAN3 User Priority	Unavailable
SVLAN3 Frame DEI	Unavailable
SVLAN3 ID, PRI, DEI	Unavailable
SVLAN4 ID	Unavailable
SVLAN4 User Priority	Unavailable
SVLAN4 Frame DEI	Unavailable
SVLAN4 ID, PRI, DEI	Unavailable
SVLAN5 ID	Unavailable
SVLAN5 User Priority	Unavailable
SVLAN5 Frame DEI	Unavailable
SVLAN5 ID, PRI, DEI	Unavailable

Port 1: 1GigE Layer 2 Traffic Term Test Report

SVLAN6 ID	Unavailable
SVLAN6 User Priority	Unavailable
SVLAN6 Frame DEI	Unavailable
SVLAN6 ID, PRI, DEI	Unavailable
SVLAN7 ID	Unavailable
SVLAN7 User Priority	Unavailable
SVLAN7 Frame DEI	Unavailable
SVLAN7 ID, PRI, DEI	Unavailable

Results: Ethernet / L2 Filter Counts	
Valid Rx Frames	732,313
Rx Acterna Frames	732,313
Rx VLAN Frames	0
Rx Q-in-Q Frames	0
Rx Stacked VLAN Frames	0
Unicast Frames	732,313
Multicast Frames	0
Broadcast Frames	0
Span Tree Frames	0
Rx Frame Bytes	374,944,256
64 Byte Frames	0
65-127 Byte Frames	0
128-255 Byte Frames	0
256-511 Byte Frames	0
512-1023 Byte Frames	732,313
1024-<Jumbo Frames	0

Results: Ethernet / BERT Stats	
Pattern Losses	1
Pattern Loss Seconds	1
Bit Error Rate	1.89E-07

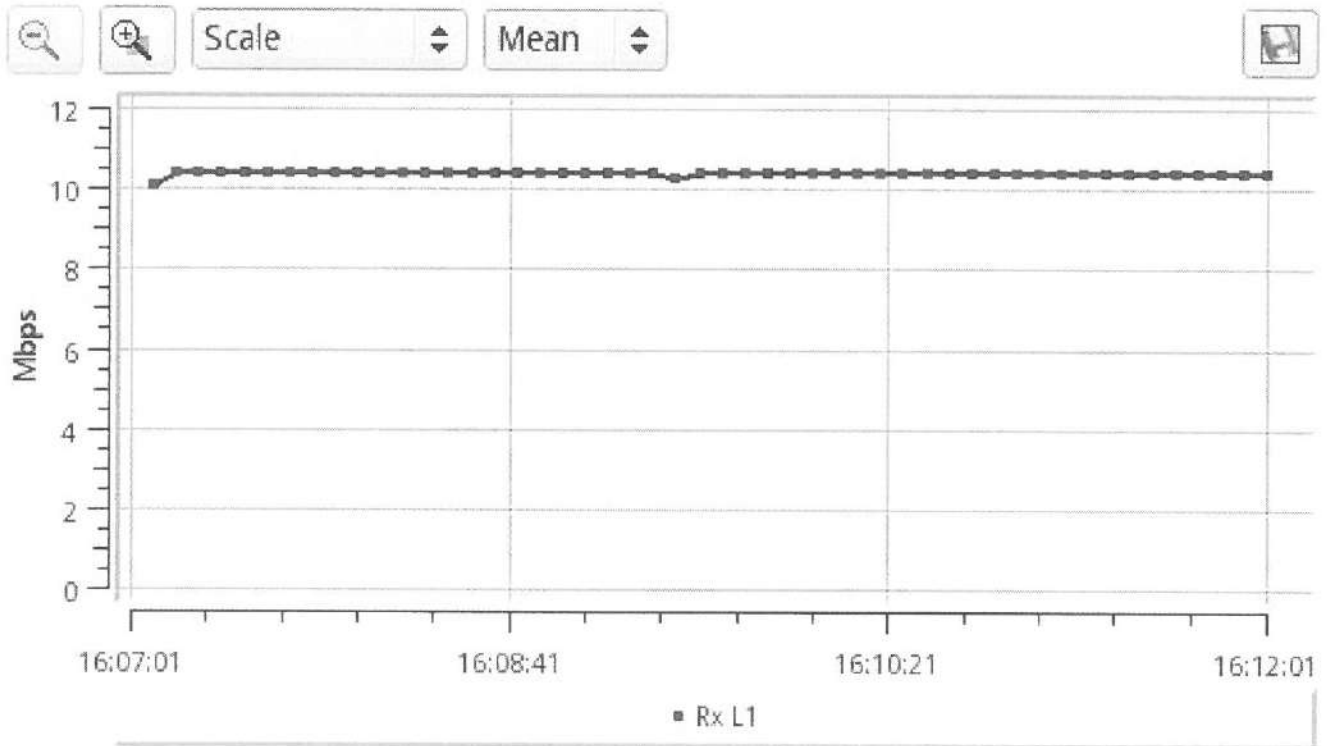
Port 1: 1GigE Layer 2 Traffic Term Test Report

Bit Errors	504
Bit Errored Seconds	1
Bit Error-Free Seconds	299
Bit Error-Free Seconds, %	99.6667

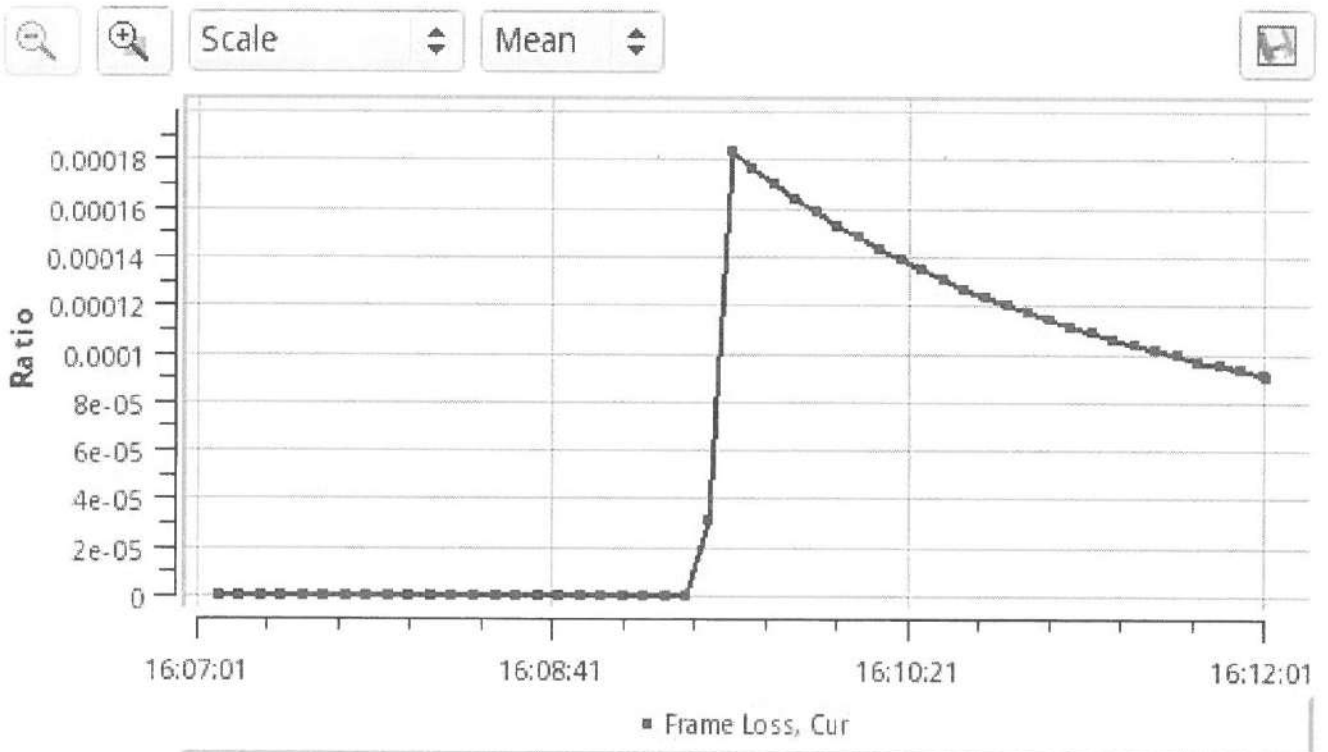
Results: Ethernet / Error Stats	
Symbol Errors	0
Code Violations	0
Code Violation Rate	0.00E+00
Code Violation Seconds	0
Undersized Frames	0
Runts	0
Jabbers	0
FCS Errored Frames	0
Errored Frames	0
Acterna Payload Errors	0
Packet Error Rate	9.01E-05
Lost Frames	66
Frame Loss Ratio	9.01E-05
OoS Frames	0
Errored Second	1
Severely Errored Second	0
Unavailable Second	0
Errored Second Ratio	3.3333E-03
Severely Errored Second Ratio	0.0000E+00

Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Graphs / Throughput

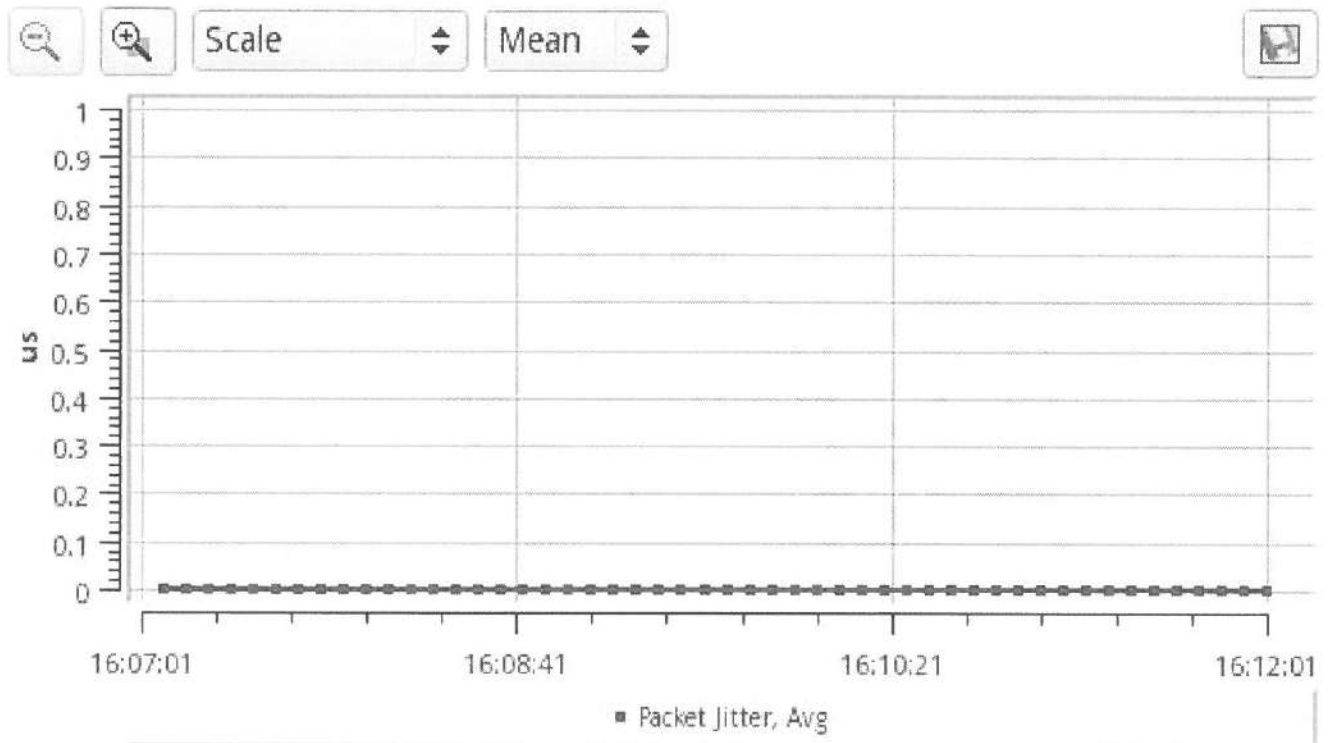


Results: Graphs / Frame Loss, Cur

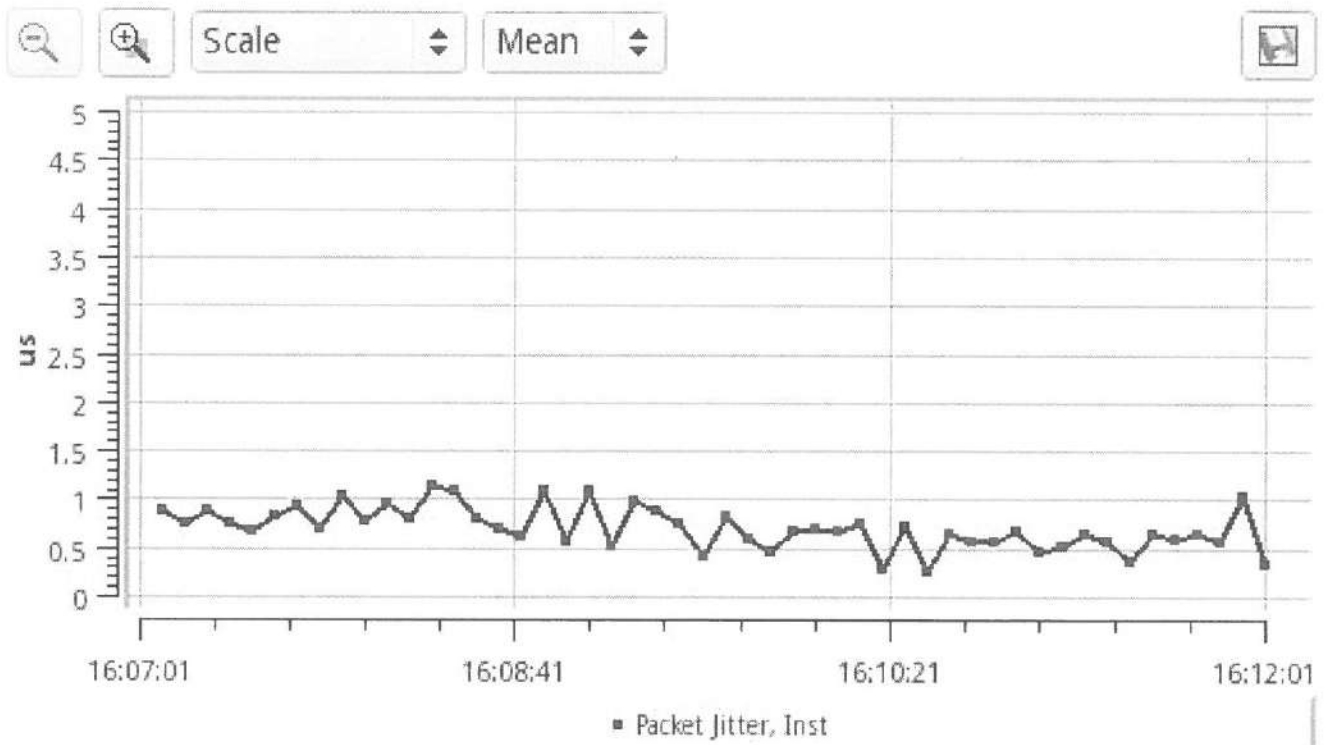


Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Graphs / Packet Jitter, Avg

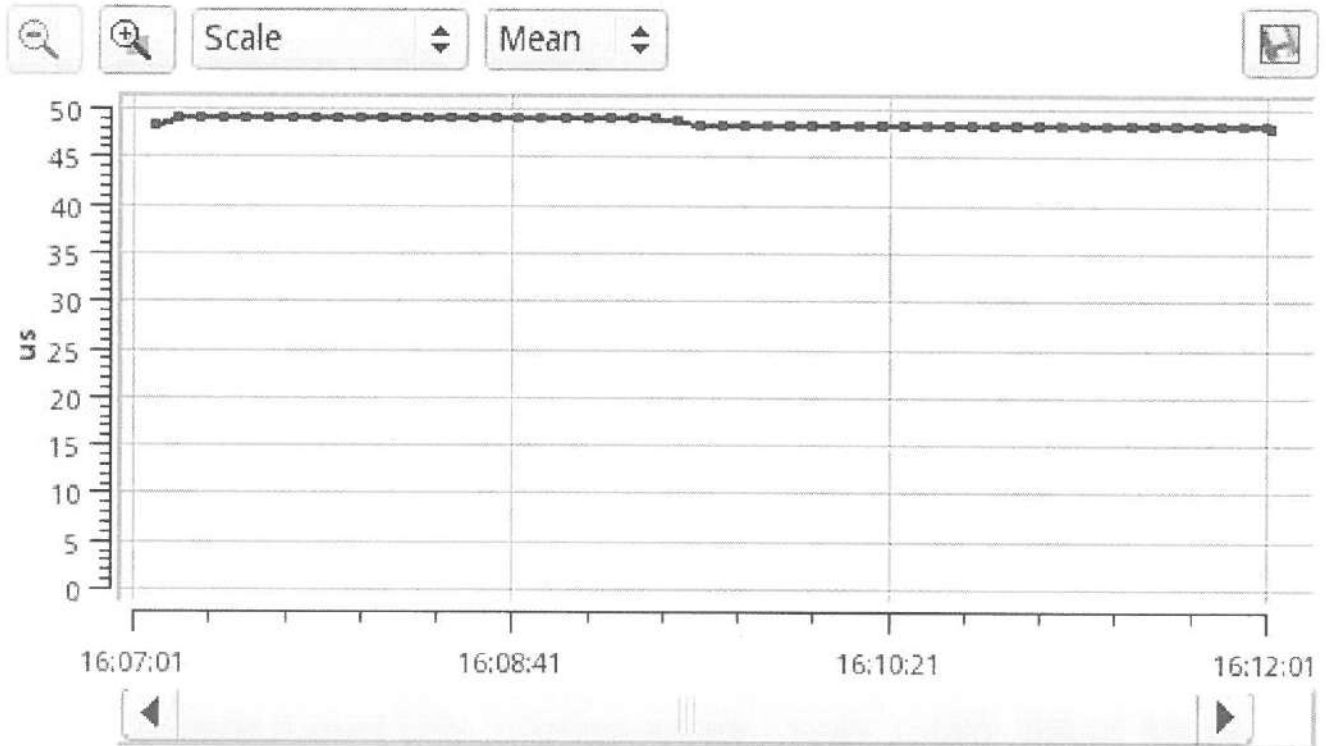


Results: Graphs / Packet Jitter, Inst

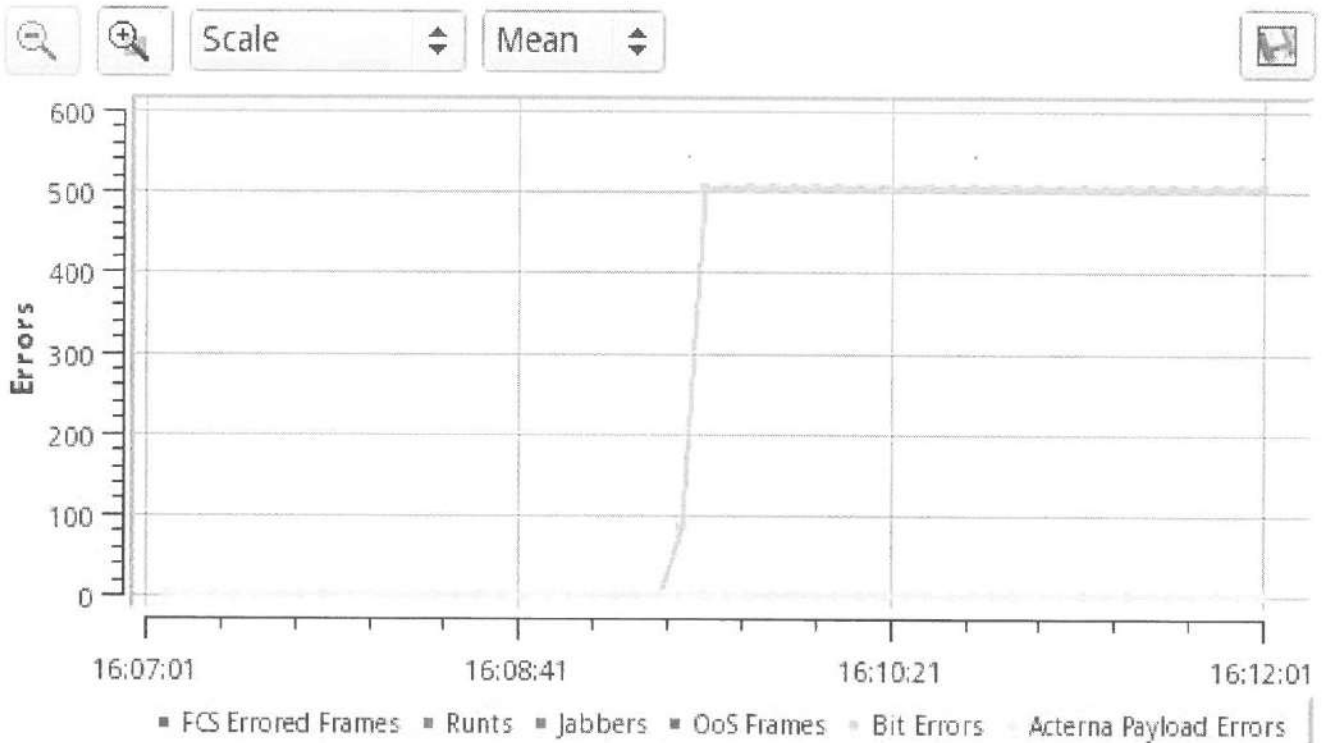


Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Graphs / Latency (RTD), Cur



Results: Graphs / Errors



Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Ethernet / AutoNeg Status	
Link Advt. Status	Done
Link Config ACK	Yes
Pause Capable	Neither
Flow Control	Off
FDX Capable	Yes
HDX Capable	Yes
Remote Fault	No

Results: LEDs / Ethernet	
Signal Present	ON
Sync Acquired	ON
Link Active	ON
Frame Detect	ON
ATP Detect	ON
Pattern Sync	ON + HISTORY
VLAN Frame Detect	OFF
SVLAN Frame Detect	OFF
Stacked VLAN Detect	OFF

Setup: Interface	
Connector/Wavelength	SFP
Clock Source	Internal
Internal - Frequency Offset (ppm)	0
Auto Negotiation	On
FDX Capable	Yes
HDX Capable	Yes
Pause Capable	Both Rx and Tx
Pause Length (Quanta)	1000
Pause Length (Time - ms)	0.512
Auto-start traffic when laser turned on	No

Port 1: 1GigE Layer 2 Traffic Term Test Report

Unit Identifier	JDSU-0120-01
Make this unit discoverable	OFF
Source IP	192.168.1.11
Default Gateway	192.168.1.10
Subnet Mask	255.255.255.0

Setup: Connector SFP	
Wavelength (nm)	1550
Nominal Bit Rate (Mbits/sec)	10,300
Minimum Bit Rate (Mbits/sec)	9,888
Maximum Bit Rate (Mbits/sec)	11,330
Power Level Type	Average Power
Vendor	HG GENUINE
Vendor PN	MTRS-1S60-01
Vendor Rev	1.0
Max Rx Level (dBm)	-1.00015
Max Tx Level (dBm)	4.00002
Diagnostic Monitoring	1
Diagnostic Byte	104
Transceiver	10G Base-ER

Setup: Ethernet	
Encapsulation	None
Test Mode	Traffic
Frame Type	DIX
Frame Size (Bytes)	512
Destination Type	Unicast
Loop Type	Broadcast
Destination MAC	00-80-16-00-00-00
Source MAC Type	Factory Default
Default MAC	00-80-16-92-34-D2

Port 1: 1GigE Layer 2 Traffic Term Test Report

Auto-increment MAC	No
# MACs in Sequence	2
EtherType	0x800
Tx Payload	Acterna
Acterna Payload	BERT
Tx BERT Pattern	2 ²³ - 1
RTD Setup	High Precision - Low Delay

Setup: Traffic	
Load Type	Constant
Load Unit	Bit Rate
Allow flooding	No
Bit Rate	Mbps
Load (Mbps)	10
Actual IR (Mbps)	10
Layer	L2

Setup: Filters / Ethernet	
Encapsulation	Don't Care
Destination Type	Don't Care
Source MAC Type	Don't Care

Setup: Filters / Byte Pattern	
Use Byte Pattern as	Don't Care

Setup: Filters / Payload	
Payload Analysis	On
Use Tx Payload settings	Yes
Rx Payload	Acterna
Rx BERT Pattern	2 ²³ - 1

Port 1: 1GigE Layer 2 Traffic Term Test Report

Setup: Filters / TPID	
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100

Setup: Timed Test	
Test Type	Timed Test
Timed Test Duration	5m:00s

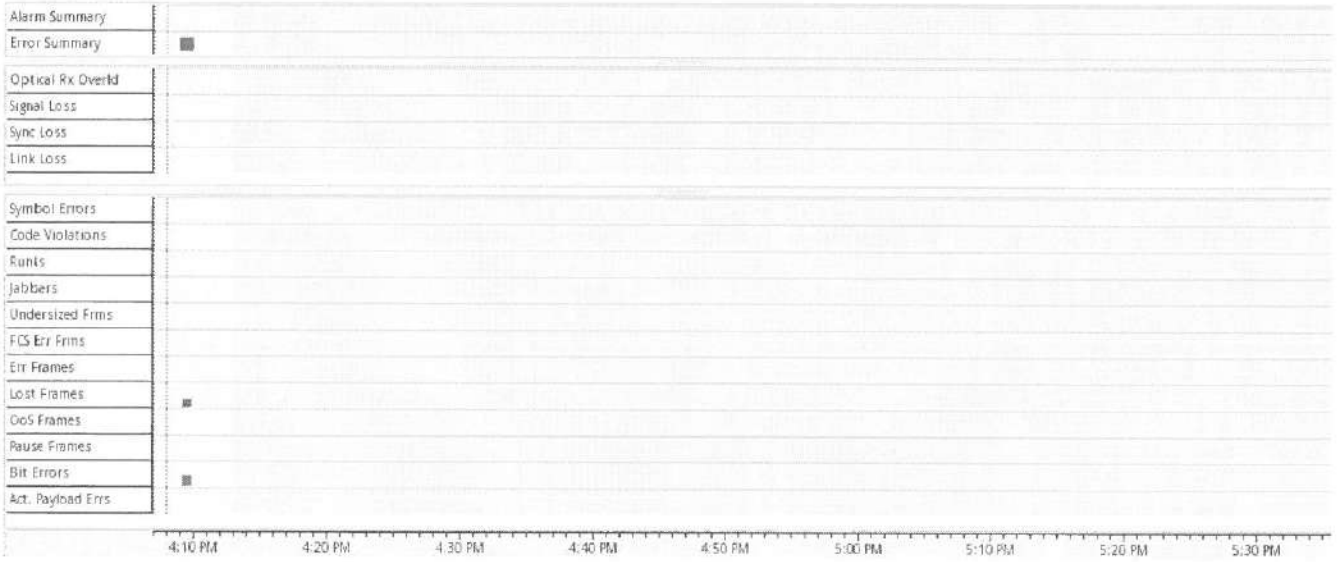
Setup: Toolbar / Service Disruption	
No applicable setups...	

Setup: Toolbar / Errors	
Error Type	Code
Insertion Style	Single

Log: Event Log					
No.	Event	Date	Start Time	Stop Time	Dur./Val.
1	START	09/27/2022	16:07:01.0	--	--
2	Bit Errors	09/27/2022	16:09:24.6	16:09:24.6	504
3	Lost Frames	09/27/2022	16:09:24.6	16:09:24.6	66
4	STOP	09/27/2022	16:12:01.0	--	--

Port 1: 1GigE Layer 2 Traffic Term Test Report

Histogram



Port 1: 1GigE Layer 2 Traffic Term Test Report

Generated by JDSU 5800 MSAM

General Info: Device Under Test	
Owner	---
Device Under Test	---
Software Revision	---
Serial Number	---
Comment	---

General Info: Tester Comments	
Test Results	---
Tester	---

General Info: Test Instrument	
Model	JDSU 5800v2
SW Revision	1.1
BERT Serial Number	0120

Results: Summary / Status	
Lost Frames	67
Bit Errors	468

Results: Summary / SLA / KPI	
Rx Mbps, L1	10.39
Tx Mbps, L1	10.39
Rx Mbps, L2	10.00
Tx Mbps, L2	10.00
Frame Loss - FLR, Lost Frames	67
Frame Loss - FLR, Frame Loss Ratio	9.15E-05
Round Trip Delay - FD (us), Average	48.58
Round Trip Delay - FD (us), Current	48.66
Round Trip Delay - FD (us), Maximum	50.86
Packet Jitter - FDV (us), Average	0

Port 1: 1GigE Layer 2 Traffic Term Test Report

Packet Jitter - FDV (us), Max Average	0
Packet Jitter - FDV (us), Peak	4.10
Packet Jitter - FDV (us), Instantaneous	0

Results: Summary / Time	
Current Date	09/27/2022
Current Time	4:33:06 PM AST
Test Elapsed Time	5m:00s
Test Time Remaining	0s

Results: Interface / Signal	
Signal Losses	0
Signal Loss Seconds	0
Sync Loss Seconds	0
Link Loss Seconds	0
Optical Rx Overload	OFF
Optical Rx Level (dBm)	-8.5
Rx Frequency (Hz)	1,250,000,959
Rx Freq Deviation (ppm)	0.8
Rx Freq Max Deviation (ppm)	0.8
Tx Clock Source	Internal
Tx Frequency (Hz)	1,250,000,000
Tx Freq Deviation (ppm)	0.0
Tx Freq Max Deviation (ppm)	0.0

Results: Ethernet / L2 Link Stats	
Total Util %, Average	1.039
Total Util %, Current	1.039
Total Util %, Minimum	1.010
Total Util %, Peak	1.039
Current Util %, Unicast	1.039
Current Util %, Multicast	0.000

Port 1: 1GigE Layer 2 Traffic Term Test Report

Current Util %, Broadcast	0.000
Rx Pause Length (ms), Current	Unavailable
Rx Pause Length (ms), Minimum	Unavailable
Rx Pause Length (ms), Maximum	Unavailable
Frame Rate, Average	2,441.04
Frame Rate, Current	2,441
Frame Rate, Minimum	2,374
Frame Rate, Peak	2,442
Frame Size, Average	512
Frame Size, Minimum	512
Frame Size, Maximum	512
Rx Mbps, Cur L1	10.39
Rx Mbps, Cur L2	10.00
Tx Mbps, Cur L1	10.39
Tx Mbps, Cur L2	10.00
Round Trip Delay (us), Average	48.58
Round Trip Delay (us), Current	48.66
Round Trip Delay (us), Minimum	46.76
Round Trip Delay (us), Maximum	50.86
Packet Jitter (us), Average	0
Packet Jitter (us), Max Average	0
Packet Jitter (us), Peak	4.10
Packet Jitter (us), Instantaneous	0
VLAN ID	Unavailable
VLAN User Priority	Unavailable
SVLAN ID	Unavailable
SVLAN User Pri	Unavailable
SVLAN Frame DEI	Unavailable
SVLAN1 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN2 ID	Unavailable

Port 1: 1GigE Layer 2 Traffic Term Test Report

Preceding SVLANs, SVLAN2 User Priority	Unavailable
Preceding SVLANs, SVLAN2 Frame DEI	Unavailable
Preceding SVLANs, SVLAN2 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN3 ID	Unavailable
Preceding SVLANs, SVLAN3 User Priority	Unavailable
Preceding SVLANs, SVLAN3 Frame DEI	Unavailable
Preceding SVLANs, SVLAN3 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN4 ID	Unavailable
Preceding SVLANs, SVLAN4 User Priority	Unavailable
Preceding SVLANs, SVLAN4 Frame DEI	Unavailable
Preceding SVLANs, SVLAN4 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN5 ID	Unavailable
Preceding SVLANs, SVLAN5 User Priority	Unavailable
Preceding SVLANs, SVLAN5 Frame DEI	Unavailable
Preceding SVLANs, SVLAN5 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN6 ID	Unavailable
Preceding SVLANs, SVLAN6 User Priority	Unavailable
Preceding SVLANs, SVLAN6 Frame DEI	Unavailable
Preceding SVLANs, SVLAN6 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN7 ID	Unavailable
Preceding SVLANs, SVLAN7 User Priority	Unavailable
Preceding SVLANs, SVLAN7 Frame DEI	Unavailable
Preceding SVLANs, SVLAN7 ID, PRI, DEI	Unavailable
Svc Disruption (us)	18289986.30

Results: Ethernet / L2 Link Counts	
Received Frames	732,312
Transmitted Frames	732,379
Rx Acterna Frames	732,312
Tx Acterna Frames	732,379
Pause Frames	0

Port 1: 1GigE Layer 2 Traffic Term Test Report

Rx VLAN Frames	0
Rx Q-in-Q Frames	0
Rx Stacked VLAN Frames	0
Unicast Frames	732,312
Multicast Frames	0
Broadcast Frames	0
Rx Frame Bytes	374,943,744
Tx Frame Bytes	374,978,048
Span Tree Frames	0
64 Byte Frames	0
65-127 Byte Frames	0
128-255 Byte Frames	0
256-511 Byte Frames	0
512-1023 Byte Frames	732,312
1024-<Jumbo Frames	0
Jumbo Frames	0

Results: Ethernet / L2 Filter Stats	
Total Util %, Average	1.039
Total Util %, Current	1.039
Total Util %, Minimum	1.010
Total Util %, Peak	1.039
Frame Rate, Average	2,441.04
Frame Rate, Current	2,441
Frame Rate, Minimum	2,374
Frame Rate, Peak	2,442
Frame Size, Average	512
Frame Size, Minimum	512
Frame Size, Maximum	512
Rx Mbps, Cur L1	10.39
Rx Mbps, Cur L2	10.00

Port 1: 1GigE Layer 2 Traffic Term Test Report

Round Trip Delay (us), Average	48.58
Round Trip Delay (us), Current	48.66
Round Trip Delay (us), Minimum	46.76
Round Trip Delay (us), Maximum	50.86
Packet Jitter (us), Average	0
Packet Jitter (us), Max Average	0
Packet Jitter (us), Peak	4.10
Packet Jitter (us), Instantaneous	0
VLAN ID	Unavailable
VLAN User Priority	Unavailable
SVLAN1 ID	Unavailable
SVLAN1 User Priority	Unavailable
SVLAN1 Frame DEI	Unavailable
SVLAN1 ID, PRI, DEI	Unavailable
SVLAN2 ID	Unavailable
SVLAN2 User Priority	Unavailable
SVLAN2 Frame DEI	Unavailable
SVLAN2 ID, PRI, DEI	Unavailable
SVLAN3 ID	Unavailable
SVLAN3 User Priority	Unavailable
SVLAN3 Frame DEI	Unavailable
SVLAN3 ID, PRI, DEI	Unavailable
SVLAN4 ID	Unavailable
SVLAN4 User Priority	Unavailable
SVLAN4 Frame DEI	Unavailable
SVLAN4 ID, PRI, DEI	Unavailable
SVLAN5 ID	Unavailable
SVLAN5 User Priority	Unavailable
SVLAN5 Frame DEI	Unavailable
SVLAN5 ID, PRI, DEI	Unavailable

Port 1: 1GigE Layer 2 Traffic Term Test Report

SVLAN6 ID	Unavailable
SVLAN6 User Priority	Unavailable
SVLAN6 Frame DEI	Unavailable
SVLAN6 ID, PRI, DEI	Unavailable
SVLAN7 ID	Unavailable
SVLAN7 User Priority	Unavailable
SVLAN7 Frame DEI	Unavailable
SVLAN7 ID, PRI, DEI	Unavailable

Results: Ethernet / L2 Filter Counts	
Valid Rx Frames	732,312
Rx Acterna Frames	732,312
Rx VLAN Frames	0
Rx Q-in-Q Frames	0
Rx Stacked VLAN Frames	0
Unicast Frames	732,312
Multicast Frames	0
Broadcast Frames	0
Span Tree Frames	0
Rx Frame Bytes	374,943,744
64 Byte Frames	0
65-127 Byte Frames	0
128-255 Byte Frames	0
256-511 Byte Frames	0
512-1023 Byte Frames	732,312
1024-<Jumbo Frames	0

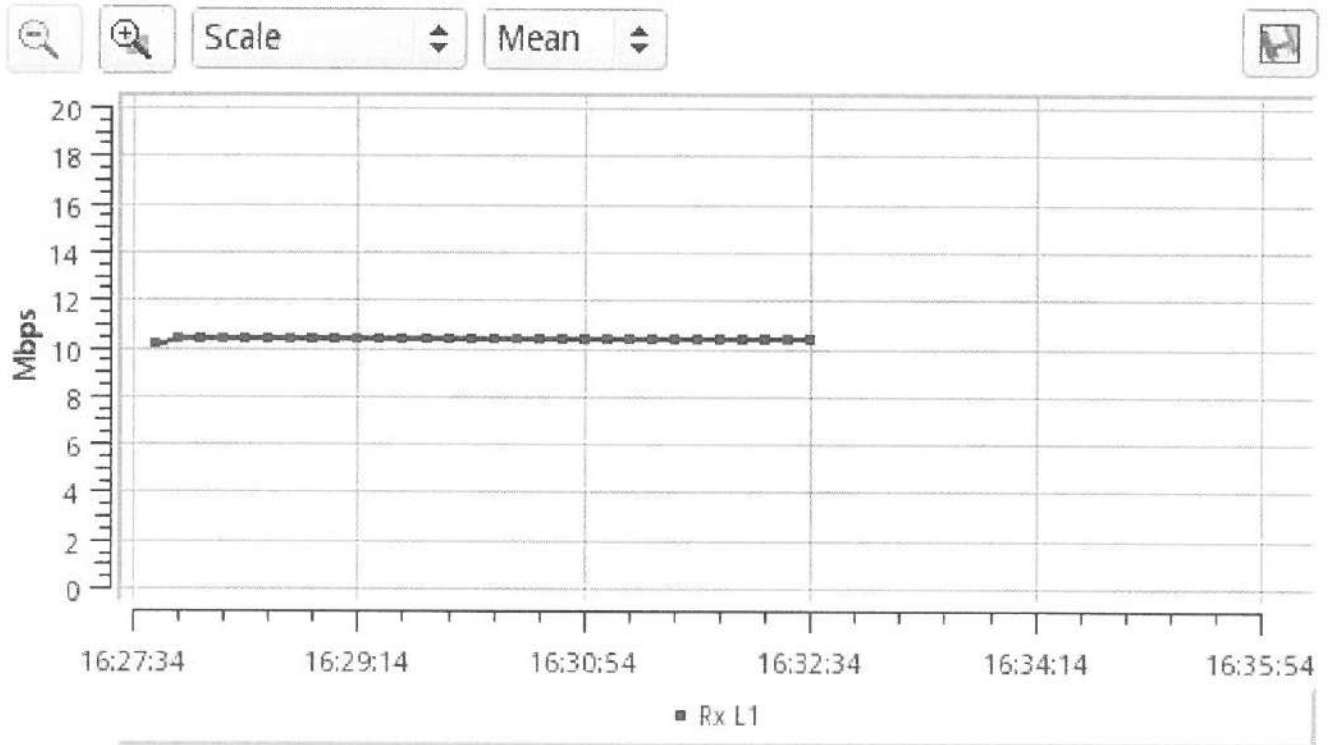
Results: Ethernet / BERT Stats	
Pattern Losses	1
Pattern Loss Seconds	1
Bit Error Rate	1.76E-07

Port 1: 1GigE Layer 2 Traffic Term Test Report

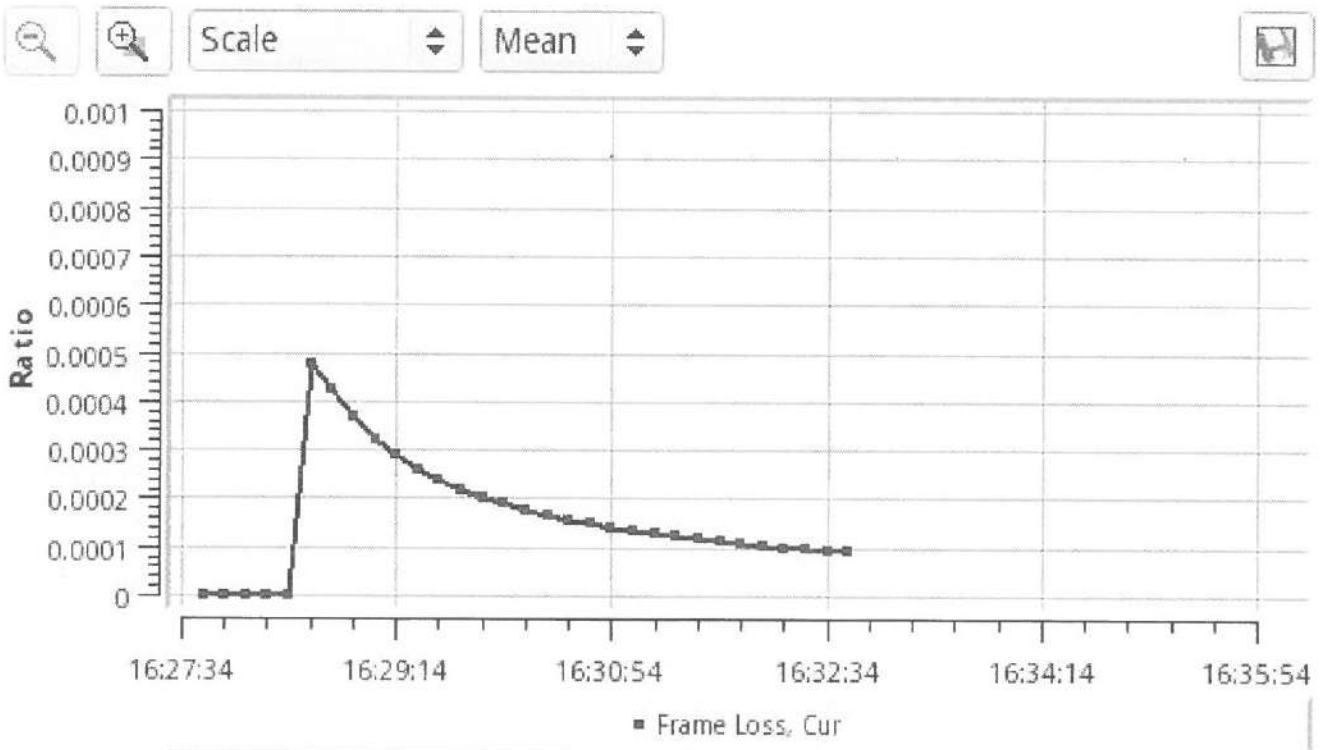
Bit Errors	468
Bit Errored Seconds	1
Bit Error-Free Seconds	299
Bit Error-Free Seconds, %	99.6667

Results: Ethernet / Error Stats	
Symbol Errors	0
Code Violations	0
Code Violation Rate	0.00E+00
Code Violation Seconds	0
Undersized Frames	0
Runts	0
Jabbers	0
FCS Errored Frames	0
Errored Frames	0
Acterna Payload Errors	0
Packet Error Rate	9.15E-05
Lost Frames	67
Frame Loss Ratio	9.15E-05
OoS Frames	0
Errored Second	1
Severely Errored Second	0
Unavailable Second	0
Errored Second Ratio	3.3333E-03
Severely Errored Second Ratio	0.0000E+00

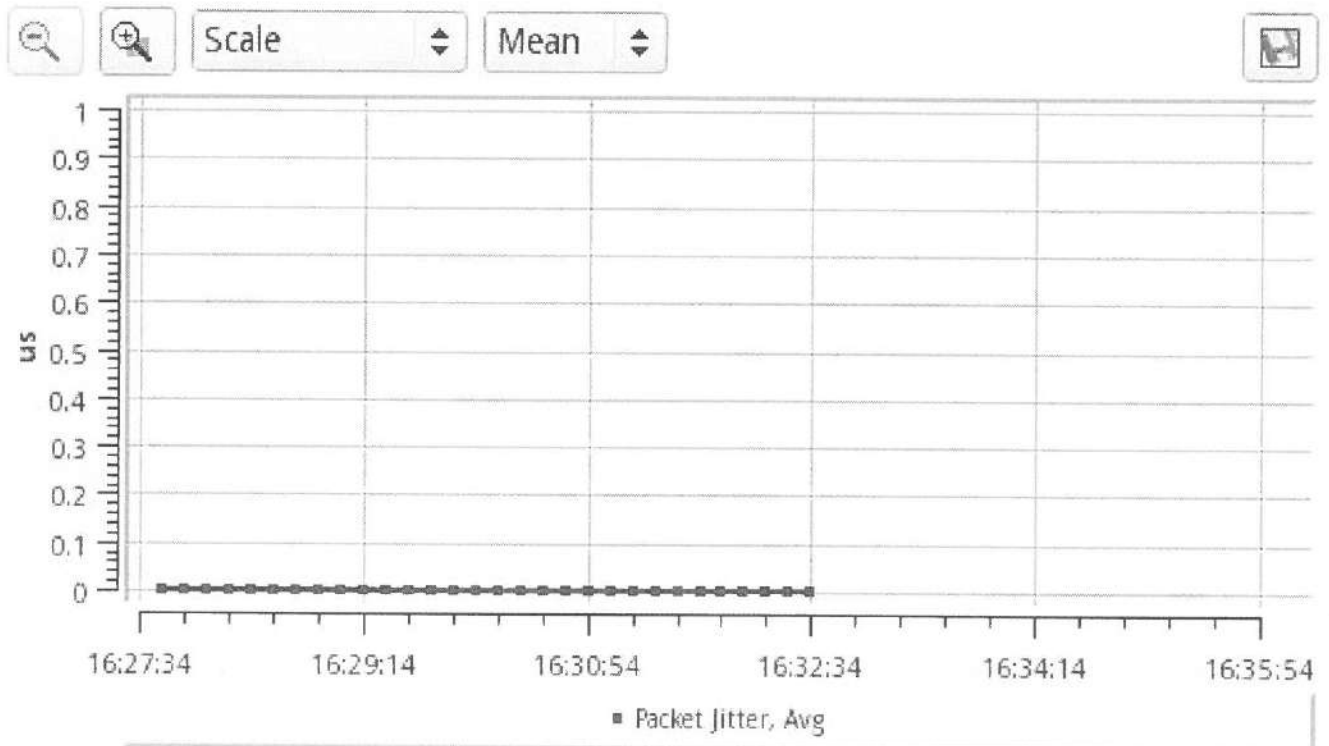
Results: Graphs / Throughput



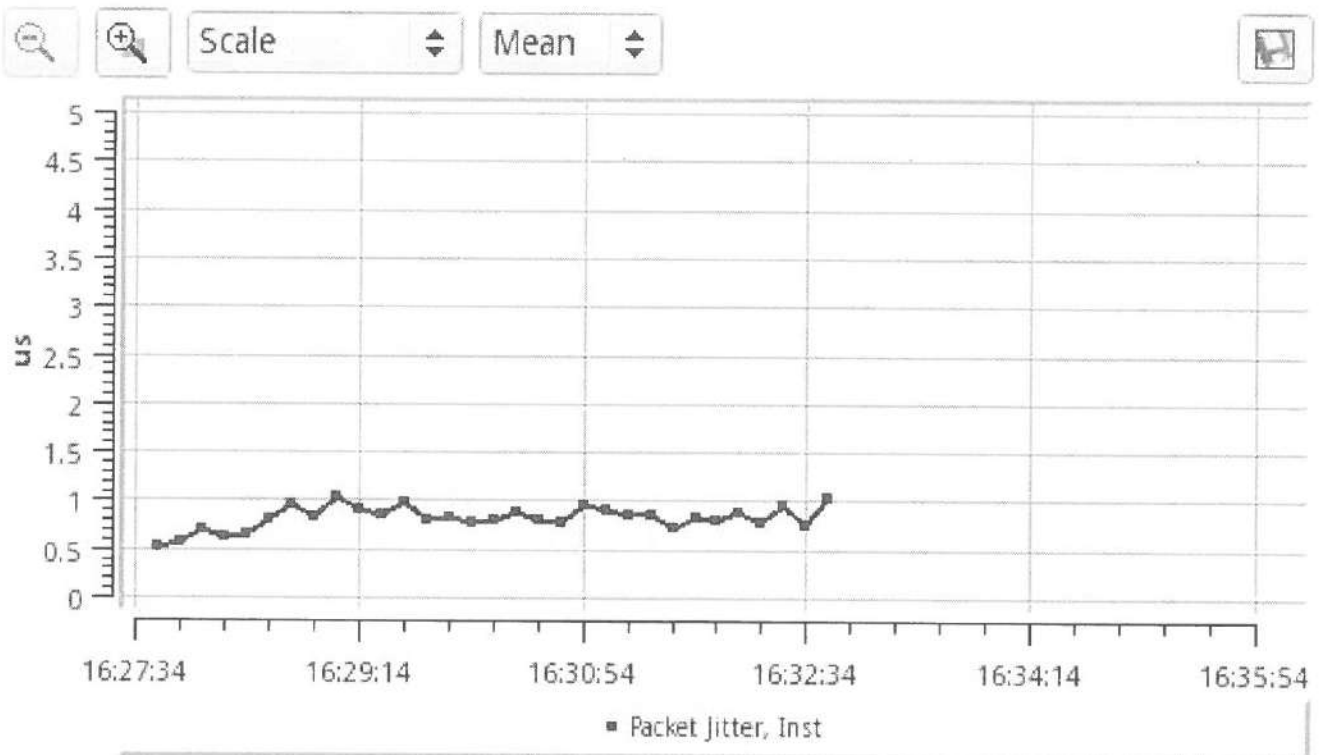
Results: Graphs / Frame Loss, Cur



Results: Graphs / Packet Jitter, Avg



Results: Graphs / Packet Jitter, Inst



Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Graphs / Latency (RTD), Cur



Results: Graphs / Errors



Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Ethernet / AutoNeg Status	
Link Advt. Status	Done
Link Config ACK	Yes
Pause Capable	Neither
Flow Control	Off
FDX Capable	Yes
HDX Capable	Yes
Remote Fault	No

Results: LEDs / Ethernet	
Signal Present	ON
Sync Acquired	ON
Link Active	ON
Frame Detect	ON
ATP Detect	ON
Pattern Sync	ON + HISTORY
VLAN Frame Detect	OFF
SVLAN Frame Detect	OFF
Stacked VLAN Detect	OFF

Setup: Interface	
Connector/Wavelength	SFP
Clock Source	Internal
Internal - Frequency Offset (ppm)	0
Auto Negotiation	On
FDX Capable	Yes
HDX Capable	Yes
Pause Capable	Both Rx and Tx
Pause Length (Quanta)	1000
Pause Length (Time - ms)	0.512
Auto-start traffic when laser turned on	No

Port 1: 1GigE Layer 2 Traffic Term Test Report

Unit Identifier	JDSU-0120-01
Make this unit discoverable	OFF
Source IP	192.168.1.11
Default Gateway	192.168.1.10
Subnet Mask	255.255.255.0

Setup: Connector SFP	
Wavelength (nm)	1550
Nominal Bit Rate (Mbits/sec)	10,300
Minimum Bit Rate (Mbits/sec)	9,888
Maximum Bit Rate (Mbits/sec)	11,330
Power Level Type	Average Power
Vendor	HG GENUINE
Vendor PN	MTRS-1S60-01
Vendor Rev	1.0
Max Rx Level (dBm)	-1.00015
Max Tx Level (dBm)	4.00002
Diagnostic Monitoring	1
Diagnostic Byte	104
Transceiver	10G Base-ER

Setup: Ethernet	
Encapsulation	None
Test Mode	Traffic
Frame Type	DIX
Frame Size (Bytes)	512
Destination Type	Unicast
Loop Type	Broadcast
Destination MAC	00-80-16-00-00-00
Source MAC Type	Factory Default
Default MAC	00-80-16-92-34-D2

Port 1: 1GigE Layer 2 Traffic Term Test Report

Auto-increment MAC	No
# MACs in Sequence	2
EtherType	0x800
Tx Payload	Acterna
Acterna Payload	BERT
Tx BERT Pattern	2 ²³ - 1
RTD Setup	High Precision - Low Delay

Setup: Traffic	
Load Type	Constant
Load Unit	Bit Rate
Allow flooding	No
Bit Rate	Mbps
Load (Mbps)	10
Actual IR (Mbps)	10
Layer	L2

Setup: Filters / Ethernet	
Encapsulation	Don't Care
Destination Type	Don't Care
Source MAC Type	Don't Care

Setup: Filters / Byte Pattern	
Use Byte Pattern as	Don't Care

Setup: Filters / Payload	
Payload Analysis	On
Use Tx Payload settings	Yes
Rx Payload	Acterna
Rx BERT Pattern	2 ²³ - 1

Port 1: 1GigE Layer 2 Traffic Term Test Report

Setup: Filters / TPID	
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100

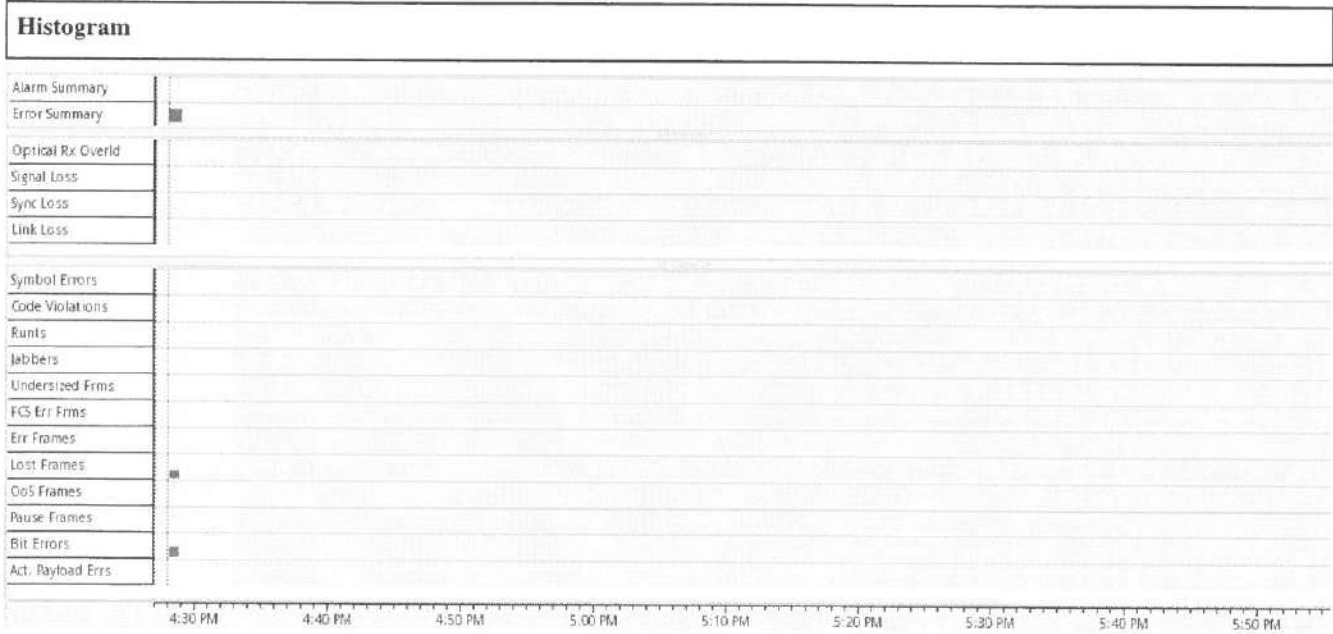
Setup: Timed Test	
Test Type	Timed Test
Timed Test Duration	5m:00s

Setup: Toolbar / Service Disruption	
No applicable setups...	

Setup: Toolbar / Errors	
Error Type	Code
Insertion Style	Single

Log: Event Log					
No.	Event	Date	Start Time	Stop Time	Dur./Val.
1	START	09/27/2022	16:27:34.0	--	--
2	Bit Errors	09/27/2022	16:28:26.8	16:28:26.8	468
3	Lost Frames	09/27/2022	16:28:26.8	16:28:26.8	67
4	STOP	09/27/2022	16:32:34.0	--	--

Port 1: 1GigE Layer 2 Traffic Term Test Report



Port 1: 1GigE Layer 2 Traffic Term Test Report

Generated by JDSU 5800 MSAM

General Info: Device Under Test	
Owner	---
Device Under Test	---
Software Revision	---
Serial Number	---
Comment	---

General Info: Tester Comments	
Test Results	---
Tester	---

General Info: Test Instrument	
Model	JDSU 5800v2
SW Revision	1.1
BERT Serial Number	0120

Results: Summary / Status	
Lost Frames	70
Bit Errors	167

Results: Summary / SLA / KPI	
Rx Mbps, L1	10.39
Tx Mbps, L1	10.39
Rx Mbps, L2	10.00
Tx Mbps, L2	10.00
Frame Loss - FLR, Lost Frames	70
Frame Loss - FLR, Frame Loss Ratio	9.56E-05
Round Trip Delay - FD (us), Average	48.54
Round Trip Delay - FD (us), Current	48.86
Round Trip Delay - FD (us), Maximum	50.86
Packet Jitter - FDV (us), Average	0

Port 1: 1GigE Layer 2 Traffic Term Test Report

Packet Jitter - FDV (us), Max Average	0
Packet Jitter - FDV (us), Peak	4.10
Packet Jitter - FDV (us), Instantaneous	0

Results: Summary / Time	
Current Date	09/27/2022
Current Time	3:35:34 PM AST
Test Elapsed Time	5m:00s
Test Time Remaining	0s

Results: Interface / Signal	
Signal Losses	0
Signal Loss Seconds	0
Sync Loss Seconds	0
Link Loss Seconds	0
Optical Rx Overload	OFF
Optical Rx Level (dBm)	-9.8
Rx Frequency (Hz)	1,250,000,960
Rx Freq Deviation (ppm)	0.8
Rx Freq Max Deviation (ppm)	0.8
Tx Clock Source	Internal
Tx Frequency (Hz)	1,250,000,000
Tx Freq Deviation (ppm)	0.0
Tx Freq Max Deviation (ppm)	0.0

Results: Ethernet / L2 Link Stats	
Total Util %, Average	1.039
Total Util %, Current	1.039
Total Util %, Minimum	1.009
Total Util %, Peak	1.039
Current Util %, Unicast	1.039
Current Util %, Multicast	0.000

Port 1: 1GigE Layer 2 Traffic Term Test Report

Current Util %, Broadcast	0.000
Rx Pause Length (ms), Current	Unavailable
Rx Pause Length (ms), Minimum	Unavailable
Rx Pause Length (ms), Maximum	Unavailable
Frame Rate, Average	2,441.03
Frame Rate, Current	2,441
Frame Rate, Minimum	2,371
Frame Rate, Peak	2,442
Frame Size, Average	512
Frame Size, Minimum	512
Frame Size, Maximum	512
Rx Mbps, Cur L1	10.39
Rx Mbps, Cur L2	10.00
Tx Mbps, Cur L1	10.39
Tx Mbps, Cur L2	10.00
Round Trip Delay (us), Average	48.54
Round Trip Delay (us), Current	48.86
Round Trip Delay (us), Minimum	46.76
Round Trip Delay (us), Maximum	50.86
Packet Jitter (us), Average	0
Packet Jitter (us), Max Average	0
Packet Jitter (us), Peak	4.10
Packet Jitter (us), Instantaneous	0
VLAN ID	Unavailable
VLAN User Priority	Unavailable
SVLAN ID	Unavailable
SVLAN User Pri	Unavailable
SVLAN Frame DEI	Unavailable
SVLAN1 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN2 ID	Unavailable

Port 1: 1GigE Layer 2 Traffic Term Test Report

Preceding SVLANs, SVLAN2 User Priority	Unavailable
Preceding SVLANs, SVLAN2 Frame DEI	Unavailable
Preceding SVLANs, SVLAN2 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN3 ID	Unavailable
Preceding SVLANs, SVLAN3 User Priority	Unavailable
Preceding SVLANs, SVLAN3 Frame DEI	Unavailable
Preceding SVLANs, SVLAN3 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN4 ID	Unavailable
Preceding SVLANs, SVLAN4 User Priority	Unavailable
Preceding SVLANs, SVLAN4 Frame DEI	Unavailable
Preceding SVLANs, SVLAN4 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN5 ID	Unavailable
Preceding SVLANs, SVLAN5 User Priority	Unavailable
Preceding SVLANs, SVLAN5 Frame DEI	Unavailable
Preceding SVLANs, SVLAN5 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN6 ID	Unavailable
Preceding SVLANs, SVLAN6 User Priority	Unavailable
Preceding SVLANs, SVLAN6 Frame DEI	Unavailable
Preceding SVLANs, SVLAN6 ID, PRI, DEI	Unavailable
Preceding SVLANs, SVLAN7 ID	Unavailable
Preceding SVLANs, SVLAN7 User Priority	Unavailable
Preceding SVLANs, SVLAN7 Frame DEI	Unavailable
Preceding SVLANs, SVLAN7 ID, PRI, DEI	Unavailable
Svc Disruption (us)	> 60,000,000

Results: Ethernet / L2 Link Counts	
Received Frames	732,309
Transmitted Frames	732,378
Rx Acterna Frames	732,309
Tx Acterna Frames	732,378
Pause Frames	0

Port 1: 1GigE Layer 2 Traffic Term Test Report

Rx VLAN Frames	0
Rx Q-in-Q Frames	0
Rx Stacked VLAN Frames	0
Unicast Frames	732,309
Multicast Frames	0
Broadcast Frames	0
Rx Frame Bytes	374,942,208
Tx Frame Bytes	374,977,536
Span Tree Frames	0
64 Byte Frames	0
65-127 Byte Frames	0
128-255 Byte Frames	0
256-511 Byte Frames	0
512-1023 Byte Frames	732,309
1024-<Jumbo Frames	0
Jumbo Frames	0

Results: Ethernet / L2 Filter Stats	
Total Util %, Average	1.039
Total Util %, Current	1.039
Total Util %, Minimum	1.009
Total Util %, Peak	1.039
Frame Rate, Average	2,441.03
Frame Rate, Current	2,441
Frame Rate, Minimum	2,371
Frame Rate, Peak	2,442
Frame Size, Average	512
Frame Size, Minimum	512
Frame Size, Maximum	512
Rx Mbps, Cur L1	10.39
Rx Mbps, Cur L2	10.00

Port 1: 1GigE Layer 2 Traffic Term Test Report

Round Trip Delay (us), Average	48.54
Round Trip Delay (us), Current	48.86
Round Trip Delay (us), Minimum	46.76
Round Trip Delay (us), Maximum	50.86
Packet Jitter (us), Average	0
Packet Jitter (us), Max Average	0
Packet Jitter (us), Peak	4.10
Packet Jitter (us), Instantaneous	0
VLAN ID	Unavailable
VLAN User Priority	Unavailable
SVLAN1 ID	Unavailable
SVLAN1 User Priority	Unavailable
SVLAN1 Frame DEI	Unavailable
SVLAN1 ID, PRI, DEI	Unavailable
SVLAN2 ID	Unavailable
SVLAN2 User Priority	Unavailable
SVLAN2 Frame DEI	Unavailable
SVLAN2 ID, PRI, DEI	Unavailable
SVLAN3 ID	Unavailable
SVLAN3 User Priority	Unavailable
SVLAN3 Frame DEI	Unavailable
SVLAN3 ID, PRI, DEI	Unavailable
SVLAN4 ID	Unavailable
SVLAN4 User Priority	Unavailable
SVLAN4 Frame DEI	Unavailable
SVLAN4 ID, PRI, DEI	Unavailable
SVLAN5 ID	Unavailable
SVLAN5 User Priority	Unavailable
SVLAN5 Frame DEI	Unavailable
SVLAN5 ID, PRI, DEI	Unavailable

Port 1: 1GigE Layer 2 Traffic Term Test Report

SVLAN6 ID	Unavailable
SVLAN6 User Priority	Unavailable
SVLAN6 Frame DEI	Unavailable
SVLAN6 ID, PRI, DEI	Unavailable
SVLAN7 ID	Unavailable
SVLAN7 User Priority	Unavailable
SVLAN7 Frame DEI	Unavailable
SVLAN7 ID, PRI, DEI	Unavailable

Results: Ethernet / L2 Filter Counts	
Valid Rx Frames	732,309
Rx Acterna Frames	732,309
Rx VLAN Frames	0
Rx Q-in-Q Frames	0
Rx Stacked VLAN Frames	0
Unicast Frames	732,309
Multicast Frames	0
Broadcast Frames	0
Span Tree Frames	0
Rx Frame Bytes	374,942,208
64 Byte Frames	0
65-127 Byte Frames	0
128-255 Byte Frames	0
256-511 Byte Frames	0
512-1023 Byte Frames	732,309
1024-<Jumbo Frames	0

Results: Ethernet / BERT Stats	
Pattern Losses	1
Pattern Loss Seconds	1
Bit Error Rate	6.28E-08

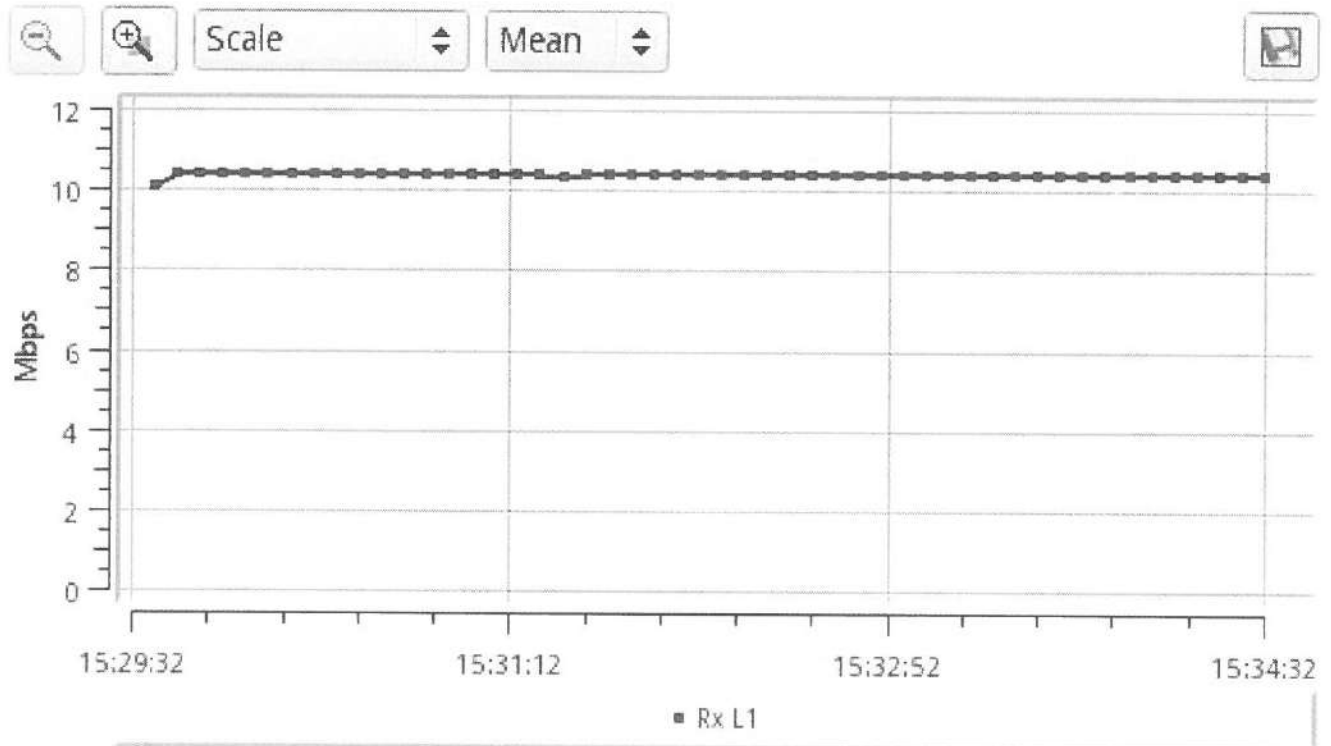
Port 1: 1GigE Layer 2 Traffic Term Test Report

Bit Errors	167
Bit Errored Seconds	1
Bit Error-Free Seconds	299
Bit Error-Free Seconds, %	99.6667

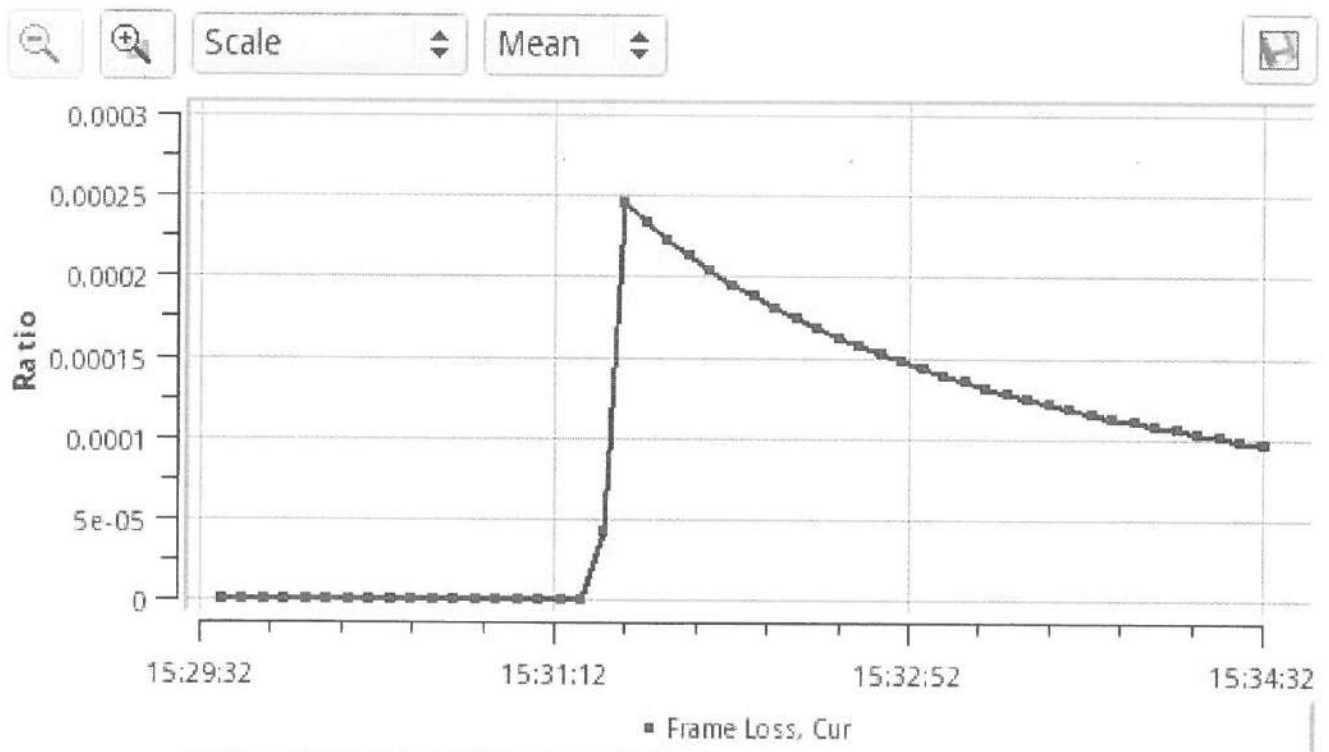
Results: Ethernet / Error Stats	
Symbol Errors	0
Code Violations	0
Code Violation Rate	0.00E+00
Code Violation Seconds	0
Undersized Frames	0
Runts	0
Jabbers	0
FCS Errored Frames	0
Errored Frames	0
Acterna Payload Errors	0
Packet Error Rate	9.56E-05
Lost Frames	70
Frame Loss Ratio	9.56E-05
OoS Frames	0
Errored Second	1
Severely Errored Second	0
Unavailable Second	0
Errored Second Ratio	3.3333E-03
Severely Errored Second Ratio	0.0000E+00

Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Graphs / Throughput

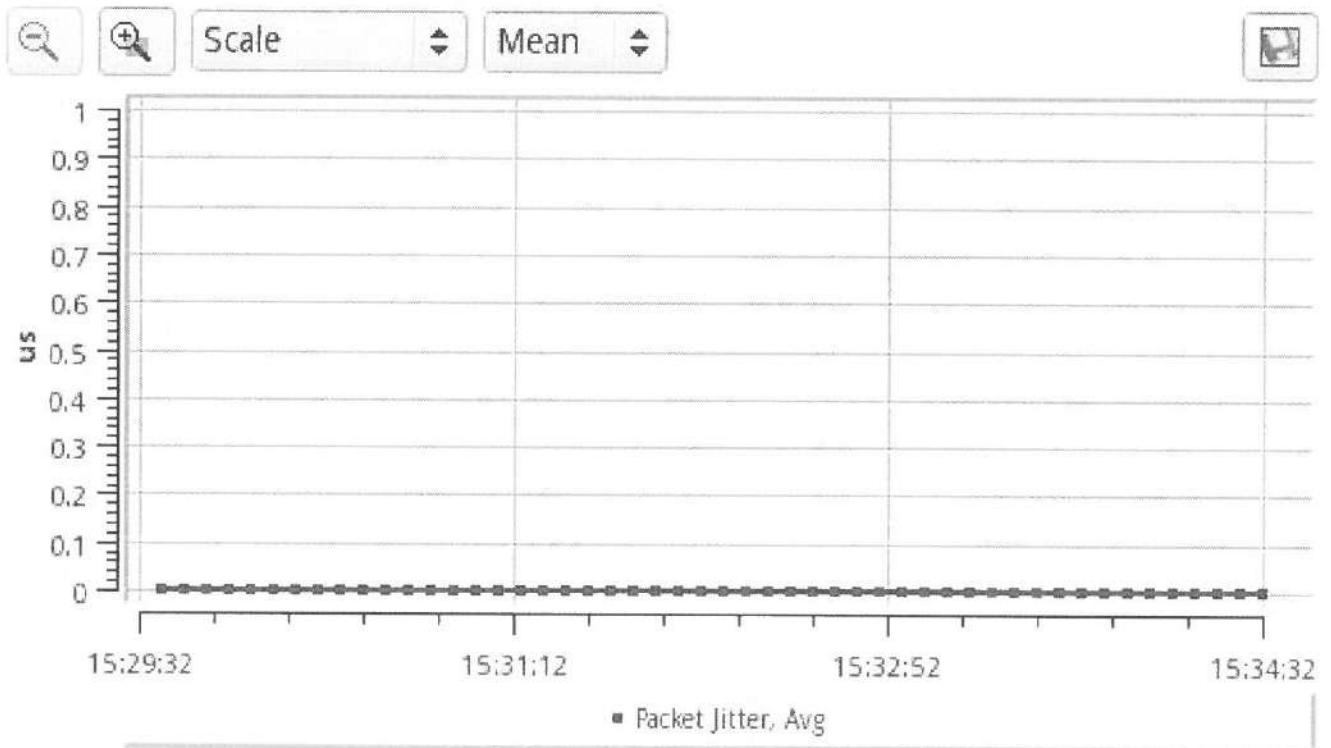


Results: Graphs / Frame Loss, Cur

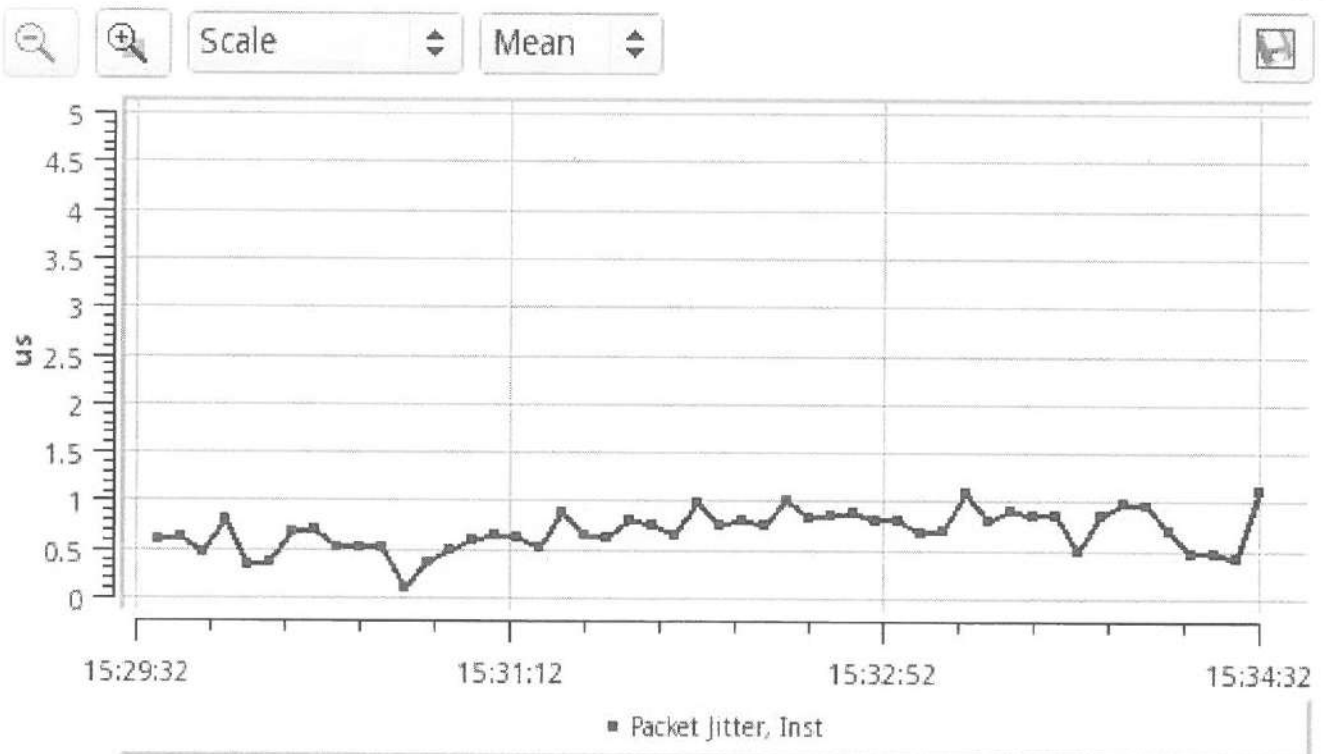


Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Graphs / Packet Jitter, Avg

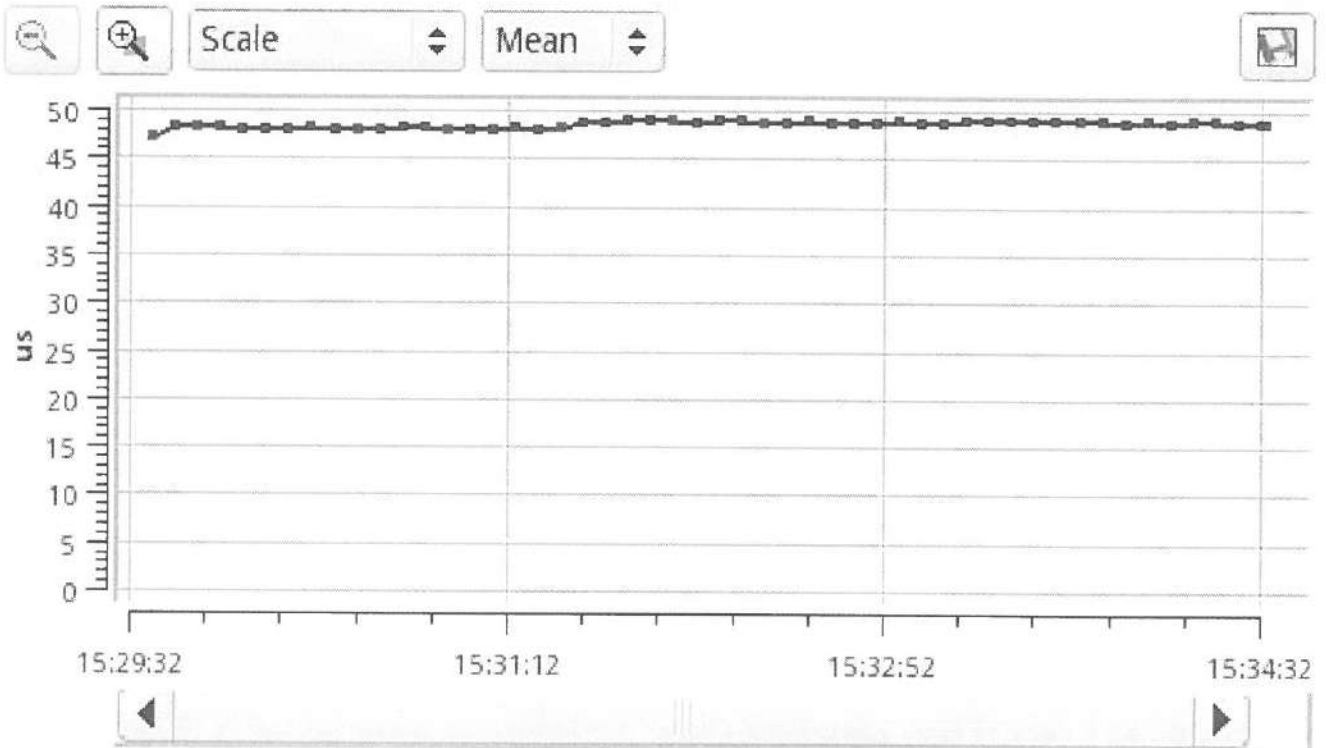


Results: Graphs / Packet Jitter, Inst

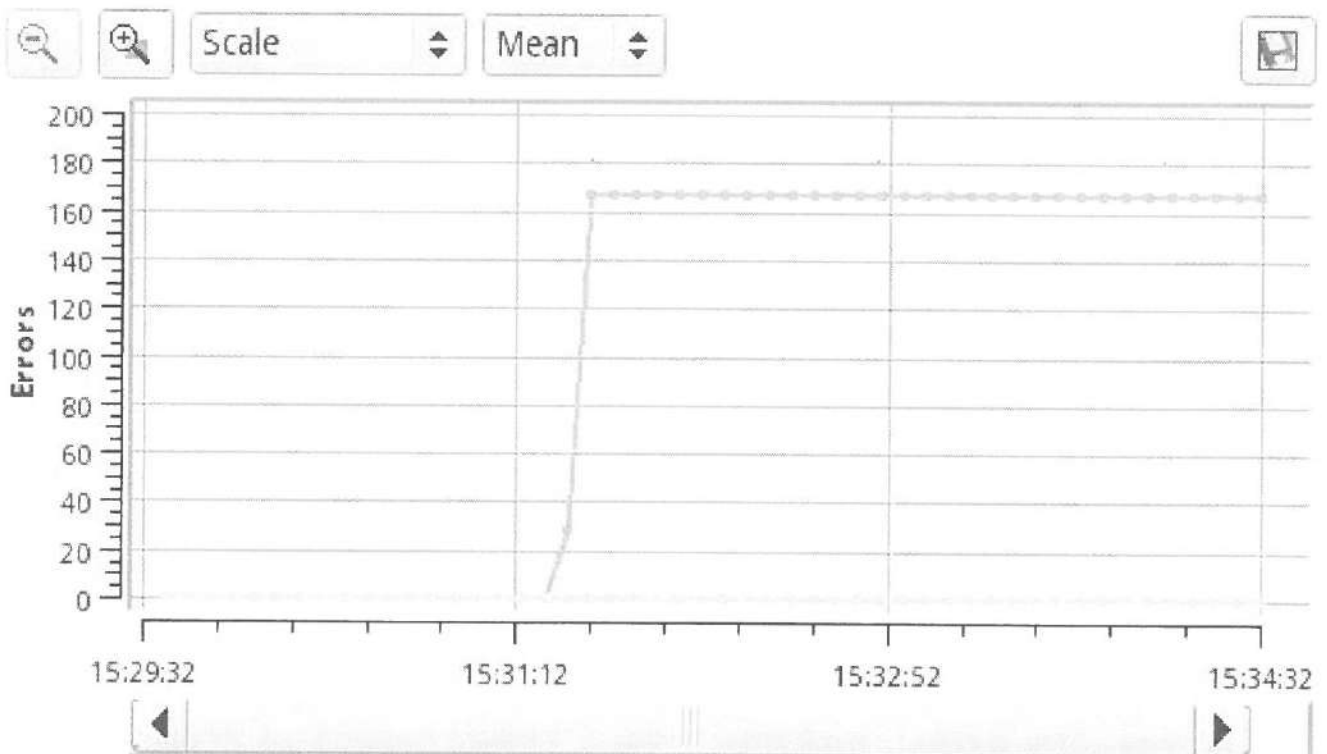


Port 1: IGigE Layer 2 Traffic Term Test Report

Results: Graphs / Latency (RTD), Cur



Results: Graphs / Errors



Port 1: 1GigE Layer 2 Traffic Term Test Report

Results: Ethernet / AutoNeg Status	
Link Advt. Status	Done
Link Config ACK	Yes
Pause Capable	Neither
Flow Control	Off
FDX Capable	Yes
HDX Capable	Yes
Remote Fault	No

Results: LEDs / Ethernet	
Signal Present	ON
Sync Acquired	ON
Link Active	ON
Frame Detect	ON
ATP Detect	ON
Pattern Sync	ON + HISTORY
VLAN Frame Detect	OFF
SVLAN Frame Detect	OFF
Stacked VLAN Detect	OFF

Setup: Interface	
Connector/Wavelength	SFP
Clock Source	Internal
Internal - Frequency Offset (ppm)	0
Auto Negotiation	On
FDX Capable	Yes
HDX Capable	Yes
Pause Capable	Both Rx and Tx
Pause Length (Quanta)	1000
Pause Length (Time - ms)	0.512
Auto-start traffic when laser turned on	No

Port 1: 1GigE Layer 2 Traffic Term Test Report

Unit Identifier	JDSU-0120-01
Make this unit discoverable	OFF
Source IP	192.168.1.11
Default Gateway	192.168.1.10
Subnet Mask	255.255.255.0

Setup: Connector SFP	
Wavelength (nm)	1550
Nominal Bit Rate (Mbits/sec)	10,300
Minimum Bit Rate (Mbits/sec)	9,888
Maximum Bit Rate (Mbits/sec)	11,330
Power Level Type	Average Power
Vendor	HG GENUINE
Vendor PN	MTRS-1S60-01
Vendor Rev	1.0
Max Rx Level (dBm)	-1.00015
Max Tx Level (dBm)	4.00002
Diagnostic Monitoring	1
Diagnostic Byte	104
Transceiver	10G Base-ER

Setup: Ethernet	
Encapsulation	None
Test Mode	Traffic
Frame Type	DIX
Frame Size (Bytes)	512
Destination Type	Unicast
Loop Type	Broadcast
Destination MAC	00-80-16-00-00-00
Source MAC Type	Factory Default
Default MAC	00-80-16-92-34-D2

Port 1: 1GigE Layer 2 Traffic Term Test Report

Auto-increment MAC	No
# MACs in Sequence	2
EtherType	0x800
Tx Payload	Acterna
Acterna Payload	BERT
Tx BERT Pattern	2 ²³ - 1
RTD Setup	High Precision - Low Delay

Setup: Traffic	
Load Type	Constant
Load Unit	Bit Rate
Allow flooding	No
Bit Rate	Mbps
Load (Mbps)	10
Actual IR (Mbps)	10
Layer	L2

Setup: Filters / Ethernet	
Encapsulation	Don't Care
Destination Type	Don't Care
Source MAC Type	Don't Care

Setup: Filters / Byte Pattern	
Use Byte Pattern as	Don't Care

Setup: Filters / Payload	
Payload Analysis	On
Use Tx Payload settings	Yes
Rx Payload	Acterna
Rx BERT Pattern	2 ²³ - 1

Port 1: 1GigE Layer 2 Traffic Term Test Report

Setup: Filters / TPID	
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100
User Allowable SVLAN TPID (hex)	0x8100

Setup: Timed Test	
Test Type	Timed Test
Timed Test Duration	5m:00s

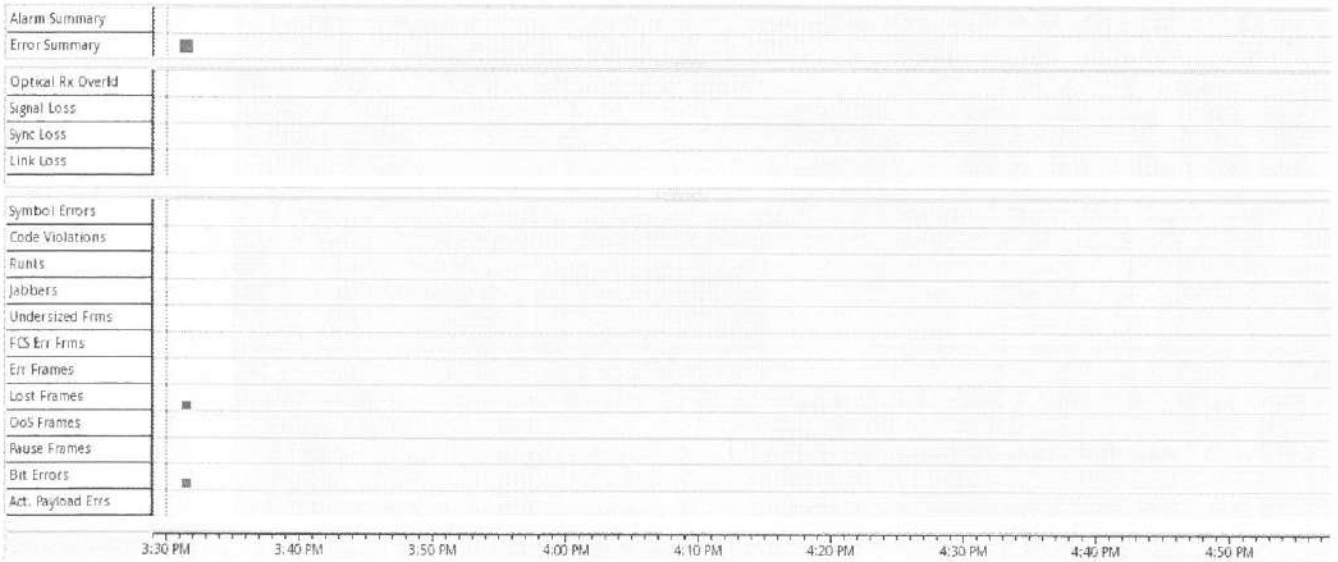
Setup: Toolbar / Service Disruption	
No applicable setups...	

Setup: Toolbar / Errors	
Error Type	Code
Insertion Style	Single

Log: Event Log					
No.	Event	Date	Start Time	Stop Time	Dur./Val.
1	START	09/27/2022	15:29:32.0	--	--
2	Bit Errors	09/27/2022	15:31:25.1	15:31:25.1	167
3	Lost Frames	09/27/2022	15:31:25.1	15:31:25.1	70
4	STOP	09/27/2022	15:34:32.0	--	--

Port 1: 1GigE Layer 2 Traffic Term Test Report

Histogram



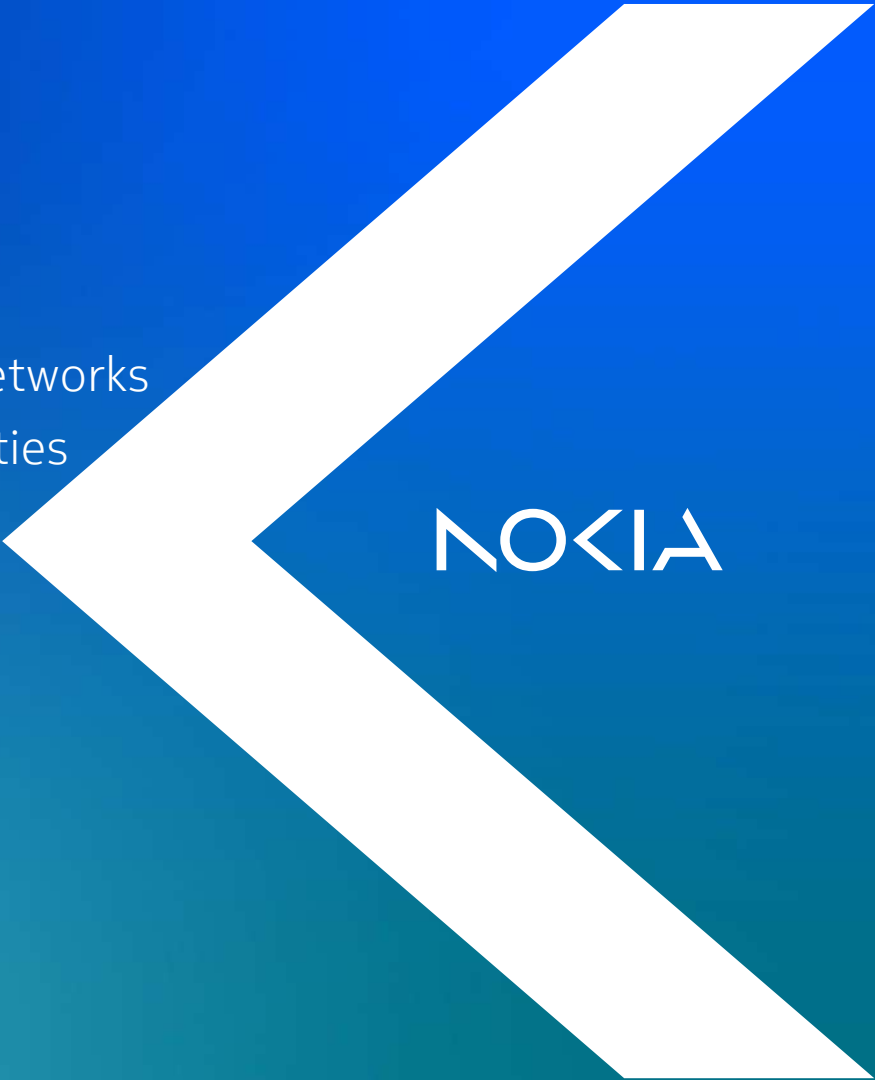
Annexure-XVI

IP/MPLS-based
critical communication
network for utilities

NOKIA

Agenda

- **Smart Grid Communication requirements**
- Nokia IP MPLS Solution for Critical Utility Networks
- Major Use cases of IP MPLS Solution in Utilities
- Long distance Inline ILA Solution with Coherent Optics
- Nokia IP/MPLS product portfolio
- References
- Conclusion

A large, stylized white arrow pointing to the left, which serves as a background for the Nokia logo. The arrow is composed of two parallel diagonal lines meeting at a point on the left.

NOKIA

Smart grid vision

Ensure reliable power delivery and quality	• Balance supply and demand • Manage power quality • Automate switching and protection systems • Incorporate renewable energy
Improve safety and operational efficiency	• Automate asset monitoring and management • Critical protection applications • Leverage data and analytics • Connect with mobile workforce whenever and wherever needed • Monitor and control renewable energy sources everywhere • Meet environmental targets and regulatory requirements
Engage customers	• Provide information or incentives for reduced or more intelligent energy usage • Implement direct load controls • Improve customer service

To help achieve this vision, build a communications bridge that enables:

- Intimacy with customers, grid assets and workforce
- Ability to predict and influence behavior, control the quality of renewable energy sources and take full advantage of physical and human resources

Highlight of grid application communications requirements

Applications	Criticality	Traffic	QoS	Challenges	Key IP/MPLS solution capabilities
Teleprotection (TDM-based)	High	Point-to-point TDM	High	Legacy I/F , assured QoS, delay symmetry (differential)	TDM PW w/ ADC
Teleprotection (87L over Ethernet, GOOSE)	High	Ethernet (non-IP payload)	High	Bridging over WAN	Eth PW or VPLS
SCADA (TDM-based)	High	TDM Multipoint	Medium	V.24/E&M P2MP	Raw socket multidrop bridging
SCADA (IP-based)	High	IP	Medium		IP VPN
Metering	Low	IP	Low		IP VPN
CCTV	Medium	P2MP IP	Medium/Low	Multicast traffic	IP multicast and hierarchical VPN

Nokia value proposition

Ensure reliable,
sustainable
power delivery
and quality

Improve safety
and operational
efficiency

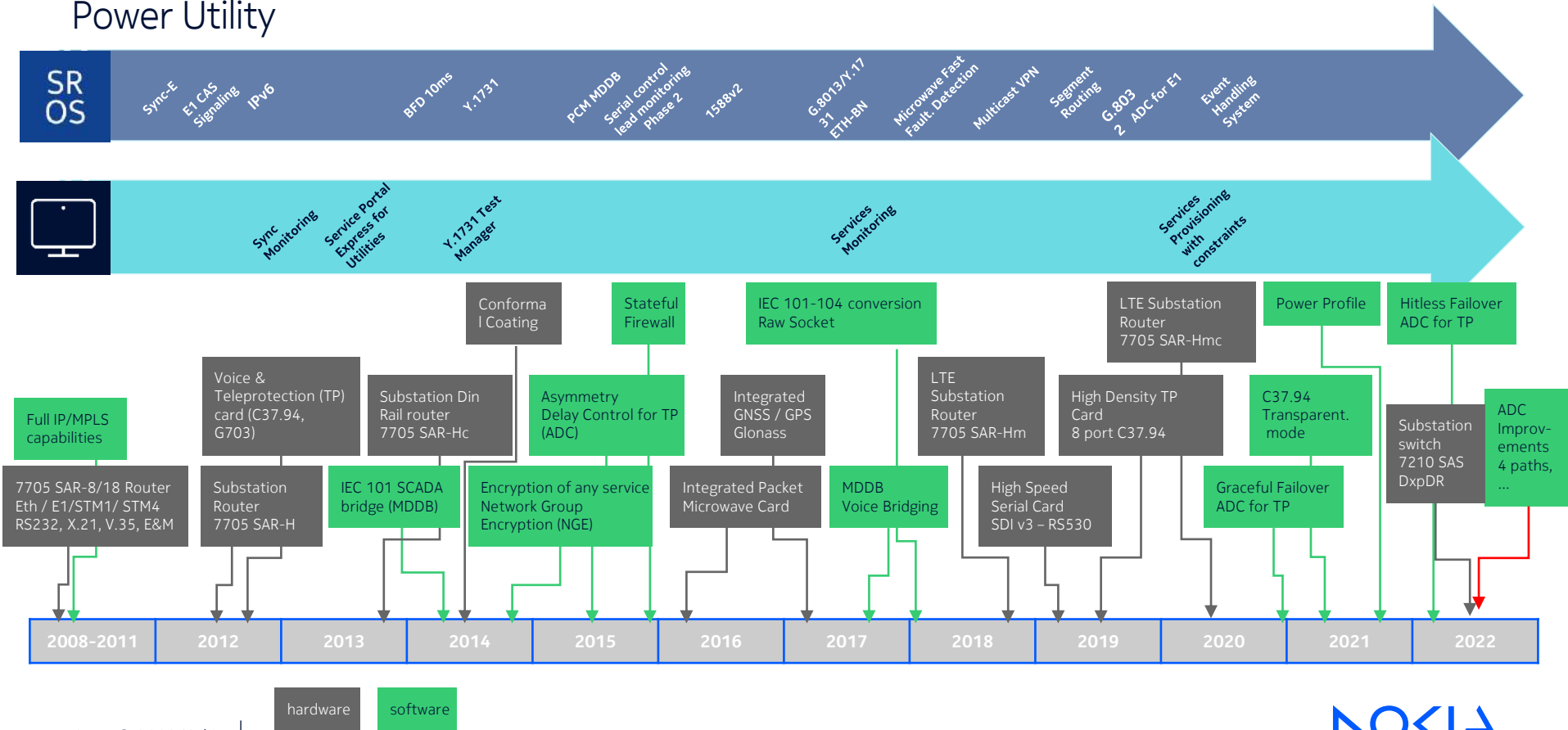
Engage
customers

Driving
smarter energy
management
and usage



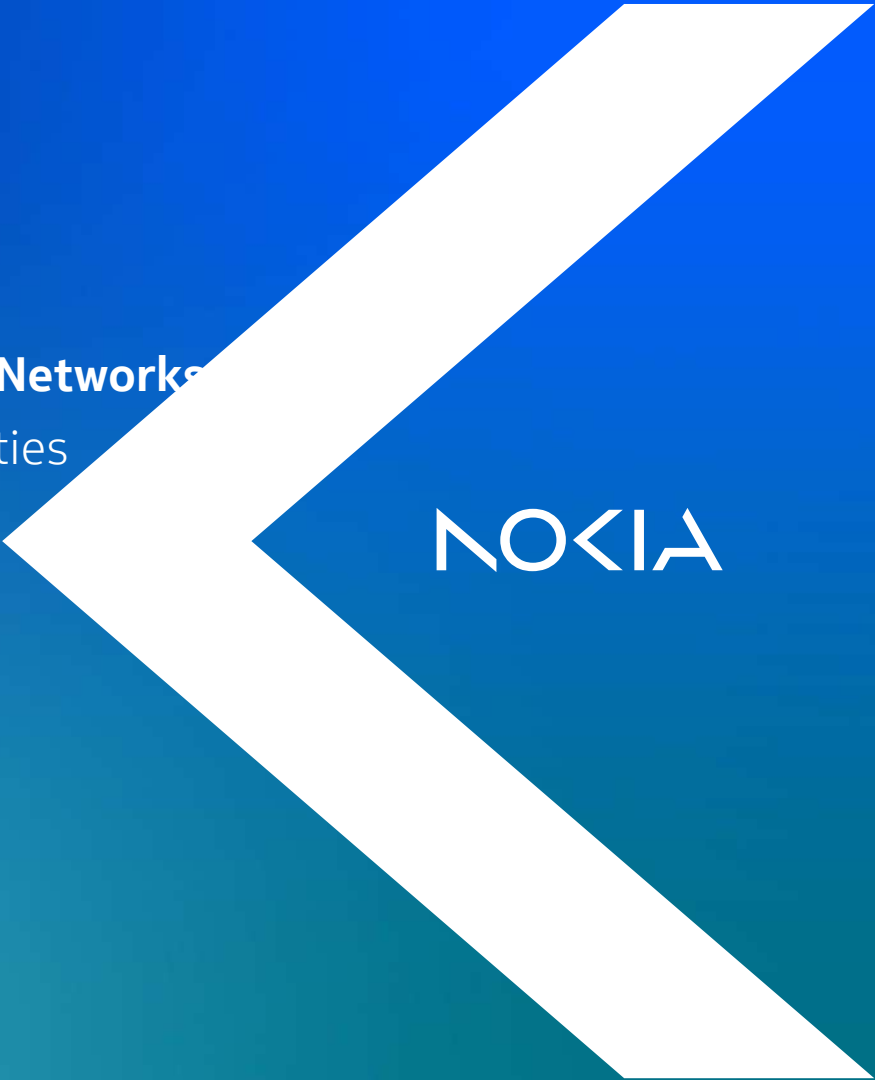
Continuous investment in Mission Critical Networks

Power Utility



Agenda

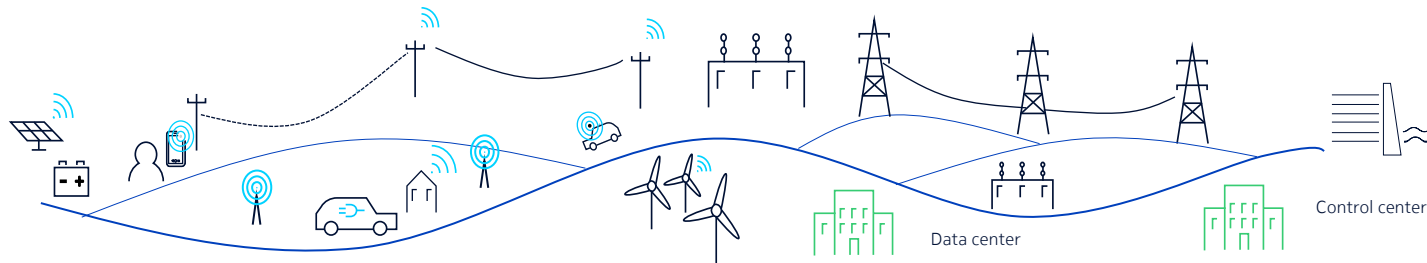
- Smart Grid Communication requirements
- **Nokia IP MPLS Solution for Critical Utility Networks**
- Major Use cases of IP MPLS Solution in Utilities
- Long distance Inline ILA Solution with Coherent Optics
- Nokia IP/MPLS product portfolio
- References
- Conclusion

The Nokia logo is displayed in white, consisting of the word "NOKIA" in a sans-serif font. It is positioned on the right side of the slide, within a large white chevron shape that points to the left. The background of the slide is a gradient of blue and teal.

NOKIA

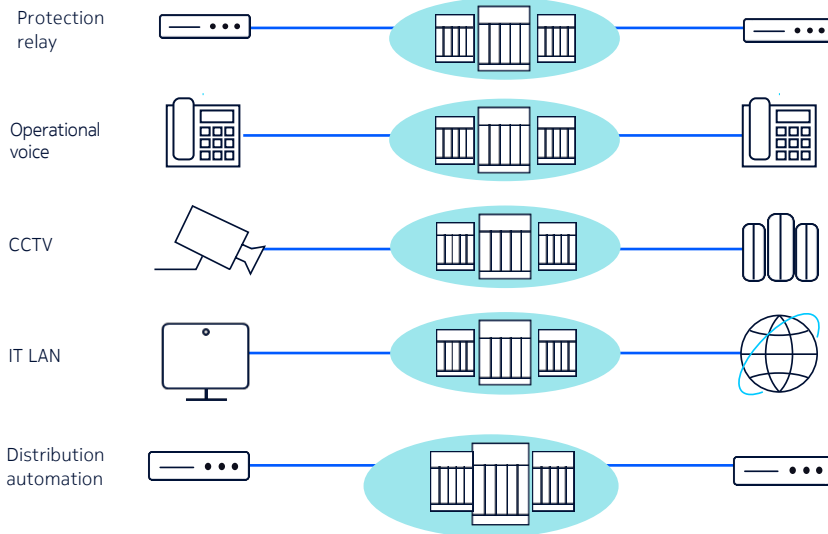
I have multiple aging networks

- How to get ready for the future?



I have a lot of legacy apps and am asked to support new, smart ones

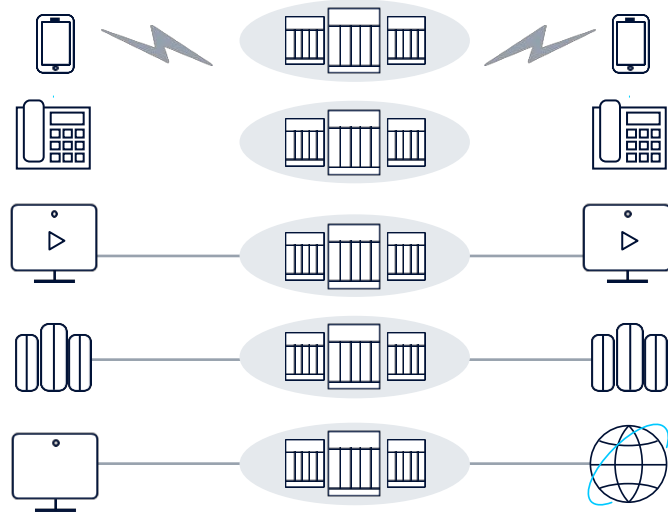
My current networks have no evolution path



Converged IP/MPLS networks

From:

Separated service networks



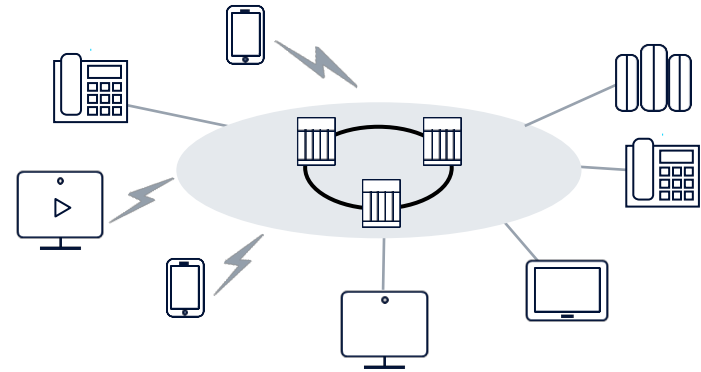
Each service has its own network
A mix of networking technologies

Optimization
Simplification



To:

Converged service network



All services in one network



CAPEX

OPEX

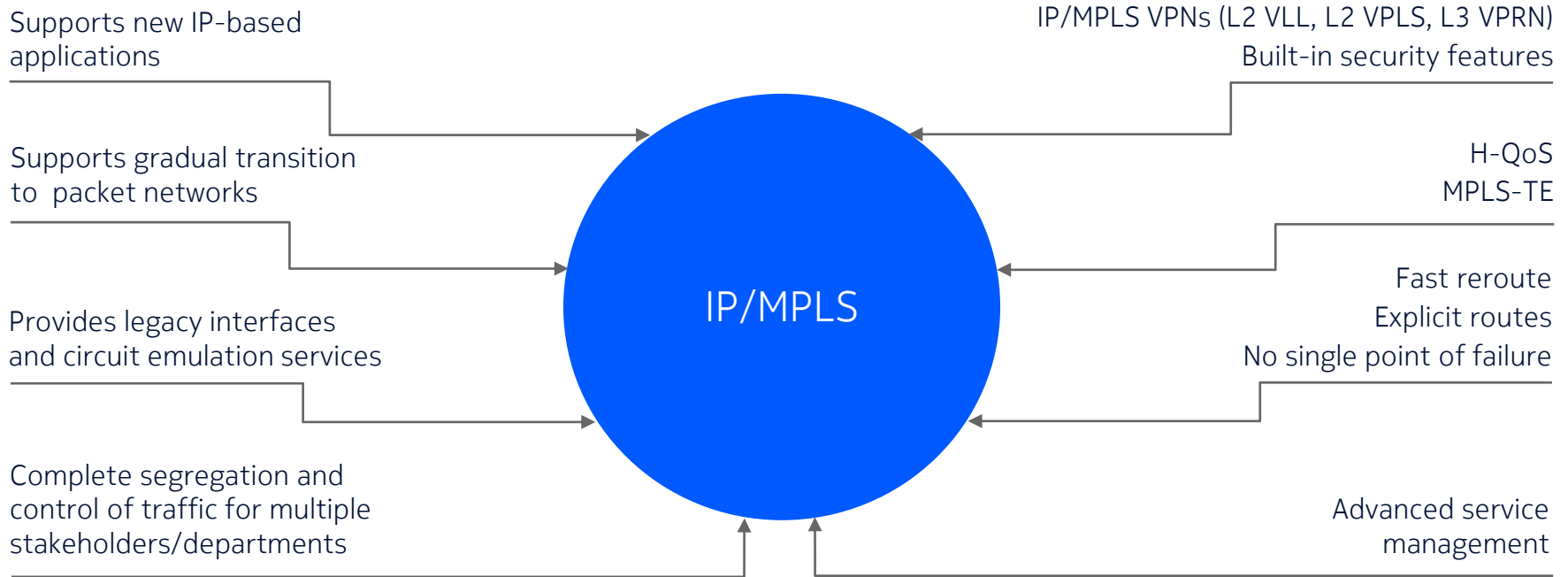
Network transformation to a single communications foundation

Design criteria for critical-communication networks

Flexibility	• Enables and adapts to new applications • Supports legacy applications
Scalability	• Handles increased bandwidth demands in efficient and cost effective way
Predictability	• Manages and enforces service quality controls, provide high resiliency
Security	• Protect the network with security-by-design, and encryption
Simplicity	• Management tools that use industry speaks to accelerate technology adoption and reduce TCO
Resiliency	• Designed for no single point of failure at the network nodal level; multi-failure recovery

No compromises

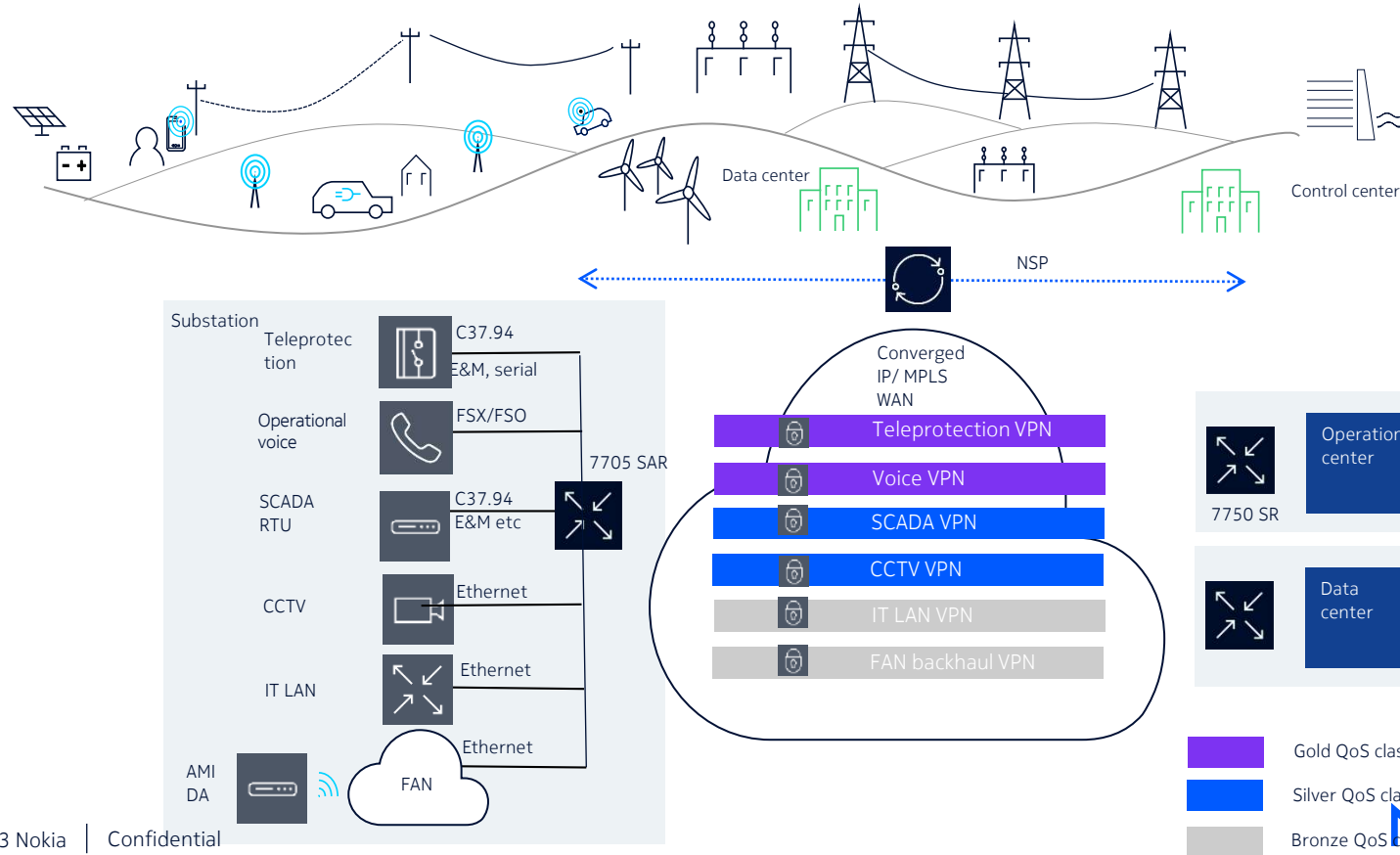
IP/MPLS addresses the challenges



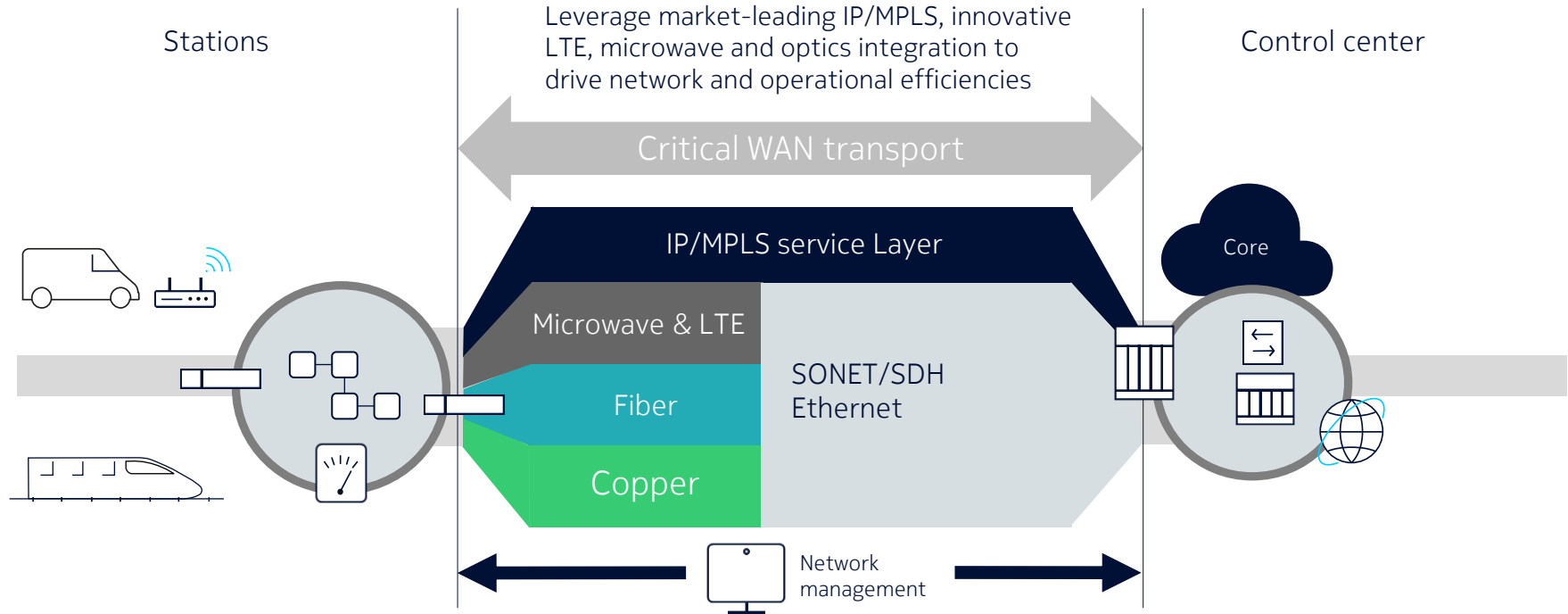
Solution found!

The Nokia mission-critical IP/MPLS WAN for utilities

Flexible, secure, resilient and converged grid communications



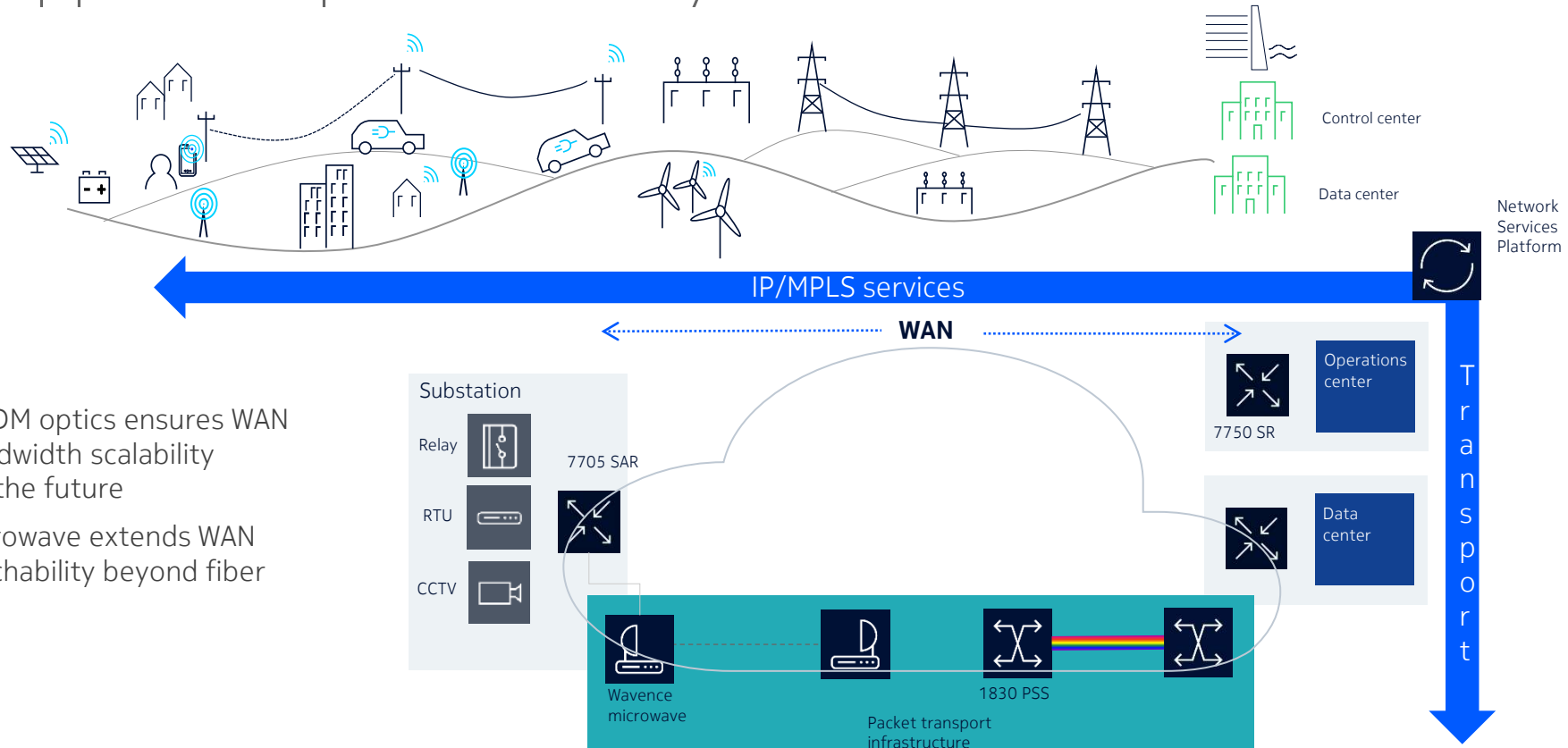
IP/MPLS critical communication architecture



Flexible, scalable, simplified

The Nokia mission-critical IP/MPLS WAN for utilities

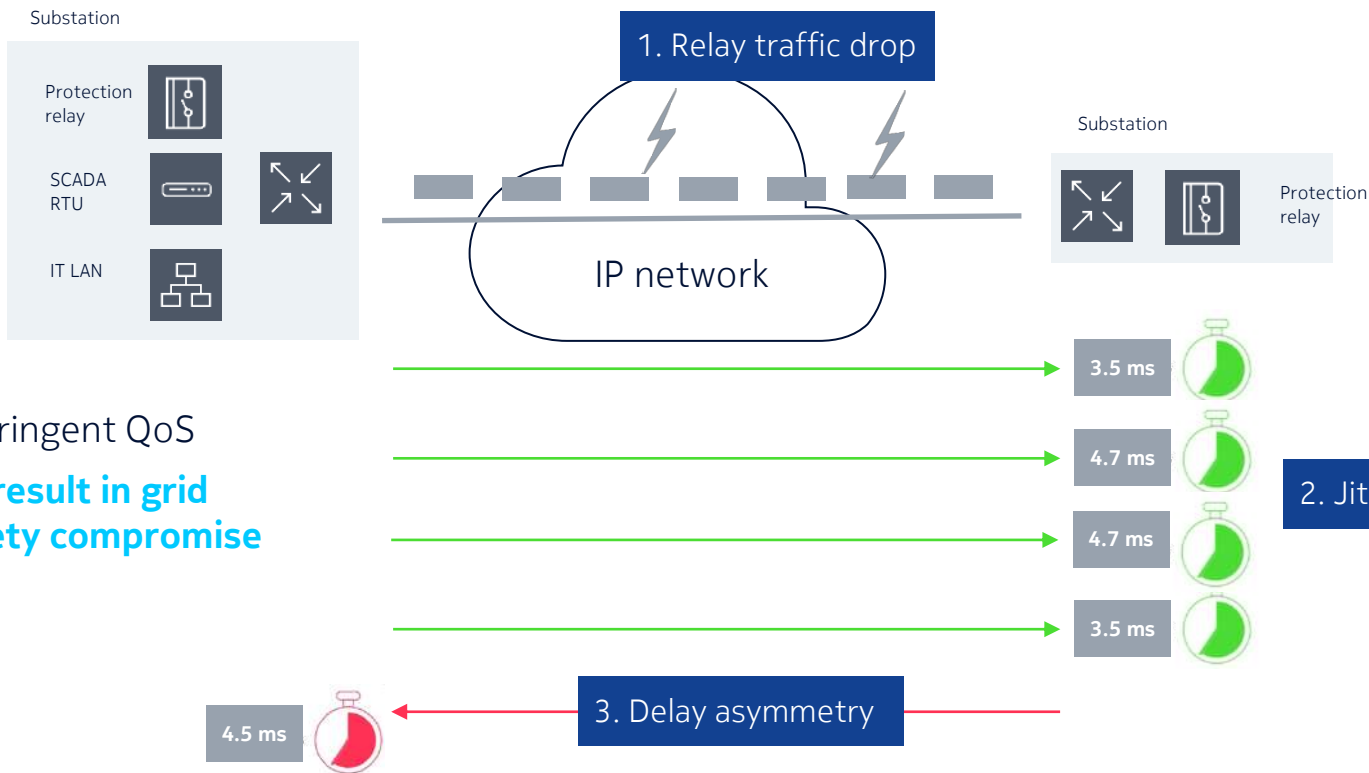
Atop packet transport for reachability and bandwidth



- DWDM optics ensures WAN bandwidth scalability for the future
- Microwave extends WAN reachability beyond fiber

I am wary of packet network performance

Would it jeopardize safety of my critical infrastructure operation?

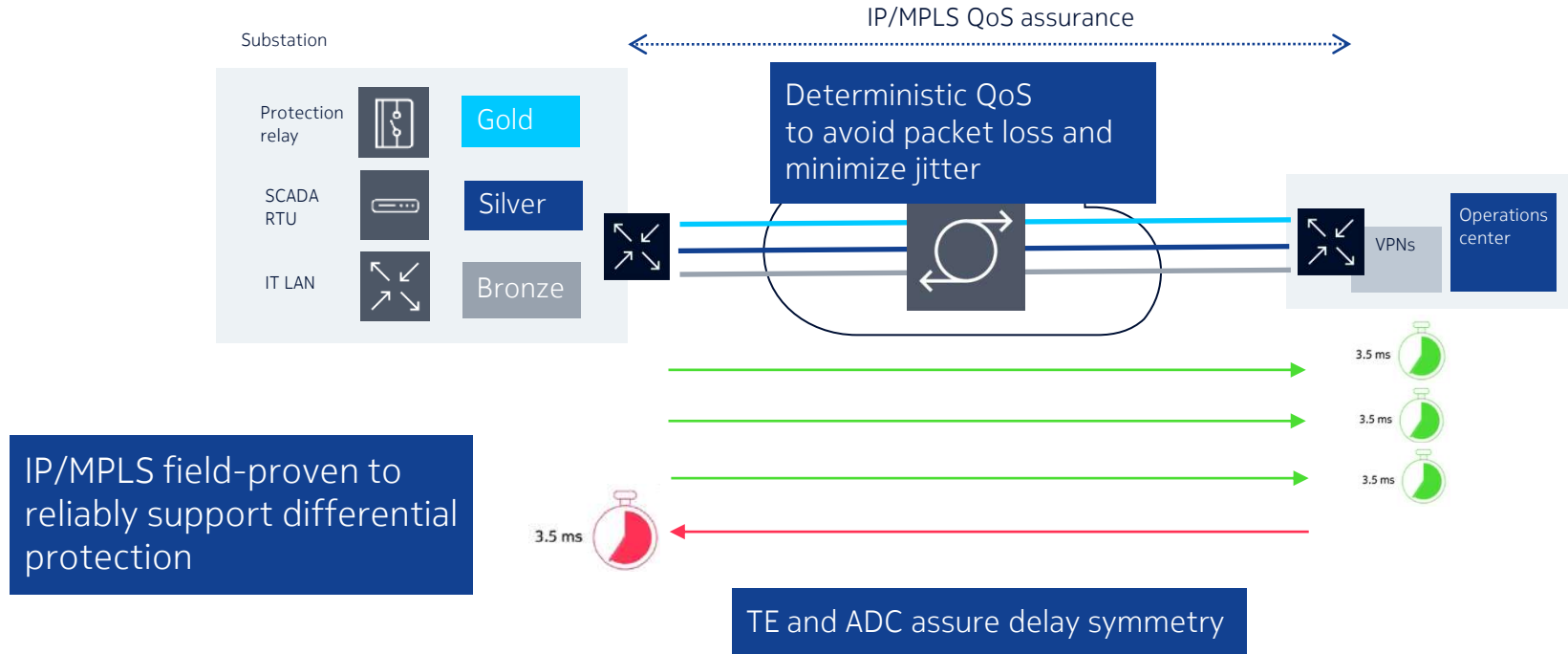


Relays expects stringent QoS

Any slack would result in grid stability and safety compromise

IP/MPLS provides assured QoS constantly

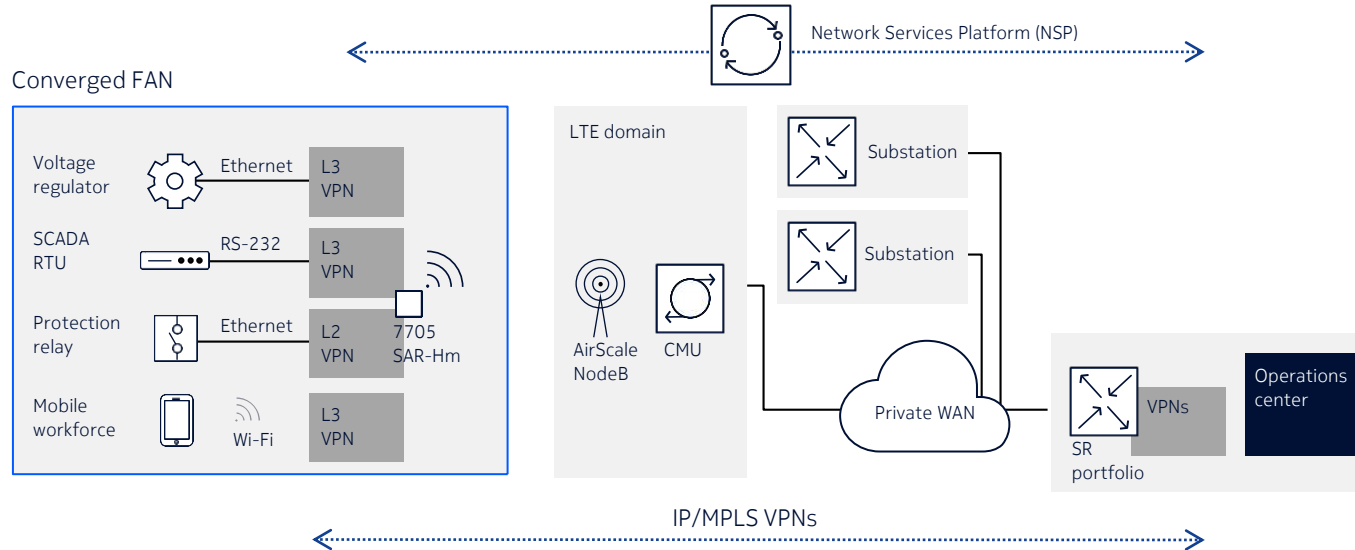
Ensure connectivity for critical applications



The converged FAN

Grounded in LTE and IP/MPLS technologies for mission-critical operations

- Consolidates all grid applications in ONE resilient FAN
- Segregated, secure everywhere communications with QoS assurance
- Optimized for communications between devices and with substations and operations centers



IP/MPLS technology – the unmatched advantages

Service versatility

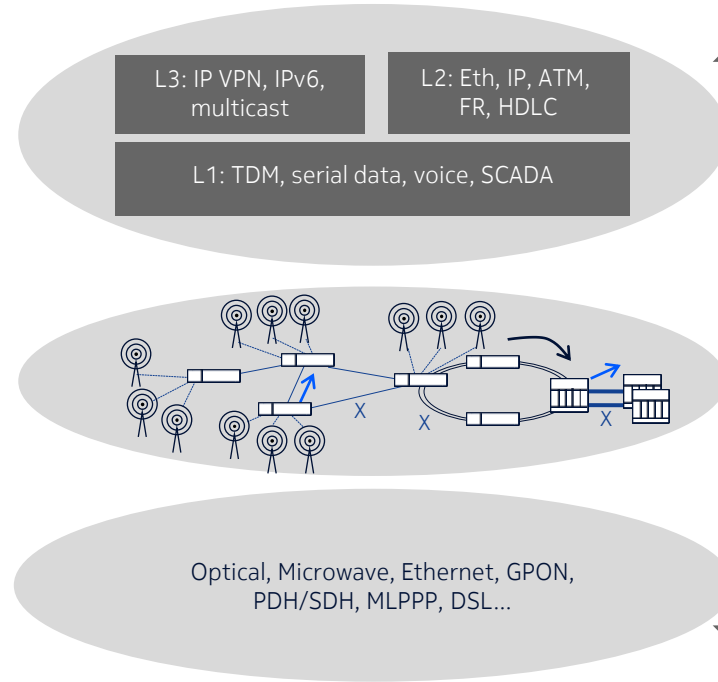
- L1/L2/L3 VPN, P2P/P2MP, multicast, IPv6
- Traffic segregation through traffic engineering and service-aware H-QoS

Universal topology

- Linear/mesh/ring/multi-ring/necklace topologies with rapid protection techniques

L1/L2 flexibility

- IP/MPLS operates over any Layer 1 media or Layer 2 protocol



Benefits

- Allow deployment of new/future operational applications and smooth migration to all-IP through support of legacy applications

Benefits

- Flexible architecture evolution
- Unsurpassed resiliency techniques rendering rapid local and E2E geo-diverse protection

Benefits

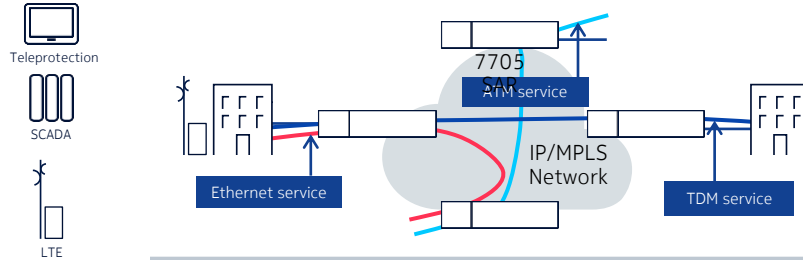
- Leverage available media for cost-effective site connection
- OPEX savings in optimal media selection

Reliable, scalable, manageable technology trusted by over 400 mission-critical network operators

MPLS-based VPN services converge applications onto one network infrastructure

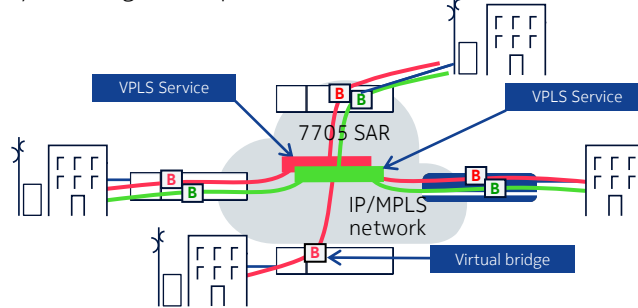
Virtual Leased Line (VLL)

Point-to-Point Pseudowire (TDM, Ethernet, FR etc.)



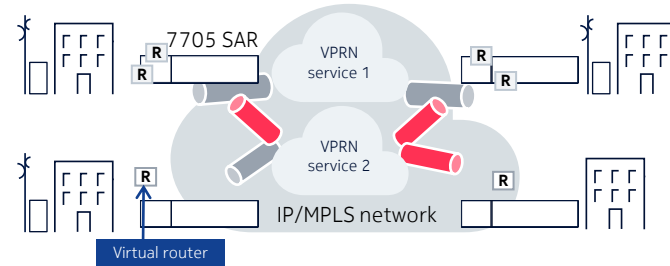
Virtual Private LAN Service (VPLS)

Layer 2 Bridged Multipoint Ethernet Service



Virtual Private Routed Network (VPRN)

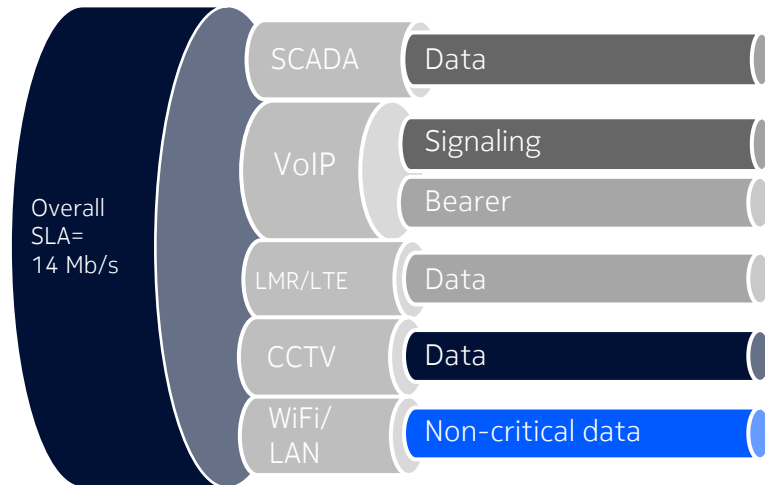
Layer 3 IP VPN



Highly granular, service-aware QoS

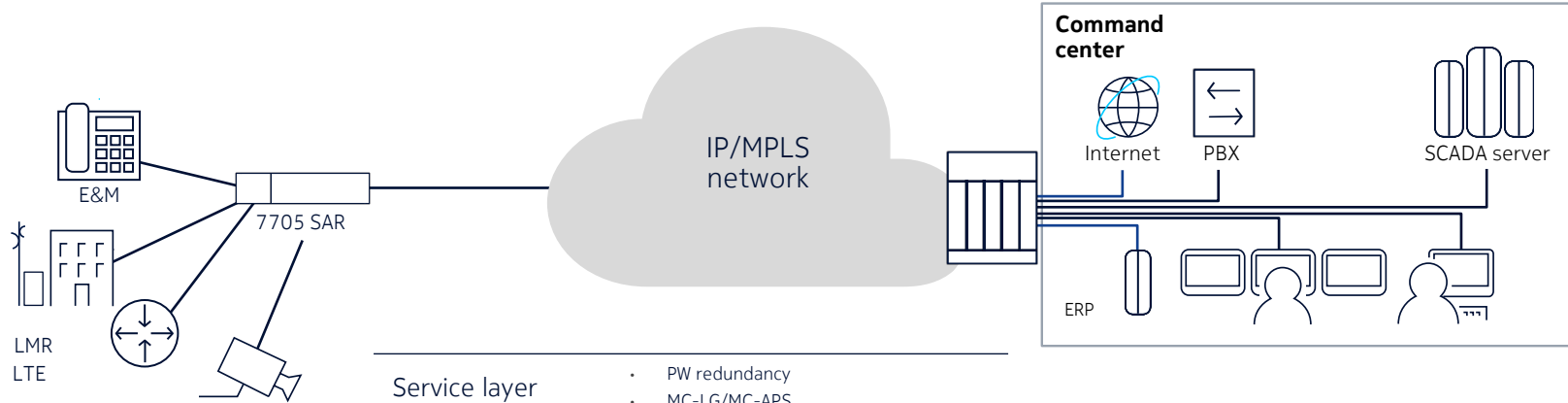
Pivotal to network convergence without performance compromise

- Service-aware QoS provides service-based queuing, policing, and shaping
- Up to 8 forwarding classes per service
- Per-service, per CoS bandwidth guarantees, application assurance, and SLA assurance
- High density of service queues
 - Profiled scheduling and queue-type based scheduling
 - Conforming and non-conforming bandwidth cap for each queue
 - Simultaneous support for Layer 2 and Layer 3 services on the same access port



Granular, service-aware QoS ensures high, consistent and predictable application performance

Building a resilient mission-critical network

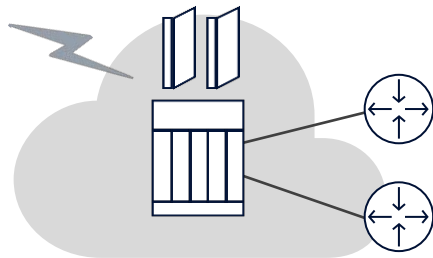


Service layer	• PW redundancy • MC-LG/MC-APS
MPLS layer	• MPLS FRR/standby LSP/ECMP • Non-stop signaling
IP layer	• IP ECMP • Non-stop routing • VRRP
Link layer	• 802.3ad Ethernet LAG • ML-PPP/ATM IMA • SONET/SDH APS
Equipment layer	• CSM/fan redundancy • Dual DC power

Uncompromised services with non-stop services

Hot standby protection with zero second interruption

- Non-Stop Forwarding
- Non-Stop Control
- Non-Stop Services



Bring reliability to the level of TDM network

Non-stop services

IP VPN, VPLS, Ethernet, TDM etc.

Non-stop control plane

BGP, OSPF, IS-IS
MPLS, PIM, DHCP

IPv4, IPv6, Ethernet
label switching, TDM

Non-stop data plane

Active control

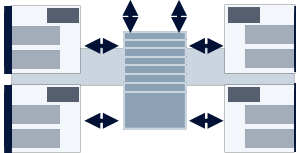


Configuration and state
hot synchronized

Standby control



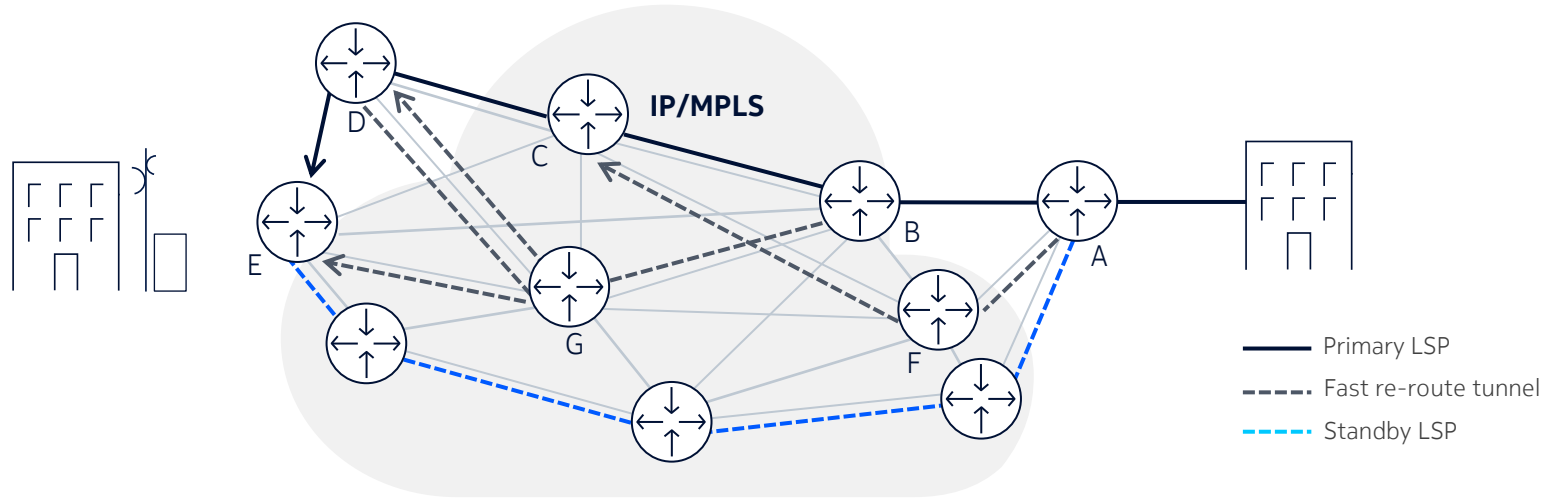
Line card



Control hardware failure:

- Standby takes over immediately
- Other routers don't even know it happened
- Zero impact on protocols and services

MPLS redundancy for high communications resiliency



Standard LSP failover

- Failure signaled at Ingress LSR
- Calculate and signal new LSP
- Reroute traffic to new LSP

Standby LSP

- Pre-established LSP
- Sub-second switchover

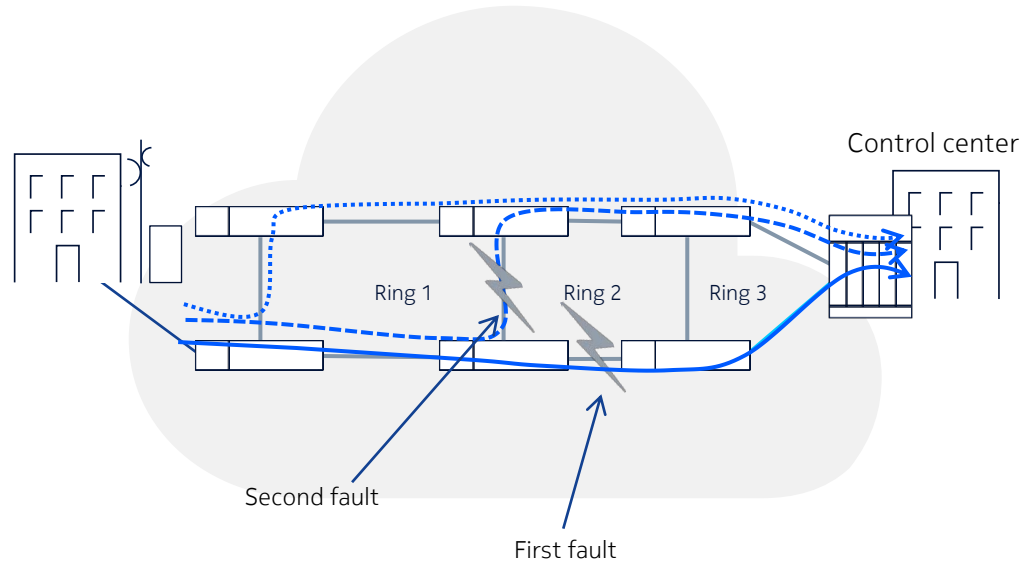
Fast re-route

- Signaled during LSP setup as topology requires
- Each LSR computes a detour path
- Supports failover in <50 ms after detection

Faster restoration for no/minimal impact on user communications

Multi-failure scenario recovery with IP/MPLS

A huge boost to network availability

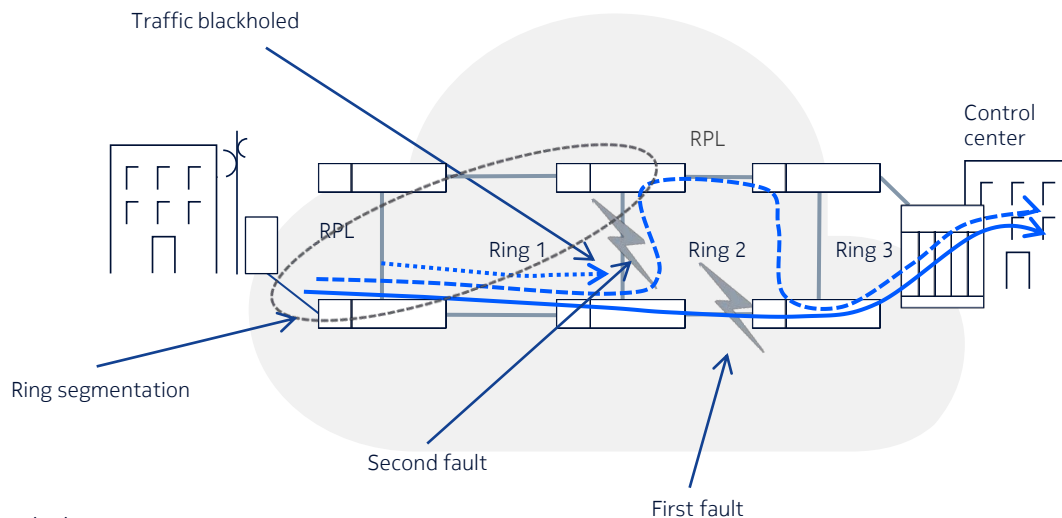


Connectivity can be restored as long as physical reachability exists, thanks to IP routing

Dynamic recovery

In multi-failure scenario with alternate technology (g.8032v2)

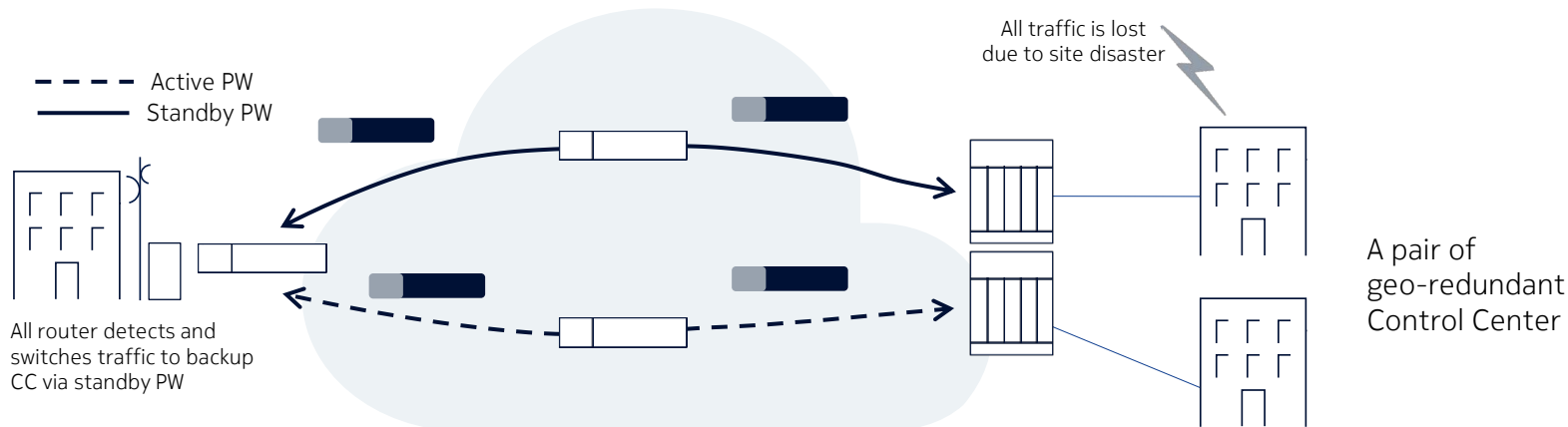
1. RPL becomes active
2. Traffic restored



RPL: Resilient Protection Link
Blocking traffic to break loop in ring

Connectivity broken despite physical reachability exists (see G.8032 appendix X)

Geo-protection via pseudowire redundancy

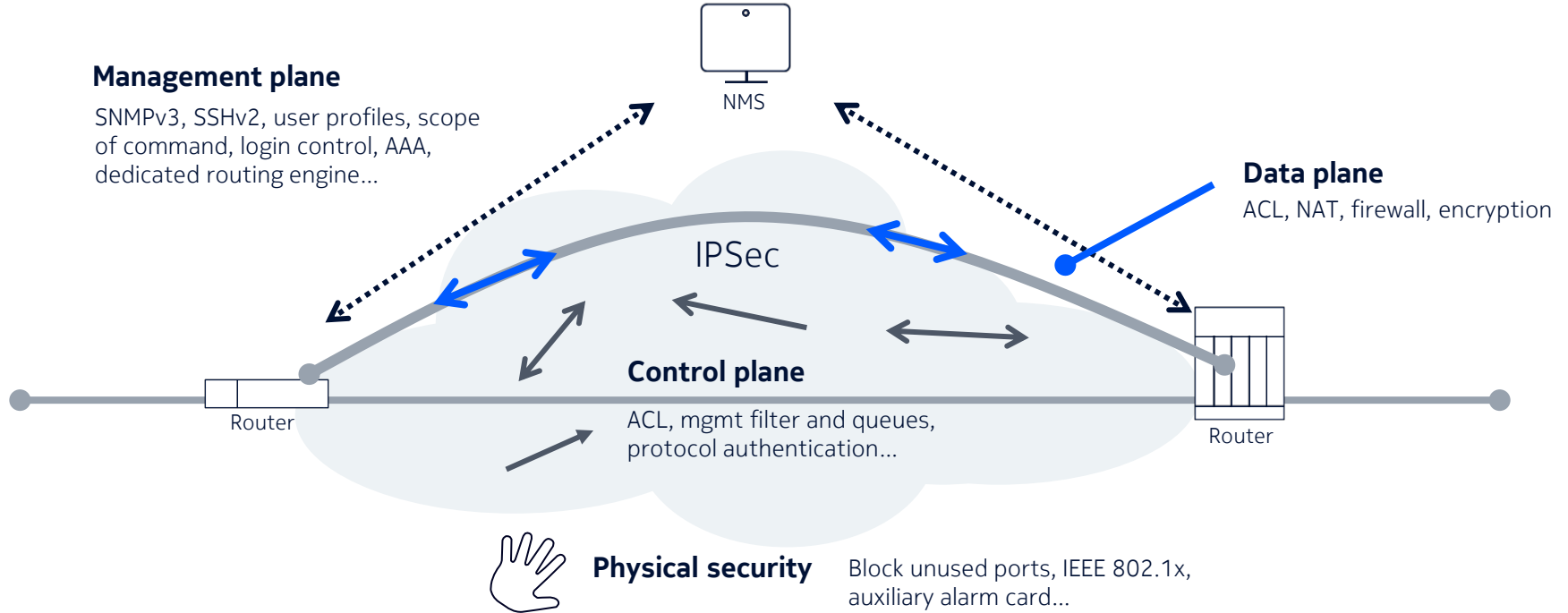


Pseudowire redundancy protects end-to-end connections

- Protection against end-point failure at control center (router, control center building etc)
- All remote routers switches automatically without manual intervention
- Multi-Chassis Synch (MCS) maintains flow/group/link state information across routers

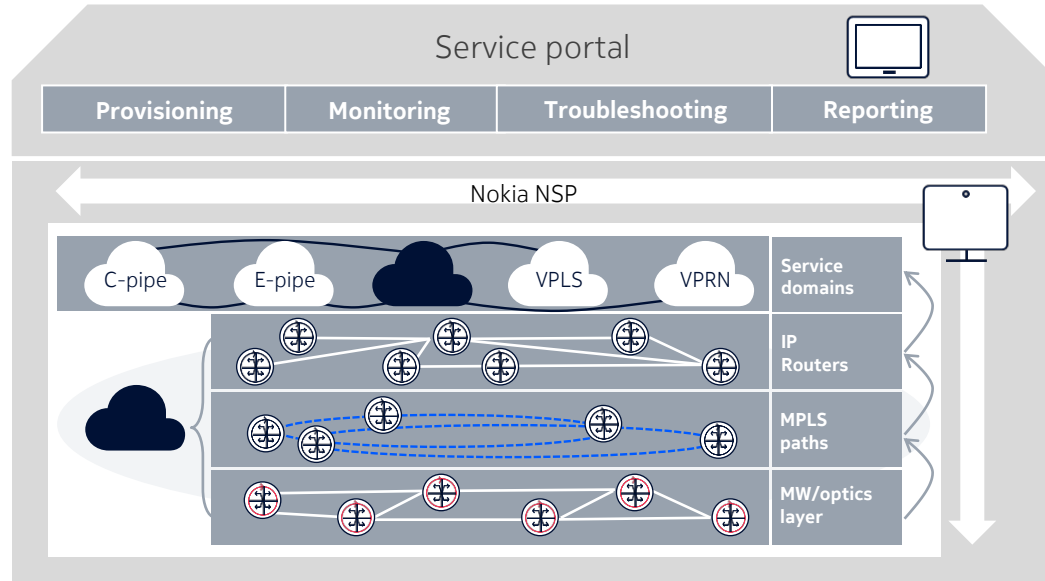
Control center site protection against disaster

Robust set of infrastructure security features



Full security suite fortifies mission-critical network's perimeter

Optimized management synergy across network domains and layers



Agile service provisioning and efficient network operation

- Service portal:
 - Simplify complex provisioning and operations workflow
 - Customized performance assurance and reporting
 - Ubiquitous web-based access from personal device
- NSP:
 - Integrated IP, MW and LTE packet core management
 - Fast provisioning through easy-to-use GUIs
 - Powerful service layer fault correlation and extensive troubleshooting capabilities
 - Proactive network wide OAM orchestration and monitoring

OAM toolset overview

Service layer

- ITU-T Y.1731
- MEF SLM
- IEEE 802.1ag CFM
- Service ping/PW VCCV
- VPLS/VPN tools
- ATM I.610

Layer 3 – Internet protocol

- Bidirectional Forwarding Detection (BFD) with 10 ms timers
- Internet Control Message Protocol (ICMP)/TWAMP

Layer 2.5 – MPLS/tunnel layer

- LSP Ping/Traceroute
- SDP Ping

Layer 2 – Ethernet

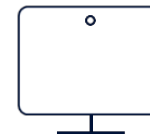
- Y.1731
- IEEE 803.1ag CFM
- MEF SLM
- IEEE 802.3ah EFM

Layer 1 – Optical transmission

- MW Link Fast Fault Detection (FFD)
- Digital Diagnostic Monitoring (DDM)

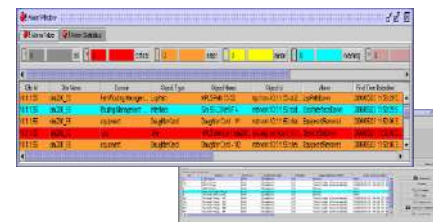
Service

OAM at
every layer



NSP

SAA automatic test suites
and SLA verification

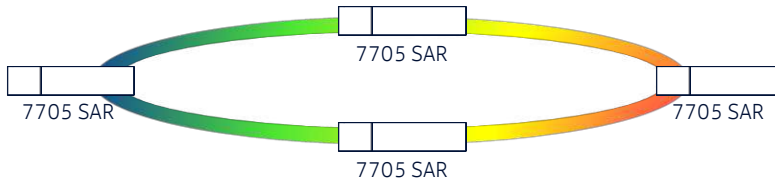


Infrastructure

7705 SAR photonic integration

More capacity on the same fiber link

- CWDM MDAs for 7705 SAR-8 and SAR-M
- Better utilization of optical infrastructure
- Support both 1 GigE and 10 GigE per lambda
- Less cost, rack space and power consumption
- Higher number of 7705 SAR routers around the ring



Nokia E2E communications portfolio for grid modernization

Control center



7750 SR-a8/a4
7250 IXR-R6



NSP

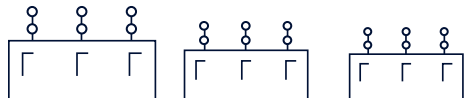
Smart grid WAN

Bulk electric system

500 KV

230 KV

115 KV



Transmission and distribution

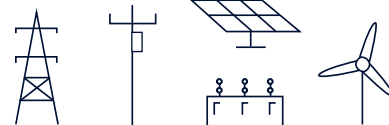
66 KV

33 KV

...and lower



Distribution and Field Area Network (FAN)



7705 SAR-8



7705 SAR-Hm



7705 SAR-Hmc

Digital substation LAN



7250 SAS-Mxp



7250 SAS-Dxp-24p



7250 SAS-Dxp-24p

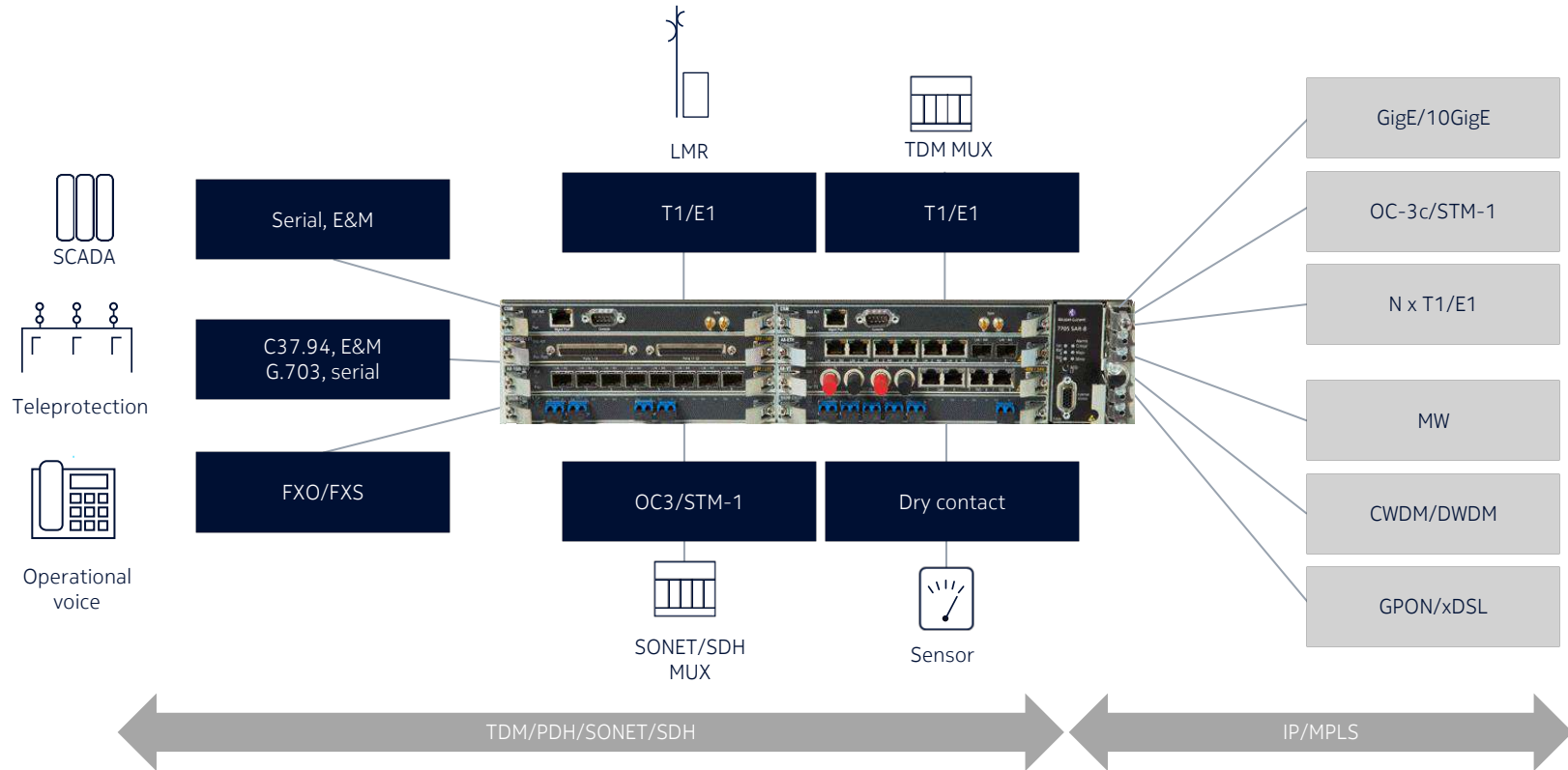
7705 SAR family

The convergence platform for critical communications for utilities



* Available on selected SAR product member only

7705 SAR-8 legacy transformation



Supporting Tele-protection interfaces on 7705 SAR-18 and SAR-8



16-port ASAP T1/E1



32-port ASAP T1/E1



12-port Serial Data Interface: RS232, X.21, V.35



8-port C37.94 teleprotection – SFP based supporting Single mode & multimode



8-port voice and teleprotection – 2 C37.94 + 2 G.703codir + 2 FXS & 2FXO ports



6-port 2/4-wire E&M voice – used in legacy distance protection equipment

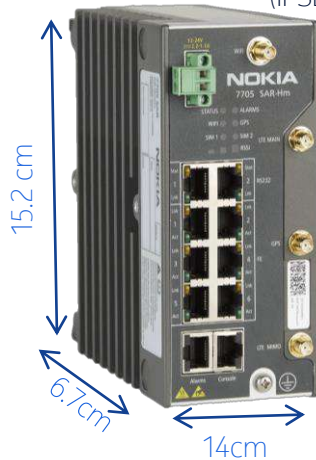
Hardened mobile secured IP/MPLS router

7705 SAR-Hm

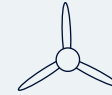
SR
OS



Encryption
(IPSEC, NGE)



Power Typical -30°C +70°C
16W



Fanless



IEC61850-3
EN-50121-4
EN 50155



IP40

Dual SIM (mini industrial)

12V/24v DC Power

2 x RS-232 async (raw socket)

6 x 10/100 UTP

Alarms

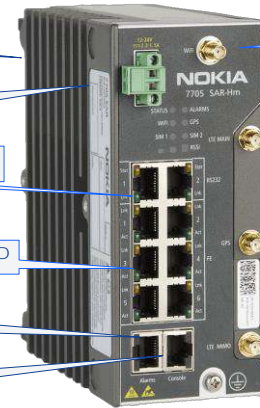
Console

Wifi

LTE WAN (external antenna)

GPS (location)

LTE MIMO



Your gateway to accelerate communications innovation

For DER, cyber security and new business models



Nokia Energy Innovation Center

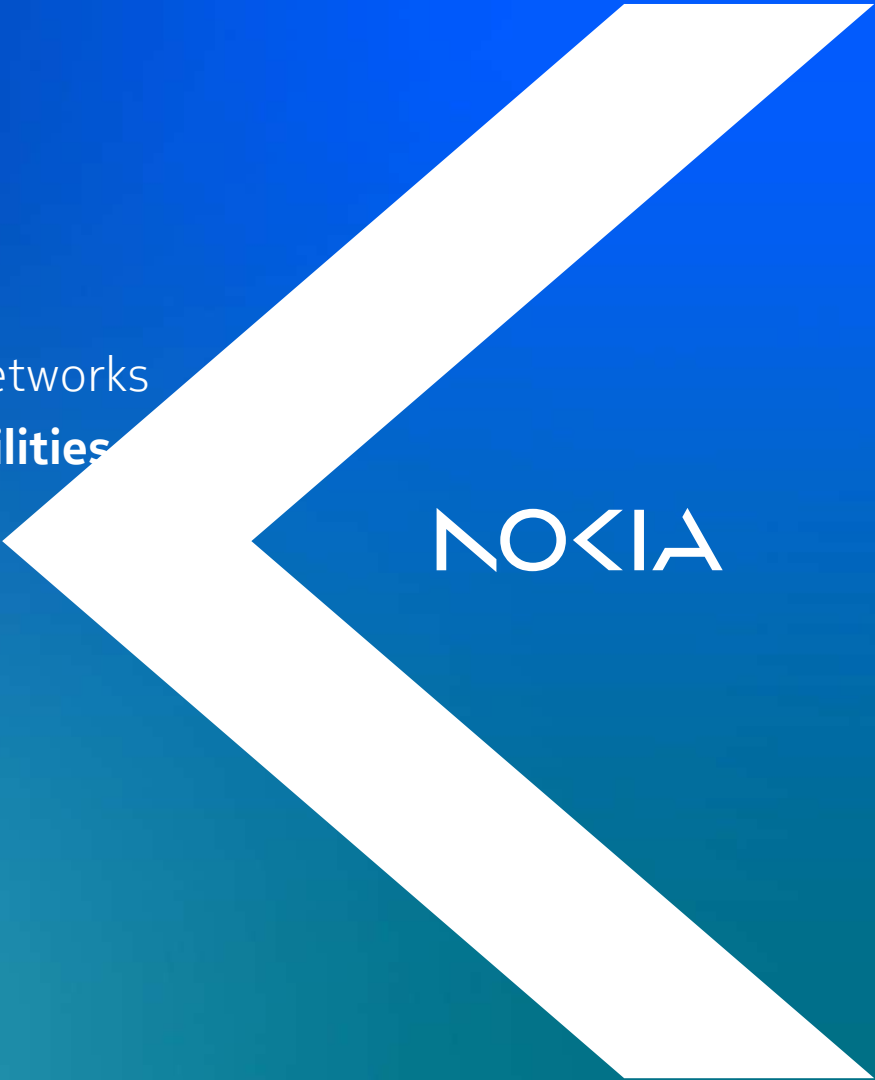
Innovation hub – define, test,
validate and de-risk

Onsite and
remote testing

Connect your lab, power your
transformation and fuel your future

Agenda

- Smart Grid Communication requirements
- Nokia IP MPLS Solution for Critical Utility Networks
- **Major Use cases of IP MPLS Solution in Utilities**
- Long distance Inline ILA Solution with Coherent Optics
- Nokia IP/MPLS product portfolio
- References
- Conclusion

A large, stylized white arrow pointing to the left, which serves as a background for the Nokia logo. The arrow is composed of two thick, parallel lines that converge to a point on the left side of the slide.

NOKIA

Use Case: Current Differential Protection over Packet Networks

For Transmission & Distribution System Operators

Customer challenge

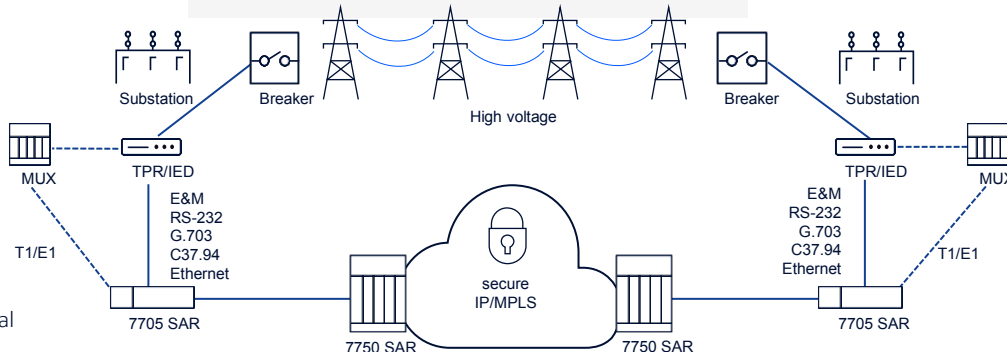
- Eliminating EoL TDM technology
- Migrating legacy mission-critical Differential protection traffic from TDM-based transport networks to new IP/MPLS-based communications networks.
- Meeting stringent latency, jitter and symmetry requirements for protection services

Nokia approach

- The Nokia 7705 SAR industrial IP/MPLS product portfolio for a converged mission-critical network is very extensive with different capacities and form factors to fit various parts in the grid.
- The 7705 SAR product family offers all types of interfaces used by protection relays
- Nokia's patented Asymmetry Delay Control ensures perfect symmetrical latency for Current Differential protection services.
- Nokia's patented Network Group Encryption ensures safe transport of protection traffic

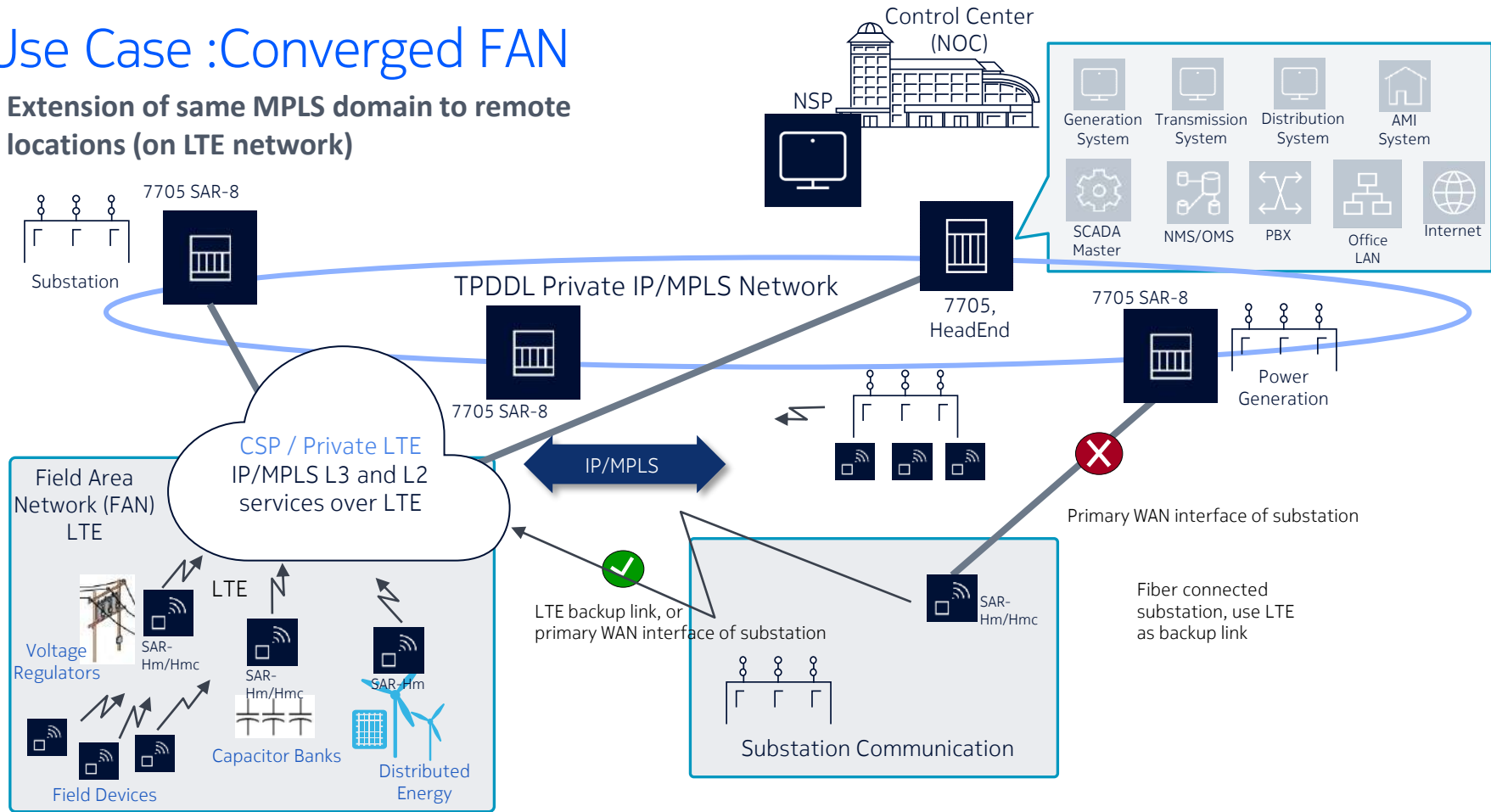
Business benefits

- Fulfill all convergence requirements, including network resiliency, quality of service (QoS), security and manageability
- Eliminate voltage surges, brownouts and prevent damage to expensive substation equipment.
- Support legacy applications allowing a combination of application traffic — old and new, mission-critical and best-effort — over the same network infrastructure without compromising performance.
- All Utility applications can evolve to Ethernet and IP seamlessly



Use Case :Converged FAN

Extension of same MPLS domain to remote locations (on LTE network)



Use Case: IEC 101 to 104 SCADA conversion

For Transmission & Distribution System Operators

Customer challenge

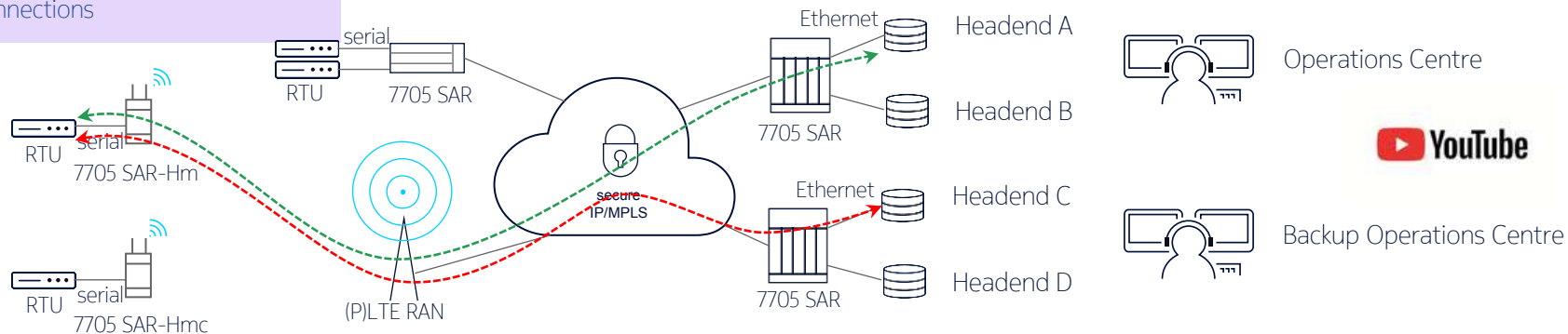
- Maintain existing legacy RTU's in the field with point-to-multipoint connections from master to slaves
- Support IEC 101 SCADA system in the field
- Evolve the SCADA head end, integrate newer RTU architecture and reduce footprint of serial connections

Nokia approach

- Use serial interface of the Nokia 7705 SAR at the RTU end
- Enable RAW socket on the 7705 SAR
- Connect SCADA head end with Ethernet to a 7705 SAR
- Encrypt end to end with Nokia's patented Network Group Encryption to secure the legacy SCADA traffic

Business benefits

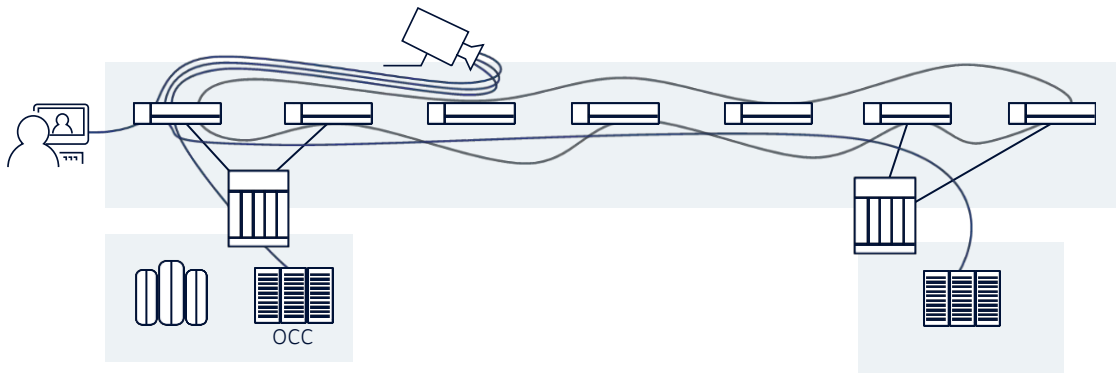
- Enable evolution of the SCADA head end
- Save costs by keeping the RTU's in the field
- Significantly reduce the footprint of the SCADA headend by eliminating serial ports
- Secure the SCADA traffic, protect against spoofing, eavesdropping & hacking



Use Case : CCTV Traffic (Multicast)

MPLS-TP always requires 10G!

Traffic sent 3 times over the links

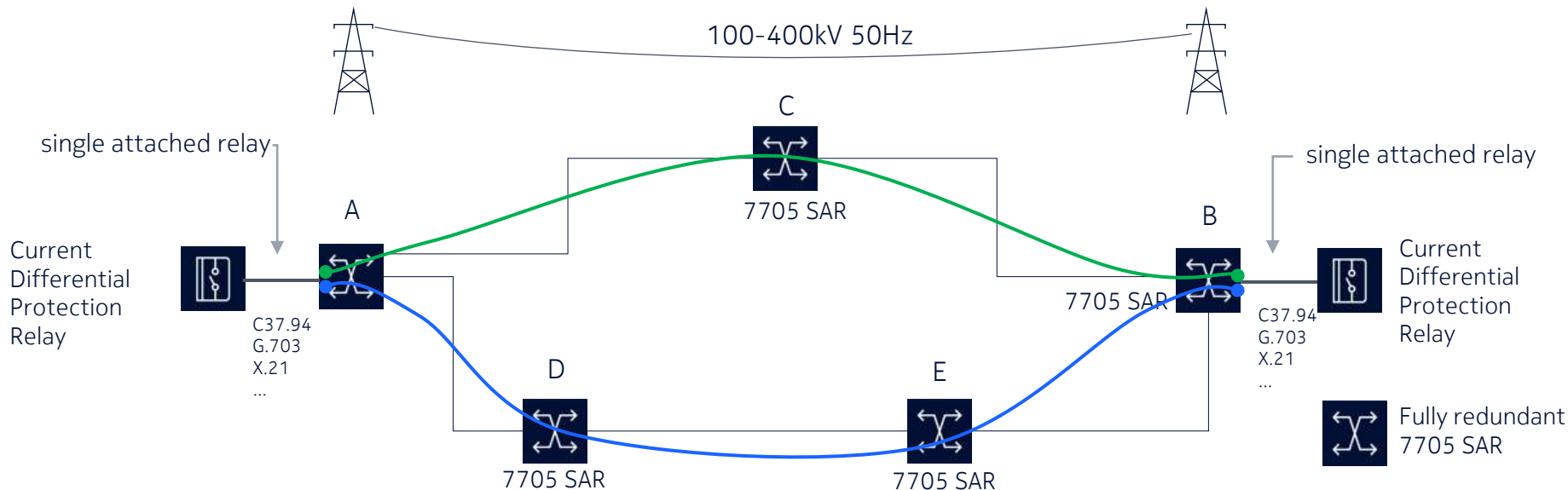


Number of storage areas	2
Number of monitoring centers	2
Number of cameras	100
BW per camera	3 Mb/s
BW without multicast awareness	1.2 Gb/s
BW with multicast awareness	300 Mb/s

- CCTV generates the highest bandwidth requirement on the network
- Without multicast awareness, traffic can be multiplied by at least 2!
- MPLS-TP brings no multicast awareness

Use Case : Current Differential Protection redundancy

Hitless Redundancy with Asymmetry Delay Control (ADC)*



Active strict path 1: ACB (active)
Active strict path 2: ADEB (active)
ACB and ADEB are not equal latency

C37.94 data is sent over two diverse paths simultaneously
Nodes A and B compensate for the difference in latency between two paths
ADC compensates for small changes in latency

Failure/Switchover of the active control card does not impact the Current Differential Protection Traffic

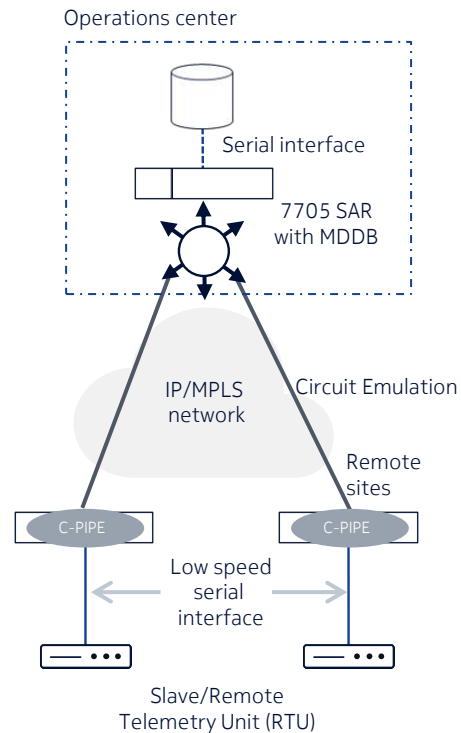
Use Case : Multi-point TDM bridging

MDDB empowers serial-based SCADA migration over IP/MPLS

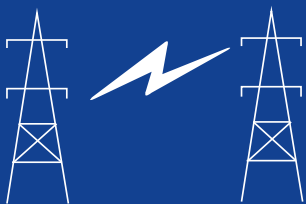
- Supervisory Control & Data Acquisition is also known as:
 - Industrial Control System (ICS) generally
 - Telecontrol equipment for power utilities
- Interlocking for rail operator
- Supervising and monitoring remote industrial processes



Integrated Services Card (ISC)



Teleprotection equipment in use/validated over Nokia IP/MPLS networks

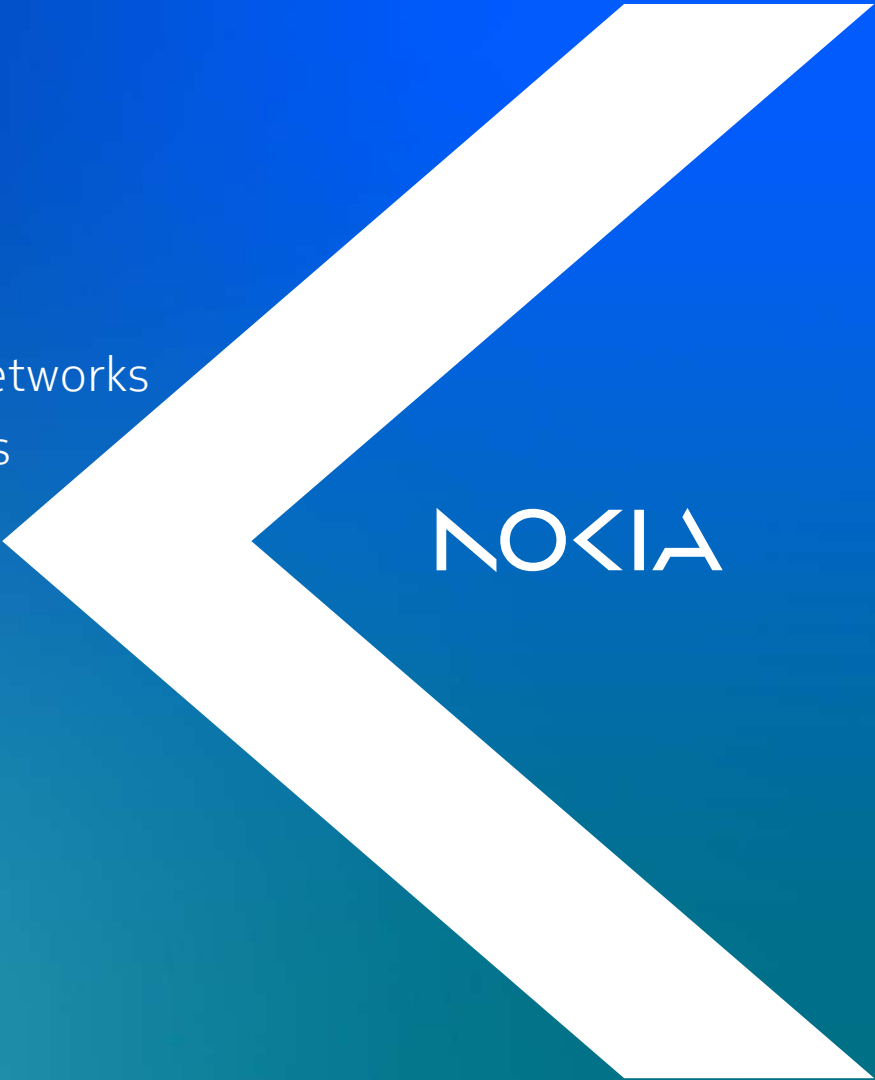


Vendor	Relay Model	Type	Interfaces
	NSD70	Distance	E&M
	NSD570	Distance	X.21, Ethernet
	RED670	Current Differential	C37.94
GRID	P541, P44x	Current Differential	X.21
	P591	Current Differential	X.21
	P545	Current Differential	C37.94
	DIP5000	Distance	X.21
	LE90	Current Differential	
	D60	Distance	G.703 CoDir
	Tone 40	Distance	E&M
	D90	Distance	G.703 CoDir
		Transfer Trip	E&M
	TPS64	Transfer Trip	G.703 CoDir
		Current Differential	Ethernet
	GARD8000	Direct transfer trip	C37.94
	P545	Current Differential	C37.94
	SEL311L	Current Differential	G.703 CoDir
	SEL311C/SEL321C	Distance	RS232
	SEL 411L	Current Differential	C37.94, RS422, RS232
	SEL2506	Transfer Trip	RS232
	7SD32	Current Differential	
	7SD52/7SA522/7SD522	Current Differential	X.21, E1, C37.94, FO5 converter
	7SD82	Current Differential	C37.94, E1
	7SL87	Current Differential	C37.94
	7XV	Distance	X.21
		Distance	X.21
	Sprecon	Current Differential	Ethernet
	GRL100	Current Differential	X.21, C37.94, Ethernet
	TPU1/AVDM	Distance	E&M, E1
	DTIVA-E5	Current Differential	C37.94 G.703 CoDir

Used & validated at	

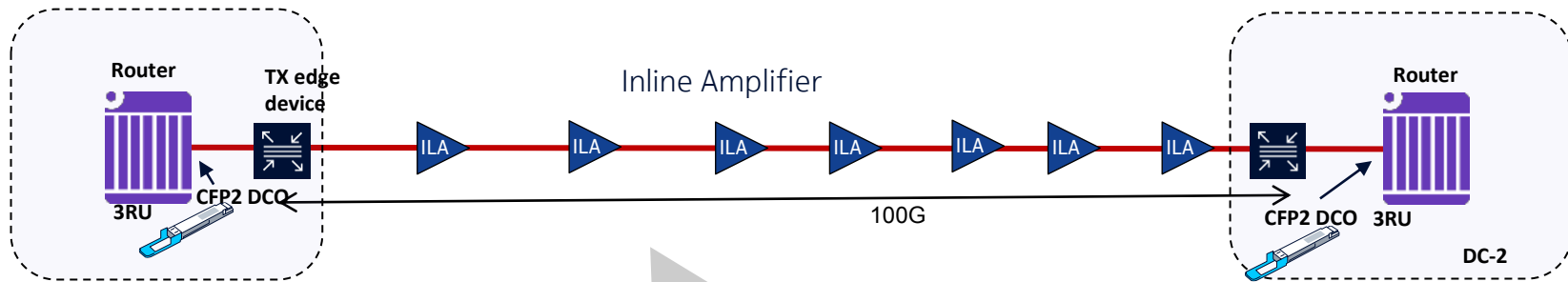
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- Smart Grid Communication requirements
- Nokia IP MPLS Solution for Critical Utility Networks
- Major Use cases IP MPLS Solution in Utilities
- **Long distance Inline ILA Solution with Coherent Optics**
- Nokia IP/MPLS product portfolio
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A large, stylized white arrow pointing to the left, which serves as a background for the Nokia logo. The arrow is composed of two parallel diagonal lines meeting at a point on the left.

NOKIA

Long Distance Inline ILA Solution with Coherent optics on Router



- Drive down cost
- Optimize operations
- Reduce equipment
- Save space
- Reduce power

Save space
and power!



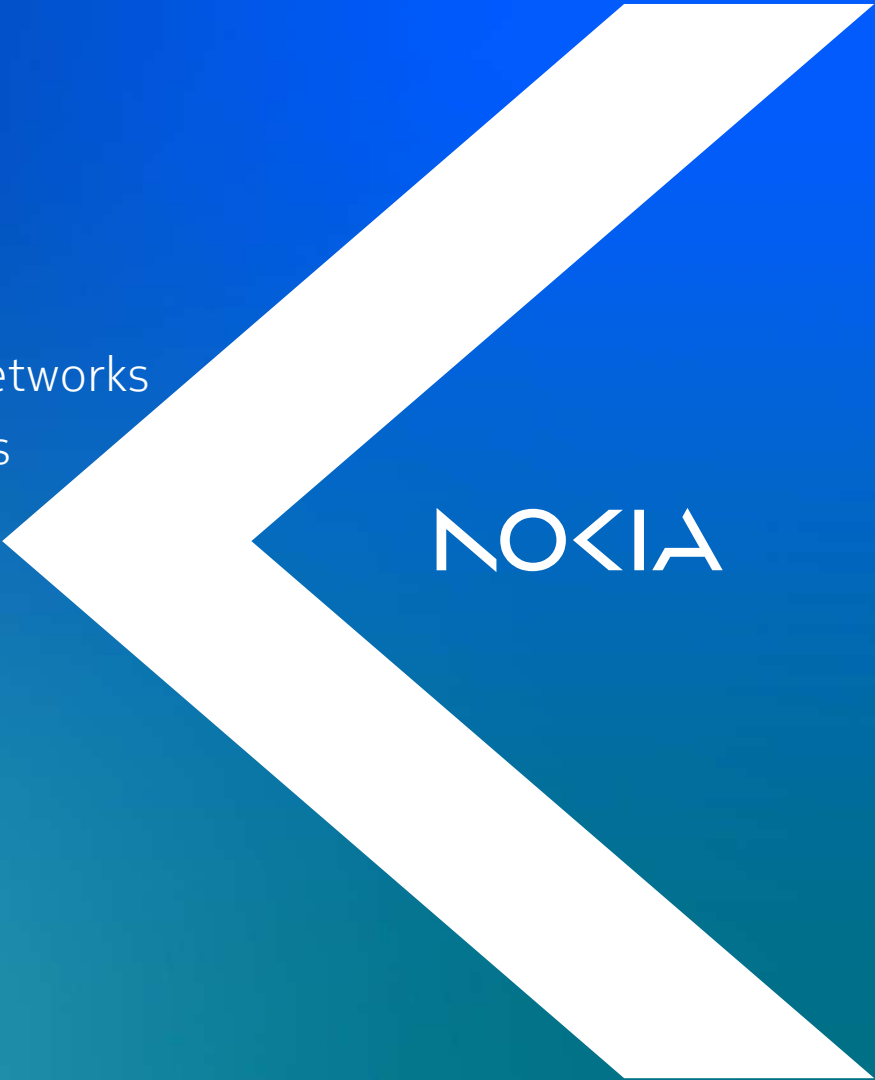
- 100GE CFP2 DCO link
- 10GE DWDM link

700+ Kms



Agenda

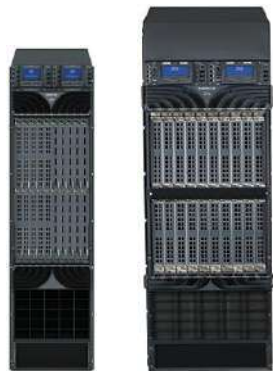
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The Nokia logo is positioned on the right side of the slide, centered vertically. It is a white, sans-serif font. The background of the slide features a large, stylized white arrow pointing to the left, which frames the logo. The overall background is a gradient of blue and teal.

NOKIA

IP routing portfolio at a glance

7950 Extensible Routing System (XRS)



7950 XRS-20

7950 XRS-20e

FP4

3.0 Tb/s network processor

SR OS

Service Router Operating System



Network Services Platform (NSP)

7750 Service Router (SR)



7750 SR-1s



7750 SR-2s



7750 SR-7s



7750 SR-14s



7750 SR-1



7750 SR-7/7450 ESS-7



7750 SR-12/7450 ESS-12



7750 SR-12e



7750 SR-a4



7750 SR-a8



7750 SR-1e



7750 SR-2e



7750 SR-3e

7250 Interconnect Router (IXR)



7250 IXR-e
(2 variants)



7250 IXR-R4



7250 IXR-R6



7250 IXR-s



7250 IXR-Xs



7250 IXR-X1



7250 IXR-6



7250 IXR-10

Virtualized Service Router (VSR)



7210 Service Access Switch (SAS)



7210 SAS-R12



7210 SAS-R6



7210 SAS-Mxp



7210 SAS-T



7210 SAS-Dxp



7210 SAS-Sx 10/100GE



7210 SAS-Sx 1/10GE



7210 SAS-S 1/10GE



7210 SAS-Sx SONET/SDH



7210 SAS-K30



7210 SAS-K12



7210 SAS-K5

7705 Service Aggregation Router (SAR)



7705 SAR-18



7705 SAR-8



7705 SAR-X



7705 SAR-M



7705 SAR-Ax



7705 SAR-A



7705 SAR-H



7705 SAR-Hc



7705 SAR-Hm and Hmc



7705 SAR-O



7705 SAR-Wx

7750 SR product portfolio

Scale breadth to right size any network location



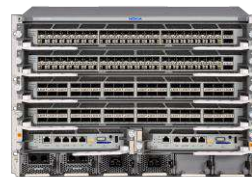
	7750 SR-a4 / 7750 SR-a8	7750 SR-1e/ 7750 SR-2e/ 7750 SR-3e	7750 SR-1	7750 SR-7/ 7750 SR-12	7750 SR-1s/ 7750 SR-2s	7750 SR-12e	7750 SR-7s/ 7750 SR-14
Technology	FP3	FP3	FP4	FP4	FP4	FP4	FP4
System capacity (HD)	200 Gb/s / 400 Gb/s	400 Gb/s / 800 Gb/s / 1.2 Tb/s	3.0Tb/s	4Tb/s / 8 Tb/s	9.6 Tb/s / 19.2 Tb/s	27 Tb/s	57.6 Tb/s / 115.2 Tb/s
Slot capacity (FD)	100 Gb/s	200 Gb/s	1.5 Tb/s	400 Gb/s	4.8 Tb/s	1.5 Tb/s	4.8 Tb/s
Interfaces supported (GE)	100/40/10/1	100/40/10/1	400/100/40 /10	400/100/40/ 25/10/1	400/100/10	400/100/25/10/1	400/100/10

Dynamic interconnectivity

7250 IXR product family - designed for longevity



- Extended temperature
- <300 mm depth for ETSI-compliant cabinets



7250 IXR-e

7250 IXR-R4
7250 IXR-R6

7250 IXR-Xs
7250 IXR-X1
7250 IXR-s

7250 IXR-6

7250 IXR-10

240-600 Gb/s
14-32 x 10GE
18-32 x GE
100, 40, 25GE and
copper interfaces
GNSS options

R4: 600 Gb/s
4 slots, 160 Gb/s
Plus 2 x 10GE, 10 x GE
fixed ports

R6: 1.6 Tb/s
6 slots, 160 Gb/s

X: 9.6 Tb/s
4-6 x 400 GE
32 x 100/40 GE
48 x 50/25/10 GE

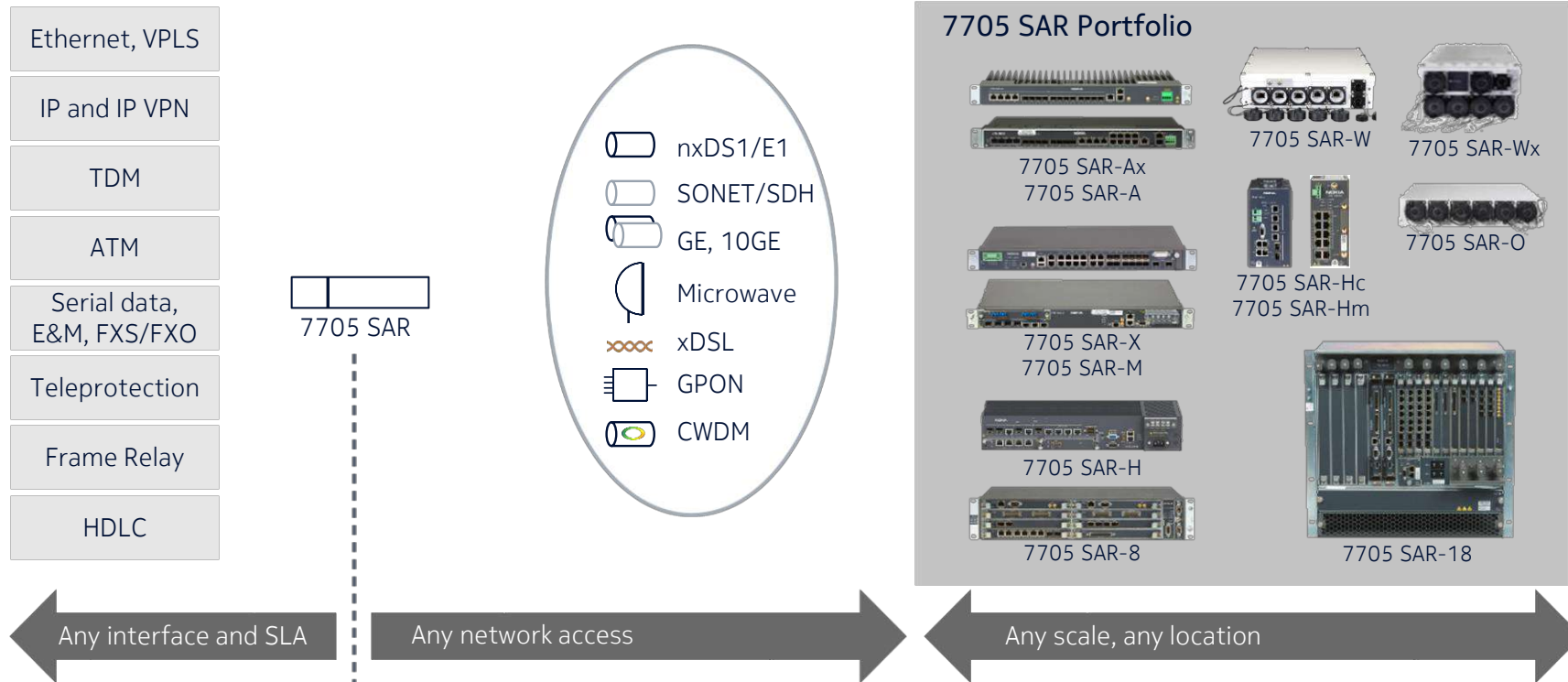
s: 1.6 Tb/s
6 x 100GE
48 x 10GE/GE

28.8 Tb/s
4 slots, 3.6 Tb/s
144 x 100GE/40GE
192 x 10GE/GE

57.6 Tb/s
8 slots, 3.6 Tb/s
288 x 100GE/40GE
384 x 10GE/GE

7705 Service Aggregation Router

Carrier Ethernet access and aggregation and mission-critical WANs



7210 SAS portfolio

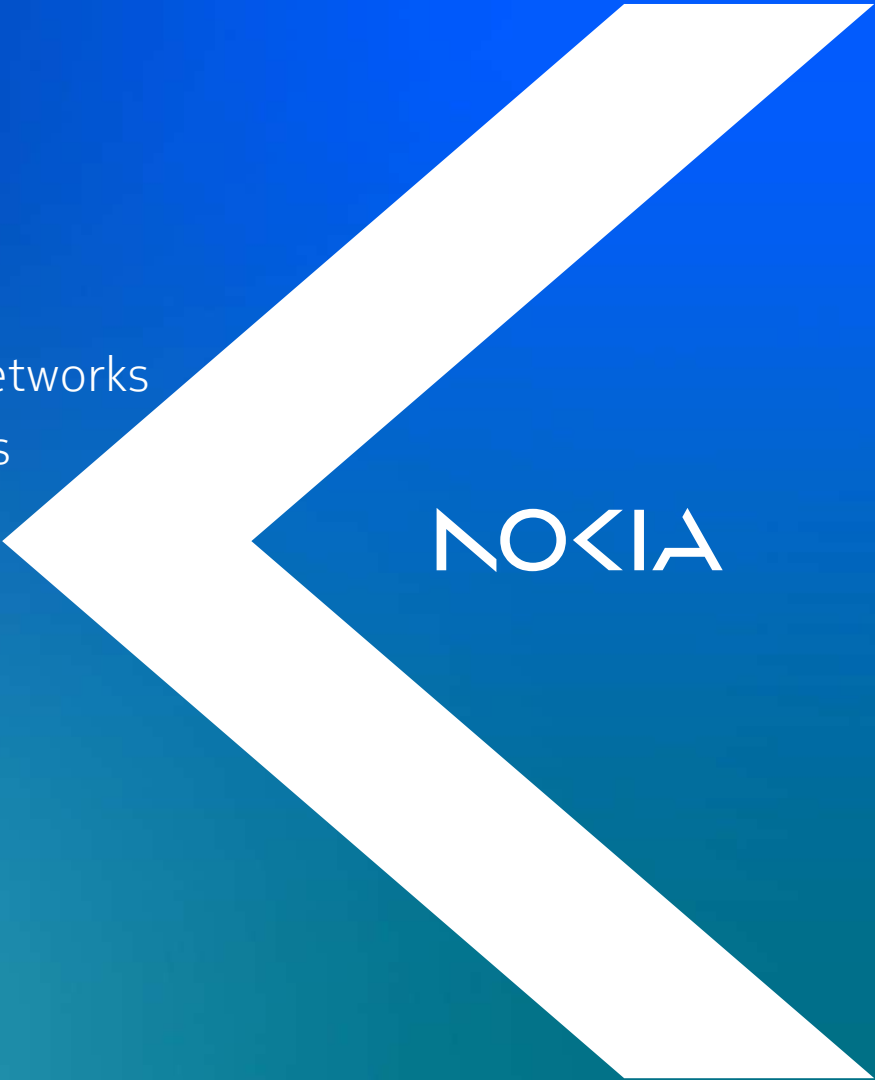
IP/MPLS and Ethernet access



7210 SAS-K5 7210 Dxp	7210 SAS-K12 7210 SAS-K30	7210 SAS-Mxp 7210 SAS-T	7210 SAS-S/Sx series	7210 SAS-R12 7210 SAS-R6
10-60 Gb/s 5-10 x GE ports Dxp: 2 x 10GE ports Ethernet only	18-60 Gb/s 8-12 x GE ports K30: 3 x 10GE ports	124-128 Gb/s 22-24 x GE 4 x 10GE	128 -176 Gb/s – 2 Tb/s 24-48 x GE, 4 x 10 GE 64 x 10GE, 4 x 100GE	960 Gb/s – 1.92 Tb/s 6-12 x 100 Gb/s slots

Agenda

- Smart Grid Communication requirements
- Nokia IP MPLS Solution for Critical Utility Networks
- Major Use cases IP MPLS Solution in Utilities
- Long distance Inline ILA Solution with Coherent Optics
- Nokia IP/MPLS product portfolio
- **References**
- Conclusion

The Nokia logo is displayed in white, consisting of the word "NOKIA" in a sans-serif font. It is positioned within a large, stylized white arrow that points to the left, set against a blue background that transitions from a darker shade at the top to a lighter shade at the bottom.

NOKIA

Réseau de Transmission d'Électricité (RTE), France



IP/MPLS WAN & LAN, Optical & Microwave backbone

“RTE’s Network spans more than **100,000**km of power lines ranging from 63kv to 400kv. To control this, we need a comprehensive **digital infrastructure** to operate this system in real time. In order to fully participate in the energy transition of the European power system, we decided almost 10 years ago to proceed with its digital transformation”. Sébastien Henry Executive Director IT&Telecom RTE

“RTE has therefore decided to base it’s new network on the Nokia IP/MPLS technology which is deployed in all substations and control centers” Tamatea Raust Telecom Project Manager RTE

Challenges

- **Evolve** the **SCADA** systems to IP
- Advance digitalization of processes
- Implement the most demanding services in terms of **synchronization**, latency and criticality, such as **Current Differential Protection**
- Enable advanced **management** of **transmission assets**

Solution

- IP/MPLS, DWDM optical & Microwave transport and multi-layer network management with Network Services Platform for **2000** network sites
- Supports all **legacy grid control** and protection applications plus new generation of IP-based applications

Benefits

- Efficient migration from PDH & SDH to modern, scalable & future proof technologies
- Improved **end-to-end control** of the transmission infrastructure
- Enables distributed renewable power
- Enables greater & more **secure** control of the smart grid in France



IP/MPLS and optical WAN

“REE is a key player in the energy transition and the challenges we face are clear, and we must be able to anticipate them, so we need to have the best tools with which to carry out our mission with the highest possible quality, safety and efficiency. In this sense, modernizing our communications network is vital in order to advance in the digitalization of our processes and to enable advanced management of transmission assets”.

- López Cormenzana, Director of Transmission Infrastructure Maintenance for Red Eléctrica de España

[Press release](#)

Challenges

- Implement the most demanding services in terms of **synchronization, latency and criticality**, such as Current Differential Protection
- Advance digitalization of processes
- Enable advanced management of transmission assets

Solution

- IP/MPLS, DWDM optical transport and multi-layer network management with Network Services Platform for **800+** network sites (**44.000 Km.** of electrical lines nationwide including Canary/ Balearic islands)
- Supports all **legacy** grid control and protection applications plus new generation of **IP-based** applications

Benefits

- Improves efficiency, extends broadband services and enables distributed **renewable power**
- Boosts digital transformation of operations to realize benefits of Industry 4.0
- Enables greater & more **secure** control of the smart grid in Spain



“We chose IP/MPLS because it allowed convergence of all our existing and future communications services, including **current differential protection** and **distance teleprotection.**” Geoff Axon, SAPN

Confidential

Nokia power utilities references

30 years experience providing mission critical communications to 200+ utilities

Americas

- AltaLink, Canada
- Ameren Services, USA
- BTES, USA
- Chelan County Public Utility, USA
- Cleco, USA
- Elektro, Brazil
- ELFEC, Bolivia
- EPB, Chattanooga, USA
- Internexa, Peru
- Kansas City Power & Light, USA
- LUS Fiber, USA
- New York Power Authority, USA
- Northeast Oklahoma Electric Coop/Bolt, USA
- OG&E, USA
- PCWA, USA

APAC

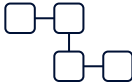
- Ausgrid, Australia
- AusNet, Australia
- CLP, Hong Kong
- CSG, China
- ElectraNet, Australia
- Endeavour Energy, Australia
- Energy Queensland, Australia
- HEC, Hong Kong
- MEA, Thailand
- PEA, Thailand
- PGCIL, India
- PLN, Indonesia
- PowerWater, Australia
- SAPN, Australia
- SGCC, China
- TNB, Malaysia
- TPC, Taiwan
- TPDDL, India
- Transgrid, Australia
- Transpower, New Zealand

EMEA

- 450connect, Germany
- ACEA, Italy
- C4 ENERGI AV, Sweden
- CEPS, Czech Republic
- CEZ, Czech Republic
- Creos, Luxembourg
- EDF (French Islands), France
- Electricite de Strasbourg, France
- ELIA, Belgium
- Energie AG, Austria
- Energie Wasser Luzern, Switzerland
- ENSO, Germany
- Equinor, Norway
- ESB, Ireland
- EWA, Bahrain
- Fingrid, Finland
- Hafslund, Norway
- Iberdrola, Spain
- IPTO, Greece
- Joököping Energi, Sweden
- Red Eléctrica de España, Spain
- Redes Energeticas Nacionais, Portugal
- Repower, Switzerland
- RTE, France
- SEPS, Slovakia
- Stedin, Netherlands
- Swissgrid, Switzerland
- TAURON, Poland
- Teletrans, Romania
- Terna, Italy
- WPD, UK

Conclusion

Nokia IP/MPLS meets all network needs

 Deterministic behavior	 Resilience	 Support for legacy services	 Low latency and jitter	 Synchronization	 Ethernet services	 Environmental hardening	 Cyber security	 Operational simplicity	 Scaling
Traffic engineering	Fast reroute	Circuit emulation	<5ms latency for CES	SyncE	VLL, VPLS, H-VPLS	-40 to +65°C	Access control	Automation NSP	Seamless MPLS
Path design	10 ms BFD	E&M, FXS, FXO	Low nodal latency	1588v2	VPN, multicast	IEC61850-3	Control plane protection	Service portal express	Massive scaling
RSVP-TE	ISSU, power and control redundancy	E1, G.703, E3 STM-1, C37.94	Low jitter	ACR, line sync	Packet microwave	IEEE1613 EN50121-4	Encryption	OAM test capability	Internet scale
	Ring, hub and spoke, mesh topologies	RS232, X.21, V.35, SCADA multidrop	Hierarchical quality of service		PoE	Conformal coating	Firewall, IDS, IPS		Service and QoS, convergence times

Conclusions on IP/MPLS

- Can transport any protocol and runs on any L1 infrastructure
- Supports ring, hub and spoke and full mesh topologies
- Can withstand multiple simultaneous failures
- Supports all resiliency schemes at L2, MPLS, L3 and Service layers
- Allows any application and service at L2 and L3
- Prevents broadcast storms and supports flexible multicast schemes
- Supports all industrial requirements for railways, utilities, military and large enterprises
- Allows significant simplification through integration of different functions
- Provides full cybersecurity
- Scales massively
- Has been widely deployed in railways, utilities, enterprises and governments
- Is future proof, allows any new application and service to be deployed
- Provides end-to-end management for the elements, network and services
- Only IP/MPLS can support all mission-critical communication needs!

Why Nokia?

+200

Utilities with
Nokia solutions

+55

Utilities with
Nokia solutions
for new services

Substation
harden IP/MPLS
routers with 7
industry awards

+1400

Teleprotection
circuits in service
on IP/MPLS

NERC/CIP

Compliant end-
to-end cyber
security

Complete grid
communications
solutions with
professional
services

€ 24.9bn

Net sales 2022

EIC

Energy Innovation
Center

MPLS

Market leader

DWDM

Market leader

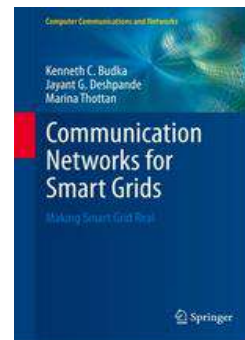
P-LTE

Market leader

SDN

Market leader

NOKIA
BELL
LABS



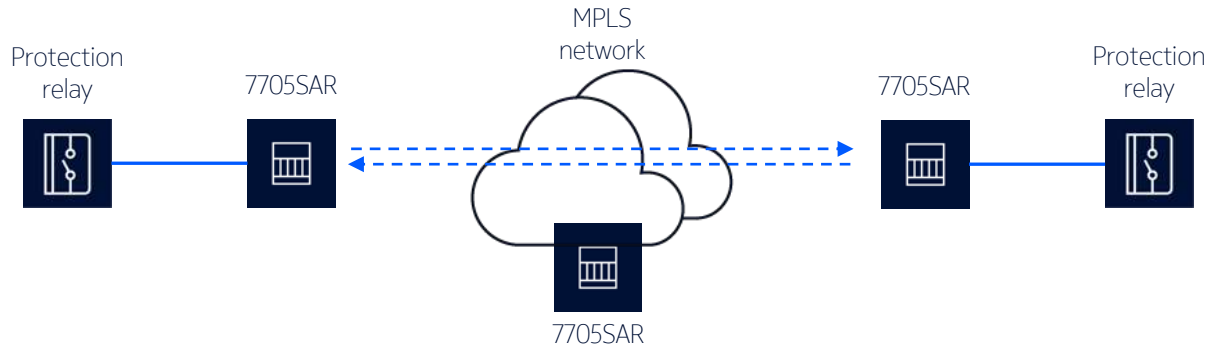
NOKIA

Asymmetrical Delay Control for current differential relays

- Current differential teleprotection relays require tight control of delay between forward/reverse communications paths
- Strict-path deterministic routing is utilized to ensure both direction follow the same path but asymmetry still can exist due to high jitter in the network.
 - Need to monitor/control asymmetry
- Nokia Patented Asymmetrical Delay Control (ADC) feature is used to control the asymmetric latency contributed by the jitter buffer. Before any traffic is forwarded, a start up analysis is performed on the circuit in order to calculate the jitter buffer size.
- Network engineering requirements
 - Use explicit-path LSPs with strict hop criteria
 - Do not use FRR on the teleprotection service path
 - Ensure both directions of the TDM PW traverse the same path end to end.
- Optionally ADC analysis can be set to repeat at configured time intervals after service is up or manually initiated through on-demand ADC.

Nokia patented ADC feature on 7705SAR

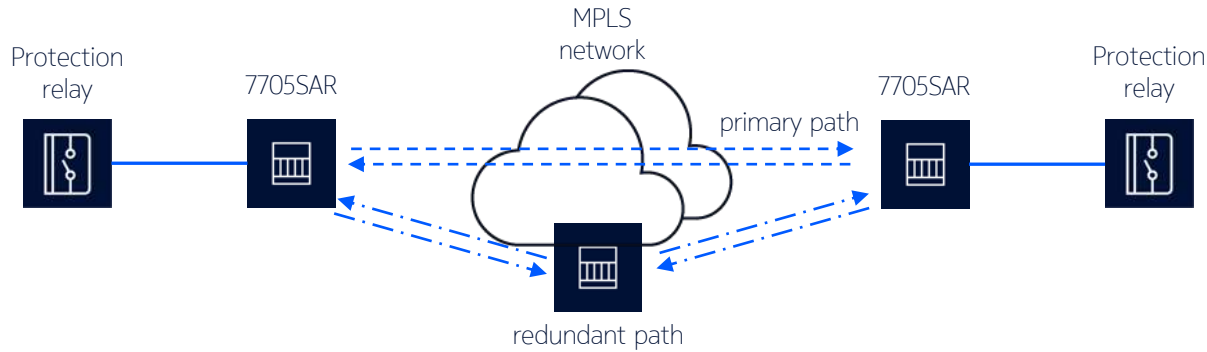
Controlling Jitter within CPIPE VLL service



- At start up or a restart, a configurable number of packets are sampled to calculate the average jitter buffer latency.
- Depending on the difference between the buffers average and expected latency, idle packets will be inserted/dropped
- In the SAR-8/SAR-18, ADC is supported on C37.94, G.703, X.21, RS-232, T1/ E1 ports
- In the SAR-A, SAR-M, SAR-X, and SAR-H, ADC is supported on the T1/E1 ports
- In the SAR-Hc, ADC is supported on the RS232 ports

Nokia patented ADC feature for Redundant Links

Controlling Jitter within CPIPE VLL service on redundant paths



- Designed to overcome asymmetry of traffic latency during path switch overs.
- Active path failure detection due to LOS, BFD failures, LSP down or spoke SDP down.
- After each path switch over, ADC automatically executes it's analysis and resets the jitter buffer latency to the engineered value.
- TDM PWs enabled with ADC receive data only from active path.



Mission Critical Communications – MPLS-TP

17th October 2023

Agenda

- MPLS-TP introduction and equipment details
- Hybrid equipment (Concurrent working of SDH and MPLS-TP)
- What are the distances covered in MPLS-TP
- MPLS-TP in Power Sector applications including teleprotection (Distance and Differential)
- Reference Cases
- Requirement of Local content

Many factors to consider for mission critical communications

Utility Environment



- Extreme temperatures, magnetic and electrical fields.
- Robust, reliable and proven capabilities needed for providing accurate functionality under extreme conditions.
- Dusty and remote environments, where regular maintenance cannot be guaranteed.

Application driven



- Installed base grew during many years, is defined, multiprotocol environment → flexible solution required
- Long-term support for traditional technology/ solutions also in new platforms required

Critical applications



- Very fast signal transmission required in case of failures in the electrical grid
- Highly delay, jitter, asymmetry sensitive applications
- Highest availability for critical services
- Needs to operate as well in case of massive problems in the electrical grid

Backbone for critical infrastructure



- Running system → not easy to migrate, long active life time of system (15 years plus)
- Long active life time requires specific solution → high MTBF in order to no compromise on availability
- Long supplier support required (15 years plus) → opposite to telecom world

What do I get with MPLS based infrastructures?

Cheaper bandwidth

- Cost of bit/s are substantially less in packet switched technologies than in synchronous technologies → massive economy of scale effect
- Optimized solution for packet based services
 - Allowing better usage of BW for pure packet based services
 - Allowing overprovisioning for less critical packet based services
- Not valid for TDM services over packet, this becomes more complex

New service types

- SDH only offers transparent point to point services
- Packet switched solutions offer more service types
 - Point to point services
 - Point to Multipoint service (tree)
 - Any to any service (VPLS)
- Transparent services
- L2 services
- L3 services

Future proof

- New applications are mainly packet based
 - SCADA 104 (TCP/IP)
 - Synchrophasor (TCP/IP)
 - IEC 61850 (Ethernet)
 - PTP time of day distribution
- Key enabler for digitalization in utility environment
 - Asset monitoring
 - Better surveillance
 - Wide area monitoring and protection applications

Internet Protocol/Multi-Protocol Label Switching

IP/MPLS

Dynamic, network defined channel routing

Without special measures, unidirectional communication channels

Link wise channel supervision

Routable protocol (cyber security, e.g. NERC-CIP)

Without special measures non-deterministic data channels

Local switchover, without special measures >> 50 ms

MPLS-TP

Static, user-defined channel routing

Bidirectional communication channels

End-to-end channel supervision

Non-routable protocol

If network is planned properly, nearly deterministic data channels

< 50 ms end-to-end channel switchover guaranteed

SDH

Static user defined channel routing

Bidirectional communication channels

End-to-end channel supervision

Non-routable protocol

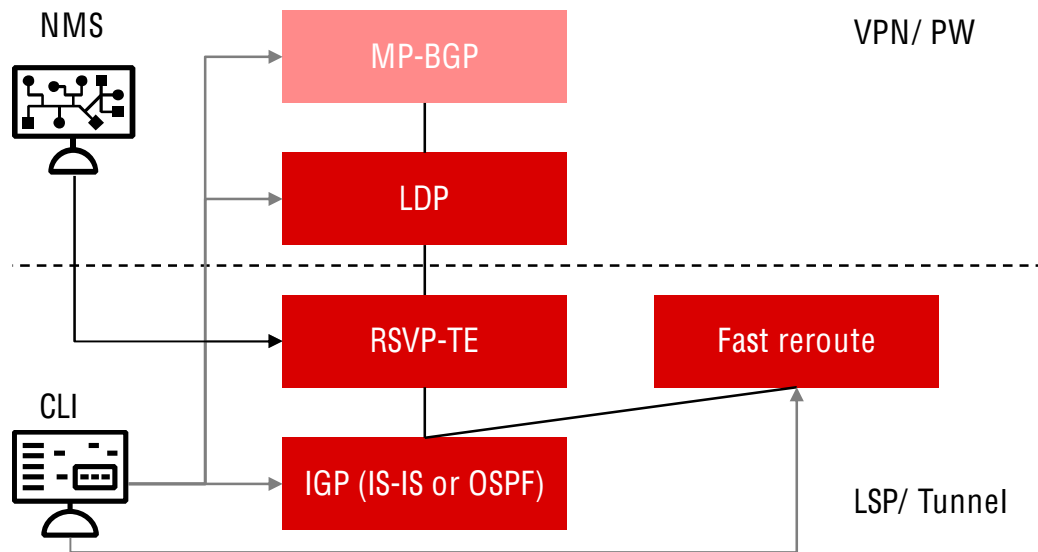
Deterministic data channels

< 50 ms end-to-end channel switchover guaranteed

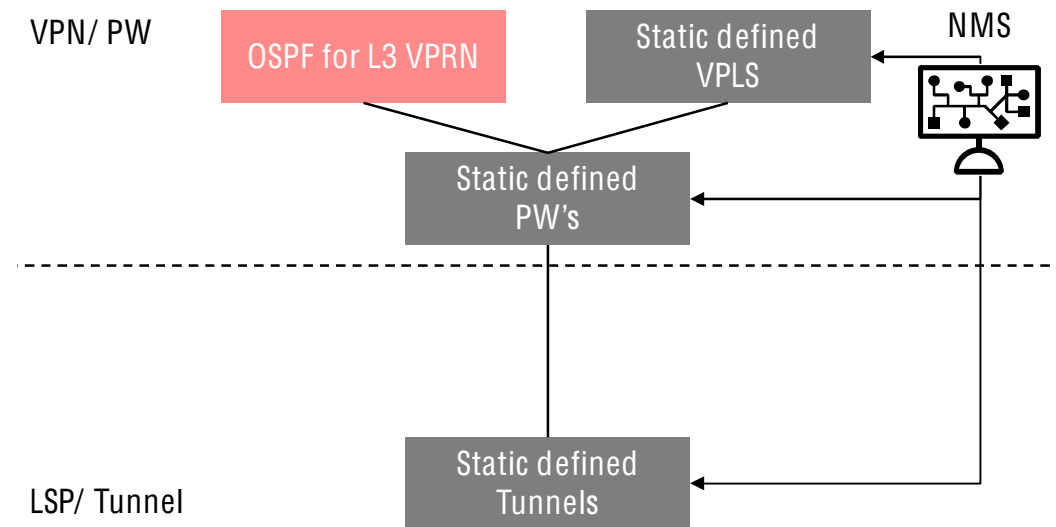
IP/MPLS vs MPLS-TP

Protocol stack needed for a bidirectional fix defined channel

IP-MPLS

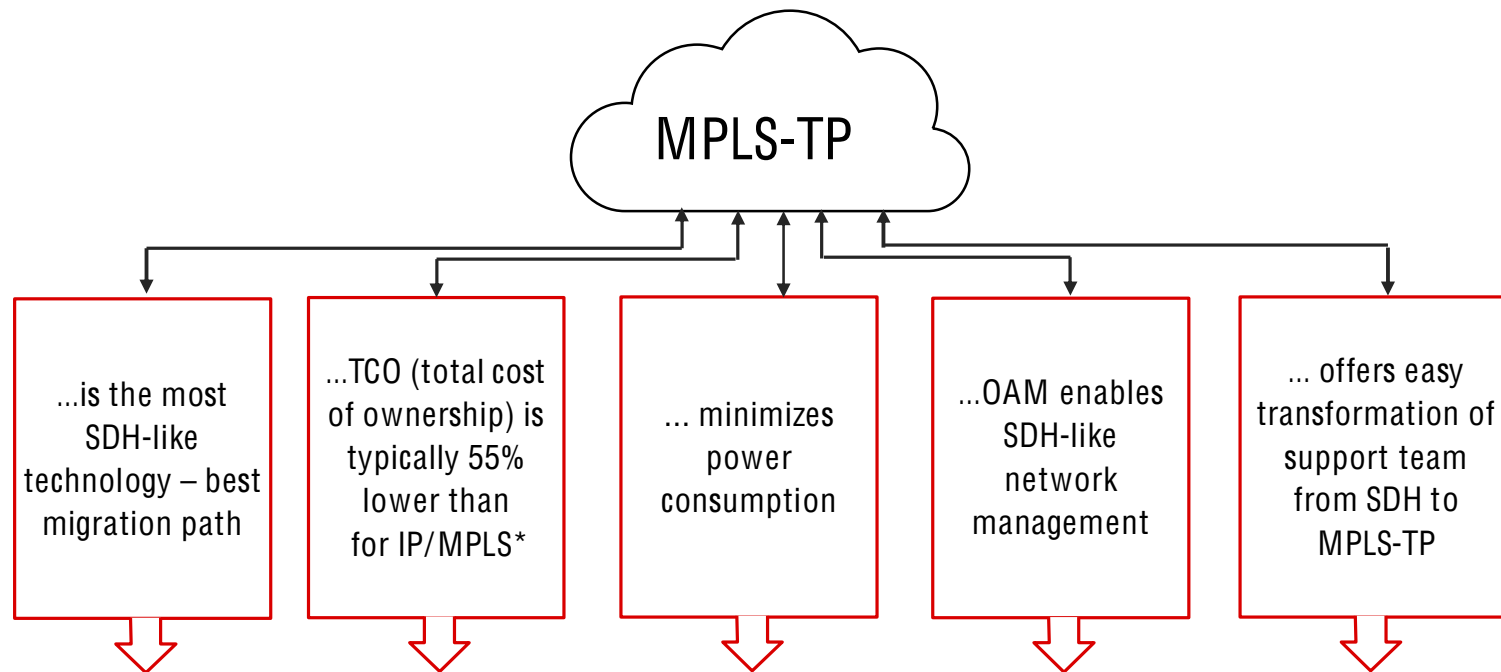


MPLS-TP



MPLS-TP does not need any complex protocol stack for static defined bidirectional communication channels, this makes it easy and efficient in operation for mission critical networks

Multi-Protocol Label Switching – Transport Profile



MPLS-TP is the most logical migration path, also supported by CIGRE as explained in CIGRE Green Book "Utility Communication Networks and services"

FOX615 Powerful multi-technology transport platform

Single MPLS-TP operation

Single Operation

Stand-alone MPLS-TP
or SDH

Concurrent Operation

Parallel MPLS-TP and SDH

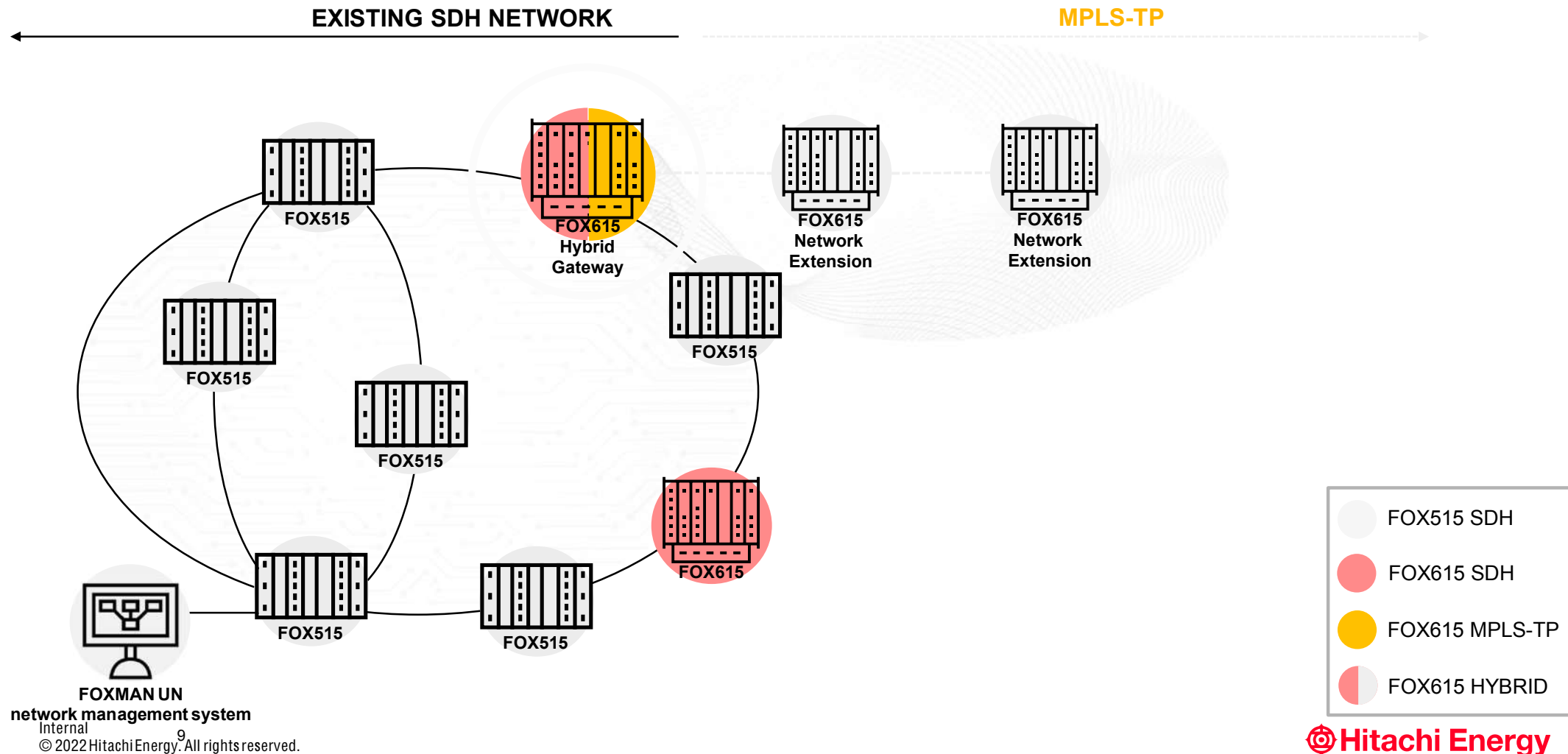
Hybrid

Single SDH operation



FOX615

HITACHI
Inspire the Next



Modular and scalable communication solutions: Hybrid & MPLS-TP



FOX610-MPLS-TP



FOX611(Hybrid)



FOX612(Hybrid)



**FOX615(Hybrid)
with EPEX1**

Height/Total Slots

19", 1HU Housing

2.2HE/4 Slots

4HE/8 Slots

8HE/21 Slots

Applications/Port Capacity

Access/(1/10 GbE)

Access/(1/10 GbE)

Access/Aggregation
(1/10 GbE)

Access/Aggregation/Core
1/10GbE

Physical MPLS-TP Ports

2x1/10G or 4x1G

4x1/10G or 8x1G

8x1/10G or 4x1G+4x10G

8x1/10G or 4x1G+4x10G +
4x1/10G or 1x40G (EPEX1)

Central units

Fixed configuration

CESM1/2

CESM1/2/3

CESM1/2/3+EPEX1

Teleprotection

External

Integrated

Integrated

Integrated

Link distance with MPLS-TP

Distance of Fiber link depends upon Power Budget Calculation with following loss budget parameter:

- OPGW fiber length = Transmission line length + 5 % (for splicing loop, sag etc.)
- Fiber attenuation = 0.35 dB/km @1310 nm and 0.21 dB/km @1550nm
- Splice loss = 0.05 dB per splice, splices every 3 km
- Connector loss = 0.5 dB per connector x 2 connectors
- Optical path penalty = 1 dB
- Maintenance margin = 2.5 dB per 100 km

Power Budget Calculation for SDH: STM – 4 & STM - 16

Sr. No.	Fibre Optic Link Name			Link Distance + SAG	Optical Interface Type	Link Losses (dB)						Total loss	Tx power End Of Life	Rx Sensitivity	Available Power	Additional Margin
	Station A	Station B	Link Distance			Fiber attenuation = 0.35 dB/km @ 1310 nm	Fiber loss = 0.21 dB/km @ 1550 nm	Splice loss = 0.05 dB/Splice, Splice at every 3 km	Connector loss = 1 dB	Optical Path Penalty = 1 dB	Maintenance Margin = 2.5 dB/100 km					
			(km)	(km)		(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dBm)	(dBm)	(dB)	(dB)
1	Local End	Remote end	128	134.4	STM -16 Optical Line Interface card (to support maximum 125 Km) Optoway SPS-93160MWG		28.224	2.3	1	1	3.36	35.884	7	-30	37	1.116
2	Local End	Remote end	146	153.3	STM - 4 Optical Line Interface card (to support maximum 146 Km) APAC Opto LS48-B3U-TI-N-DI		32.193	2.65	1	1	3.8325	40.6755	7	-35	42	1.3245

Power Budget Calculation: 1G and 10G SFP

Sr. No.	Fibre Optic Link Name		Link Distance	Link Distance + SAG	Optical Interface	Link Losses (dB)						Total loss	Tx power End Of Life	Rx Sensitivity	Available Power	Additional Margin
	Station A	Station B			Type	Fiber attenuation = 0.35 dB/km @ 1310 nm	Fiber loss = 0.21 dB/km @ 1550 nm	Splice loss = 0.05 dB/Splice, Splice at every 3 km	Connector loss = 1 dB	Optical Path Penalty = 1 dB	Maintenance Margin = 2.5 dB/100 km					
			(km)	(km)		(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dB)	(dBm)	(dBm)	(dB)	(dB)
1	Local End	Remote end	150	157.5	SFP - SPS-73200WG support maximum 150) 1G MPLS-TP		33.075	2.7	1	1	3.9375	41.7125	7	-36	43	1.2875
2	Local End	Remote end	94	98.7	SFP-SPS-2380WG support maximum 90) 10G MPLS-TP		20.727	1.7	1	1	2.4675	26.8945	4	-24	28	1.1055

FOX XXX Components: 1/2

Subracks



FOX 615 & FOX 615R2
Subrack with ED cover, 19" 8 HU, 21 slots,
MPLS-TP 1/10 GbE , SDH STM1/4/16.



FOX 612
Subrack with ED cover,
19" 4 HU, 8 slots,
MPLS-TP 1/10 GbE ,
SDH STM1/4/16



FOX 611
Subrack with ED
cover, 19" 2,2 HU,
4 slots and
MPLS-TP 1/10 GbE ,
SDH STM1/4/16

Core/MPLS-TP Units



CESM1
64+ Gbps switching
2 x 1/10 GbE
Uplink Core Unit



CESM2
64+ Gbps switching
2 x 10 GbE 2 x 1 GbE
Uplink Core Unit



CESM3
148+ Gbps switching
4 x 1 GbE OR 4 x 10 GbE
Uplink Core Unit

SDH Units



SAM02
2 x SDH STM-16/STM-4
- 2 x SDH STM-4/STM-1

Ethernet -Units



ETOP1/ ETO12-F
12 x GbE SFP L2 Ethernet
optical unit



ELET1
24 x 10/100/1000
Base T L2 Ethernet
electrical Unit



EP011
12 x 10/100/1000 Base T
L2 Ethernet
electrical Unit

Routing



EROP1
12 x GbE Ethernet SFP
L3 Routing

FOX XXX Components: 2/2

Voice



LEDA1
2/4 Wire E & M
EPAX nterface



LEXI1
12-Port FXO, 2-wire
voice interface



LESU1
16 Port FXS, 2 wire
voice interface

Data



LECO1
G.703 64 kbps,
8 interfaces



LEDS1
Serial DCE,
4 interfaces &
1x Ethernet

Interwork



CEPI1
Circuit emulation over packet+
8 x E1/ G.703 Interfaces



LEDE1
G.703 2 Mbps,
8 interfaces

Teleprotection



TEPI2
4 x protection commads
Hybrid distance protection
interface module

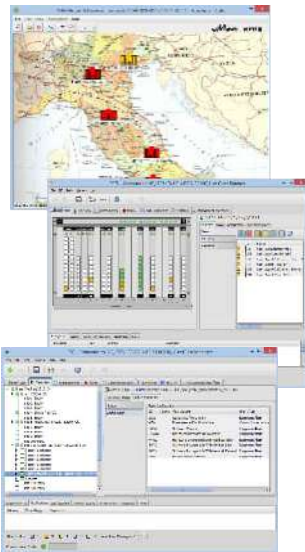


OPIC2
4 x differential protection
ports, IEEE C37.94
MM SFP 850 nm, LC/PC
SM SFP 1310 nm, LC/PC



TEGO1
4 x FE/ GbE interfaces
GOOSE messages for
distance protection
Sampled Value (SV) for
differential protection
Direct connection with
the station/process bus of
IEC 61850 substations.

NMS



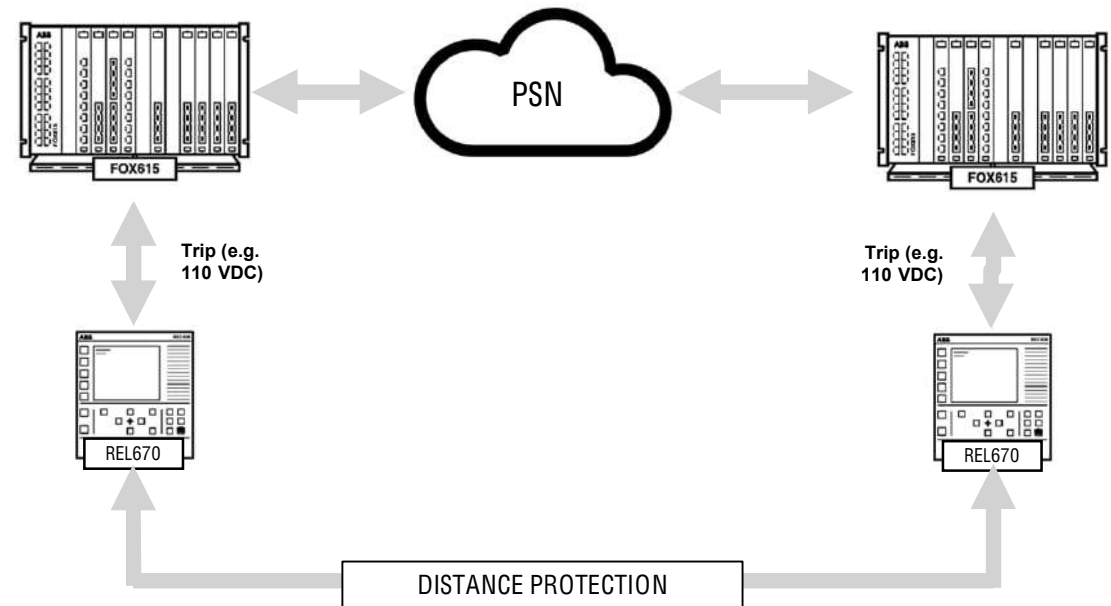
UNEM
Local craft terminals
ECST/ UCST

FOX xxx & TEPI2 enabling distance protection via PSN

Requirements for reliable operation

Distance Protection via PSN

- Reliable transmission of trip signals
- Guaranteed latency time of < 10 ms
- Ensured dependability and security as per IEC60834-1
- Ensure data integrity of trip signals in packet based wide area networks
- Ensure availability of > 99.999% for mission critical applications
- End to end real time channel supervision and centralized alarming in NMS
- Advanced testing & measurement functions such as loop tests, latency measurement, packet counters and event recorder
- Unblocking signal for protection relay in case of communication failure

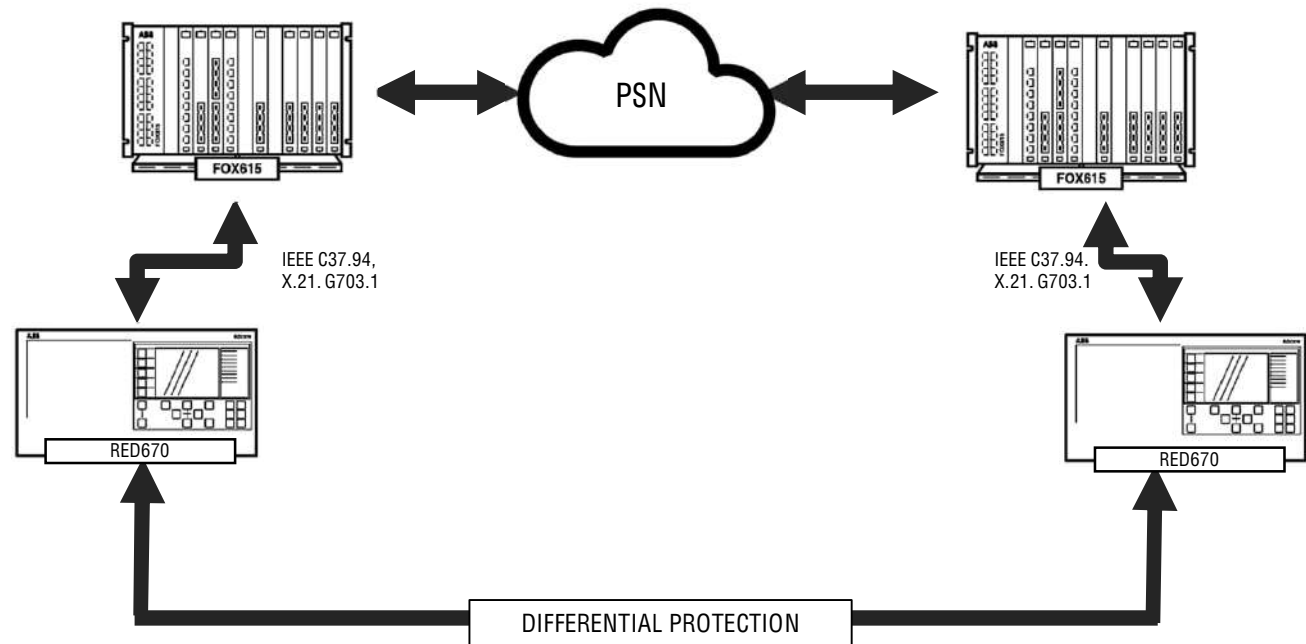


FOX615 & OPIC2 enabling differential protection via PSN

Requirements for reliable operation

Differential Protection via PSN

- Reliable transmission of current, voltage or phasor measurements
- Guaranteed latency time of < 10 ms
- Ensured that no wrong tripping is caused due to communication problems
- Guaranteed symmetry of data channel of < 150 μ s
- Guaranteed jitter/ wander of < 150 μ s
- Ensure data integrity of trip signals in packet based wide area networks
- Ensure availability of > 99.999% for mission critical applications
- End to end channel supervision and centralized alarming in NMS



Mission Critical Communication: MPLS-TP Customer Success

HITACHI
Inspire the Next



Tantransco, India

Hitachi Energy India Limited deployed one of the first utility hybrid FOTE solution for its mission critical communication network migrating the legacy Time-Division Multiplexing (TDM) method of transferring signals like Ethernet (IEC 60870-5-104), RTU/SAS on Serial V.24/V.28, Distance & Differential Protection & to a packet-switched (MPLS-TP) technology at Tamil Nadu Transmission Corporation.



CESC, Kolkata

Hitachi Energy India Limited successfully implemented the migration of existing old SDH STM-1/STM-4 Time-Division Multiplexing (TDM) based services over MPLS-TP mission critical communication network for Ethernet (IEC 60870-5-104 data) Distance and Differential protection over IEEE C 37.94 at CESC India Limited, Kolkata



CKW, SWITZERLAND

Hitachi Energy's FOX615-based network uniquely met Centralschweizerische Kraftwerke's cybersecurity standards especially for protection applications based on optimized MPLS-TP technology and the Precision Time Protocol (PTP) as well as interoperability between conventional and modern protection applications.



TRANSENER, ARGENTINA

Hitachi Energy provides the communication solution for the 500kV grid of Argentina. This network builds the core backbone for Argentina's energy supply. The FOX615 hybrid platform enables Transener to migrate to packet networks without performance compromises and unnecessary risks.



Reference – Hybrid/MPLS-TP Implementation: CKW

The Project

- Modernization of OT network
- Converge multiple applications on the same infrastructure
- Simplify management of legacy and packet networks

Proposed Solution

- FOX615 Hybrid Multiservice platform Transport: 10GbE MPLS-TP-capable
- Quantum-safe encryption for superior network security
- IEC61850 proxy gateway with GOOSE and sampled values

Benefits

- Increased efficiency with a single packet-switched OT network
- Ensured high availability during a complex migration
- Operation of a utility-grade MPLS-TP network with limited OPEX

“

The astounding lifecycle of the FOX615 communication solutions, its operational reliability and flexibility allows us to optimize CapEx and OpEx, protects our investment and extends the life of our installed base and assets.

”

Remo Niffeler

Head of Grid Communication CKW
Grid Communication 2020+ project



Reference – Hybrid/MPLS-TP Implementation: Tantransco

The Project

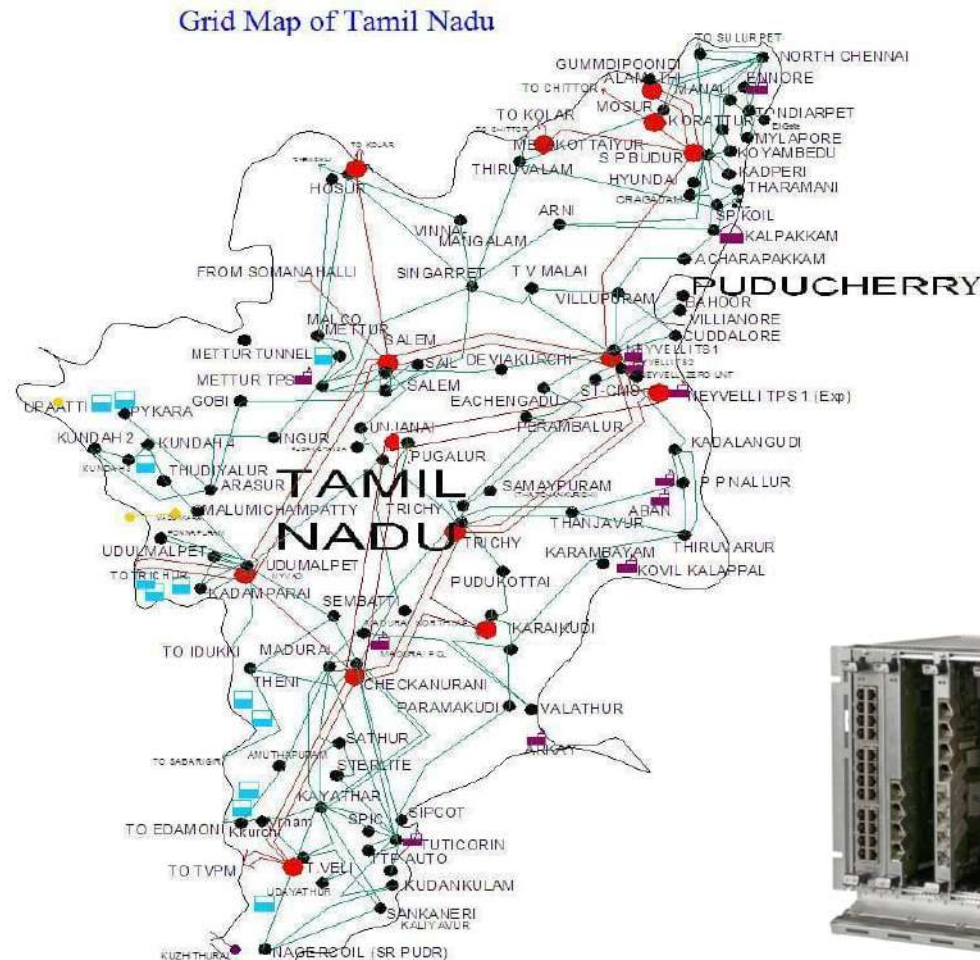
- Migration of TDM based legacy application for OT network with Hybrid FOTE over 230 KV above and MPLS-TP for 110 KV S/S
- Converge multiple applications, Data (IEC 60870-5-104 & 101) Differential & Distance Teleprotection on the same infrastructure
- Simplify management of legacy and packet networks

Proposed solution

- FOX615 Hybrid Multiservice platform Transport: 1G/10GbE Hybrid & MPLS-TP- capable
- Ethernet IEC 60870-5-104 & IEC 60870-5-101 data.
- Differential & Distance Teleprotection for intertripping application

Benefits

- Increased efficiency with a single packet-switched OT network
- Single NMS for overall network with all application including teleprotection.
- Ensured high availability during a complex migration



Reference – Hybrid/MPLS-TP Implementation: CESC

The Project

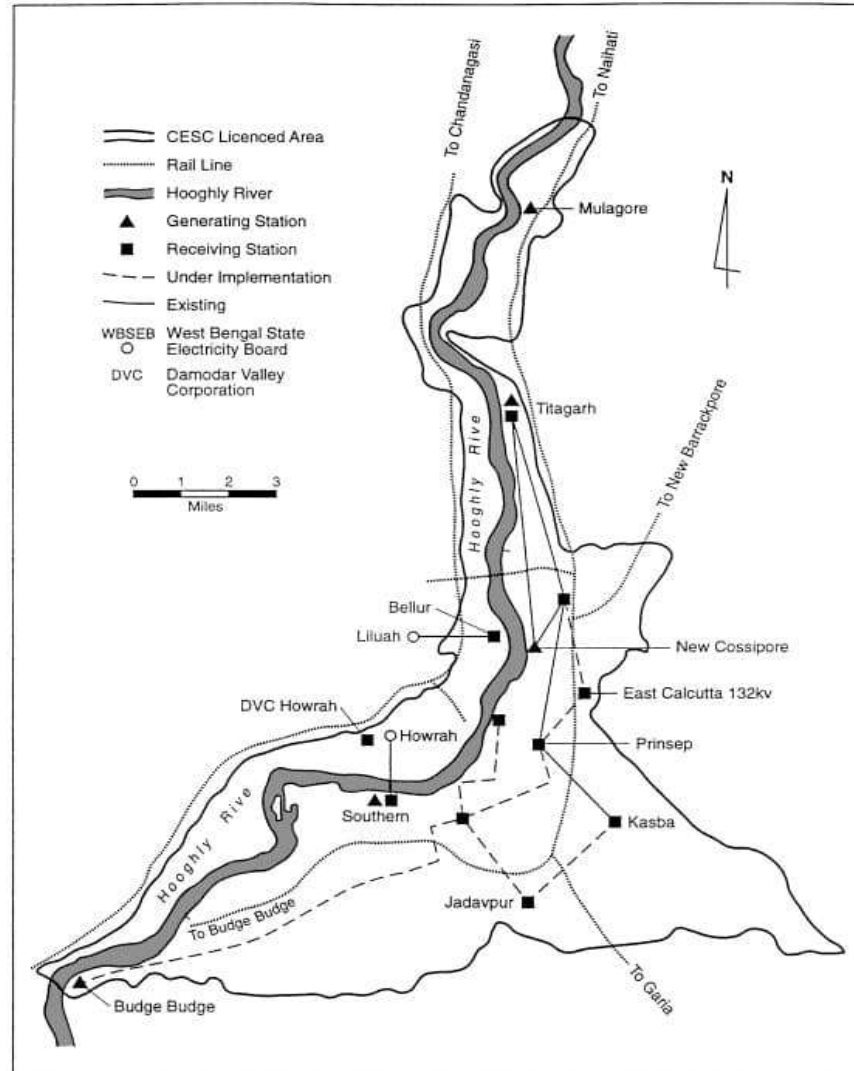
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- One NMS for overall network with all application.
- Ensured high availability during a complex migration



Challenges – Requirement of Local Content

Hitachi Energy India is a manufacturer of Power Line Carrier serving the Communication needs of Power Utilities for last 5 decades – our factory started operations in India in 1968 –ETBA/ ETBB / ETI/ ETL

We started manufacture of Fiber Optics equipment FOX in 1995 – Hardware based (FOX-20), Software controlled Multiplexer PDH (FOX-U) , SDH (FOX-515/ 615) and now MPLS-TP / Hybrid (FOX-615).

During these 5 decades our single focus has been to serve the long distance Communication needs of Power Utilities in India in terms of Teleprotection, Data and Voice irrespective of the medium i.e Power Line or Fiber.

MII policy looks at FOTE as a product while Power Utility Telecom buys a Communication System and hence should we be saying that all the Services (like Survey, Installation, Commissioning, Training) related to this Communication System are non value add ?

MII policy says that the purpose of the policy is to allow adequate competition and that it should discourage creating any monopoly. However, what is our situation in India today ?

We have adequately represented to CEA and Customers and hope for a solution soon.

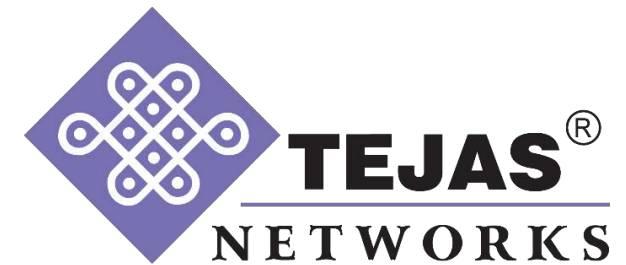


Annexure-XVIII

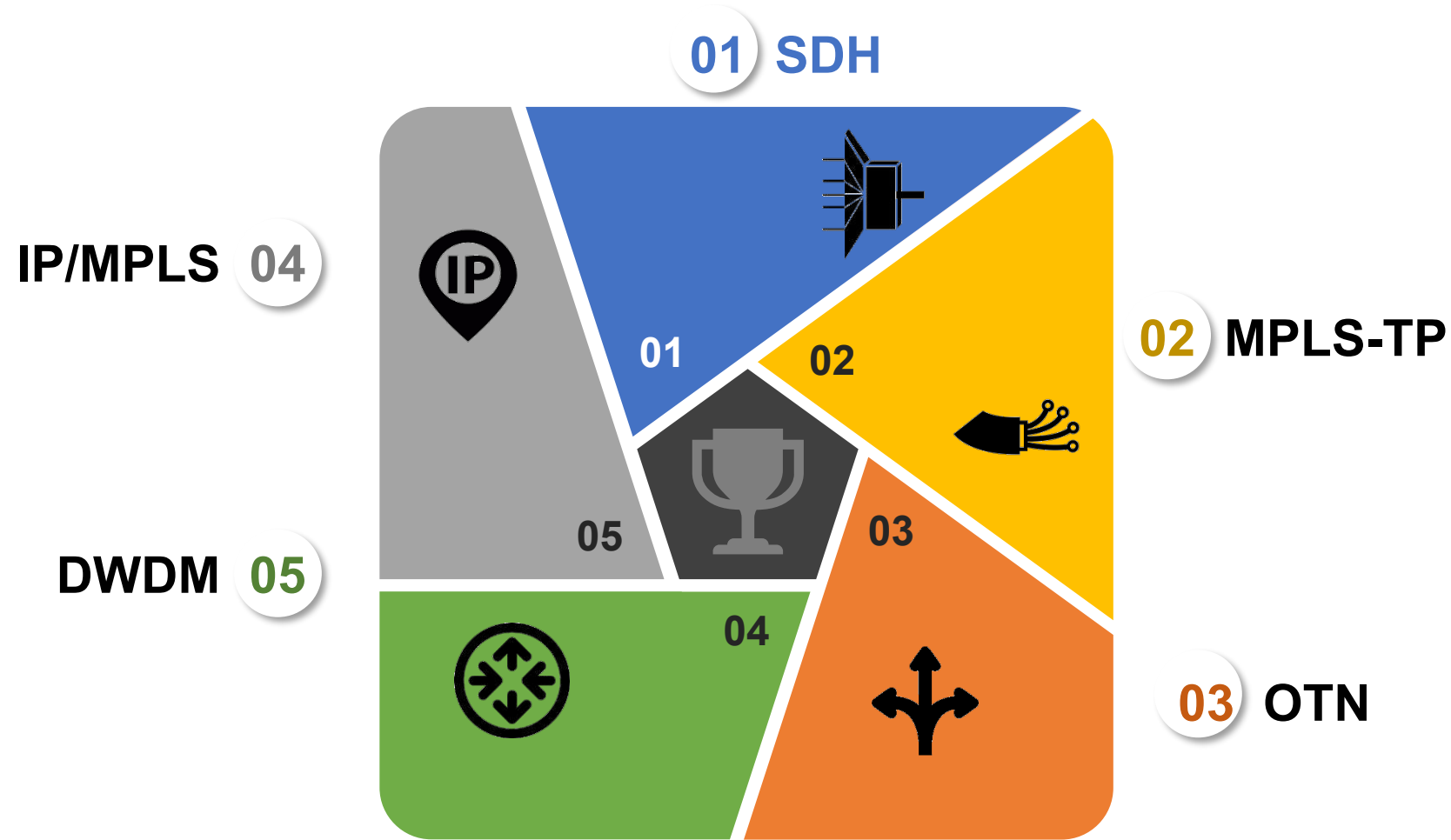


Technology Overview

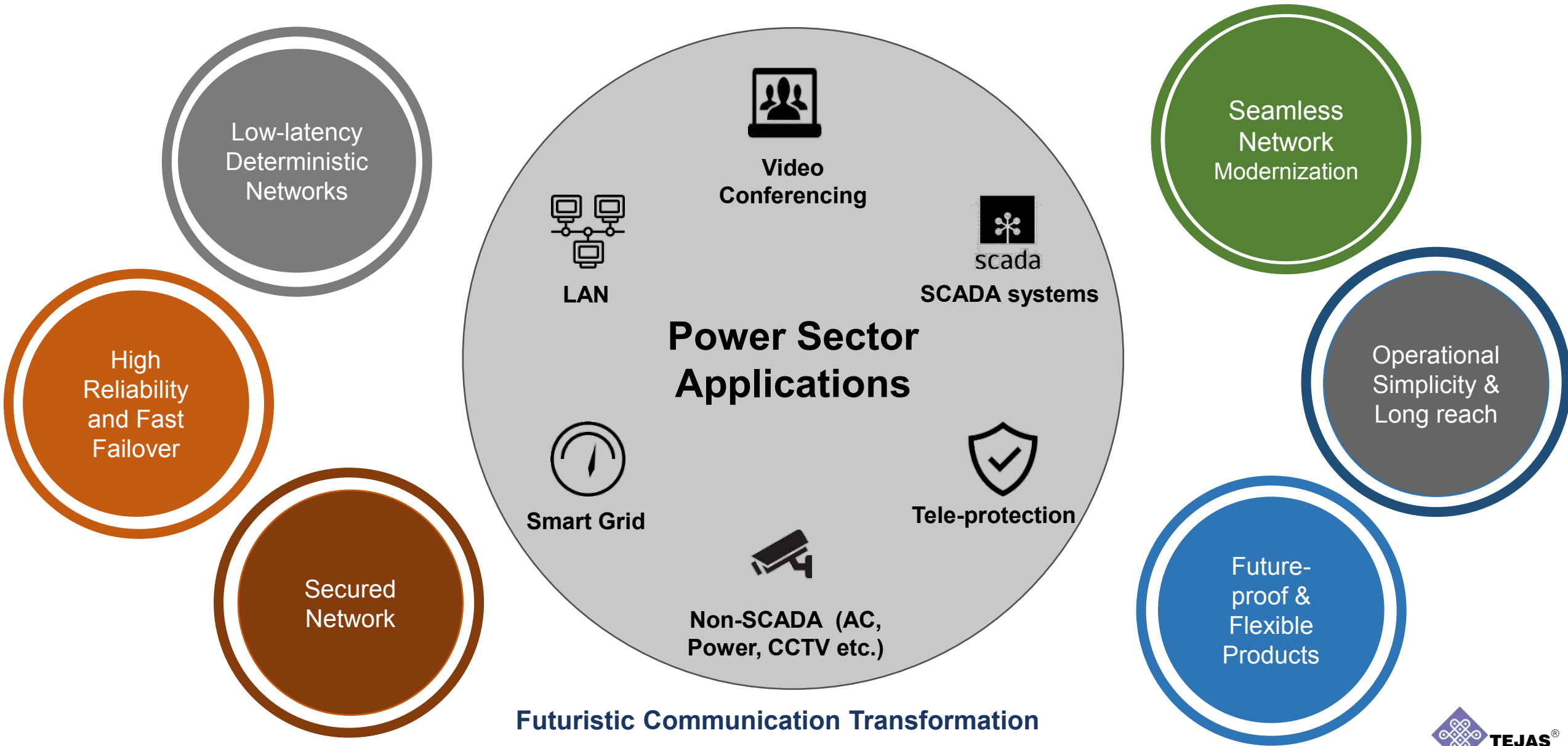
December 2023



Technologies in Optical Transmission



Power Utility Network Requirements



Way ahead for SDH in Power utility

- Migrate to OTN
 - ITU-T standard currently used in Core networks with 10G and 100G links
 - Relevant to Edge/Aggregation as traffic increases and GigE Services (ODU0) proliferate
- Migrate to MPLS-TP
 - Fine control of Packet Network characteristics
 - Traffic Engineering for 50-ms switching, OAM
 - Synchronization

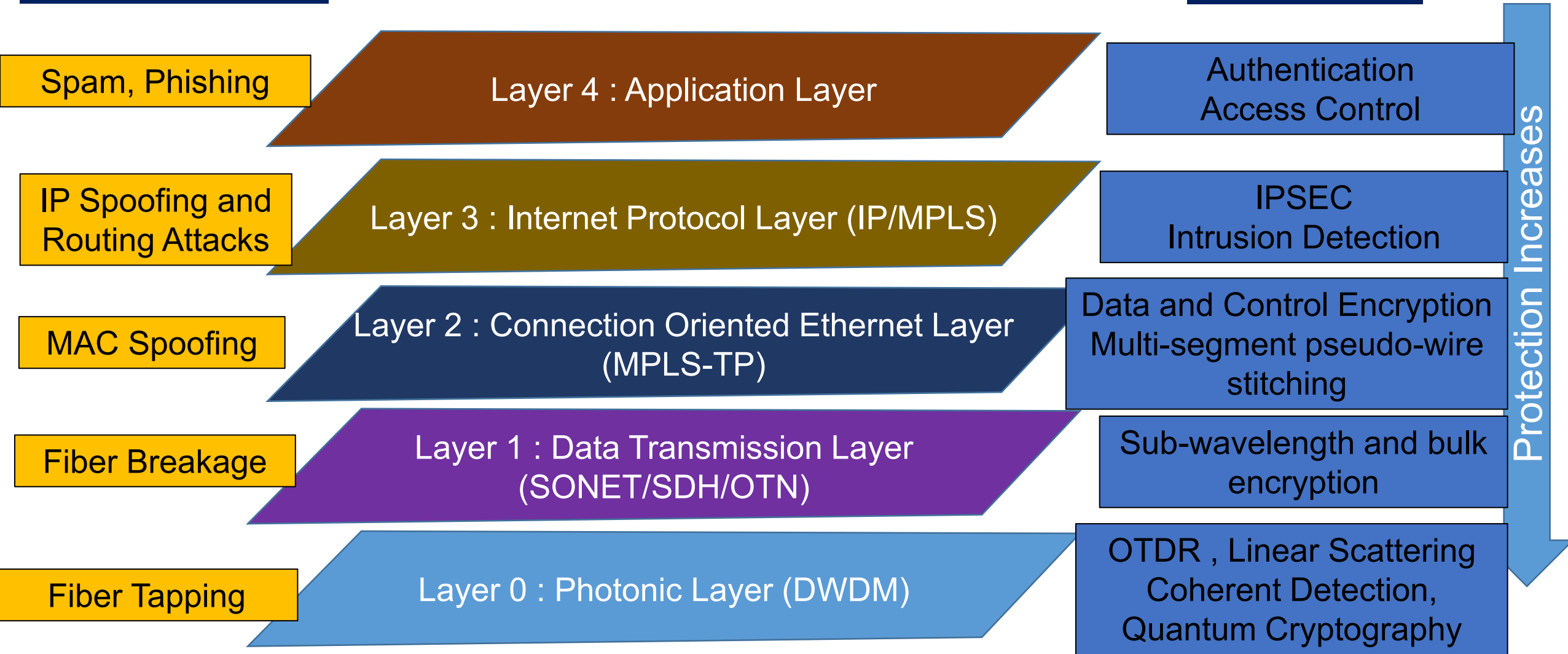
Note : Cannot use IP-MPLS, a connectionless packet network, for Critical networks

- Due to non-deterministic nature
- Due to high latency

Vulnerabilities in Transport Layer for Utilities

Vulnerabilities

Mitigation



Synchronous Digital Hierarchy(SDH)

- Synchronous Digital Hierarchy is a Digital Communication Transmission Technology that is standardized to transmit very large volumes of data over extremely long distances with the help of fiber optic cables. It was primarily used by telephone companies to ensure high-speed links in Layer 1.
- The hardware for SDH is manufactured to ensure reliable service and better communication to the users. SDH can transfer multiple data streams simultaneously over optical fiber with the help of laser beams and LEDs.

Pros:

- SDH offers excellent network survivability features and is highly compatible with legacy, existing, as well as future networks.
- SDH offers high efficiency and low latency and is capable of transporting all forms of traffic.
- SDH simplifies remote operation capabilities as it can be remotely provisioned, inventoried, tested, reconfigured as well as customized. Offer 50 ms of switching time with zero packet loss.
- Other benefits of SDH setup include easy de-multiplexing, standard optical interference, out of band management system, and very high efficiency and high reliability(99.999%).
- SDH is not prone to cyber attacks.
- Connection oriented Technology having all control with the user.

Cons:

- Maximum Bandwidth is **10 Gbit/s**.

Connection-Oriented vs Connection-Less : Cyber Security Considerations

	Connection Oriented	Connection-less
Vulnerability	Less Vulnerable	More Vulnerable
Source authentication	Requires Authentication of CPE (802.1X, ACS, AAA, Secure UNI)	No Authentication
Control Plane Attack	No peer to peer control plane at UNI and hence less susceptible	Peer to Peer CP is Highly susceptible, secured through MD5
Data Plane Attacks	Rigid path definition, well-defined forwarding scope and universal address space reduce cyber attacks	Cloud nature of connectivity, without any restriction on forwarding scope, allows access to all part of the network, makes Snooping and Spoofing is easy
Transport Technology	MPLS-TP, SONET/SDH, OTN, DWDM	IP/MPLS

Multiprotocol Label Switching

- Multiprotocol Label Switching was designed in the **1990s** predominantly to ensure a unified data service for packet-switching and circuit-based clients offering a datagram service model.
- In **2000's** MPLS was envisaged as **packet-based connection-oriented technology to replace or migrate SONET/SDH networks!**
- **IP-MPLS:** IP MPLS is a routing system that enables fast data switching from one node to the next based on labels. Commonly, the packets in IP networks need to consider the destination addresses to control the function of the routers, which takes time. IP MPLS finds an alternative to this process by switching packets based on the label.
- **MPLS-TP:** It is an extension of Multiprotocol Label Switching (MPLS), the protocol that allows most packets to be forwarded at the Layer 2 (switching) level rather than at the Layer 3 (routing) level.
- The data packets are preassigned labels, and all packet-forwarding decisions are based on the contents of these labels, eliminating the need to examine the contents of the packet. Users can create comprehensive circuits across different types of traffic mediums.

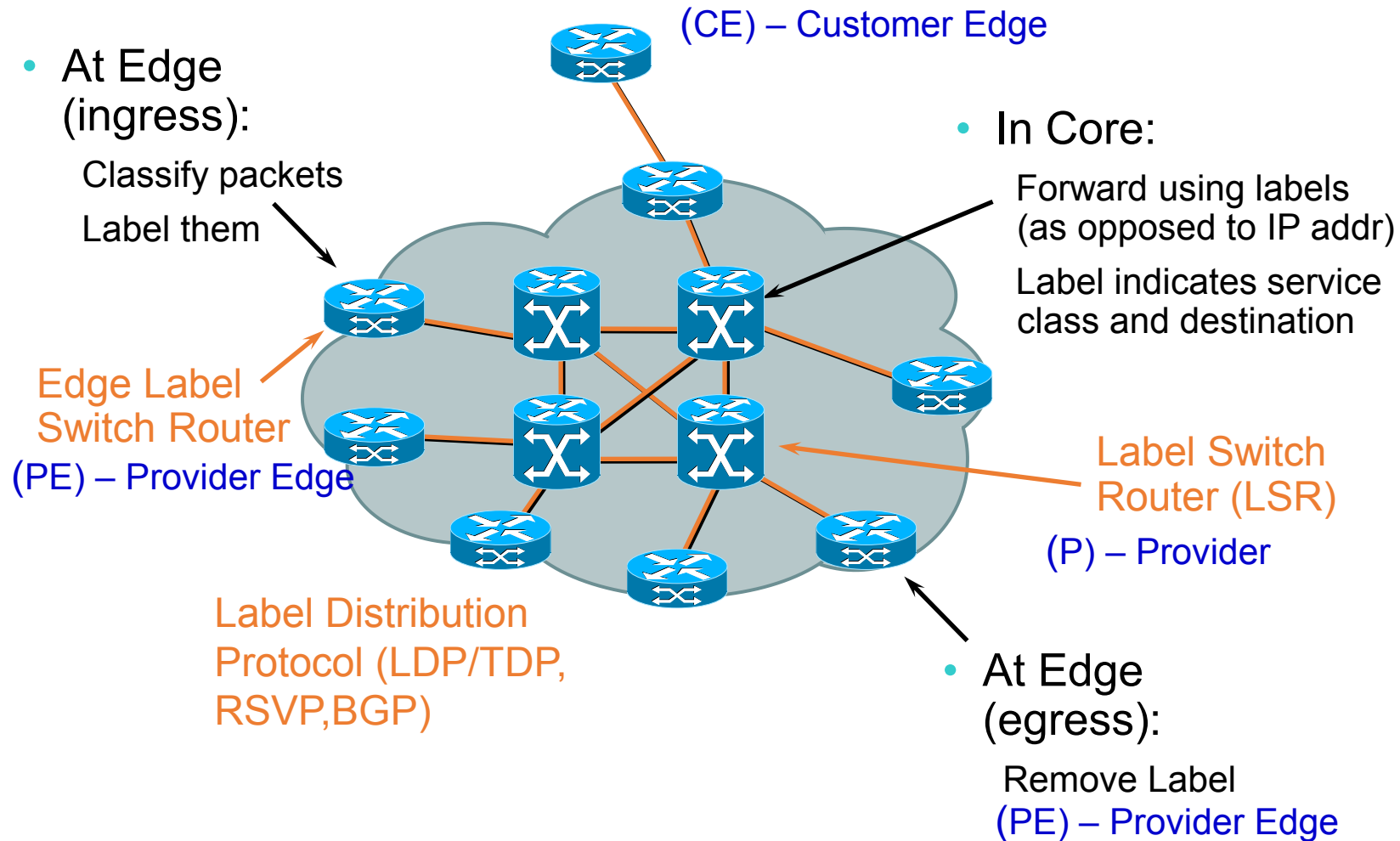
Pros:

- It works towards improving bandwidth by using Statmux gain.
- The optional or failover paths for traffic also contribute towards reducing congestion.
- Higher Bandwidth : Substantial Fabric Cards supporting 100 Gbit/s Interfaces.

Cons:

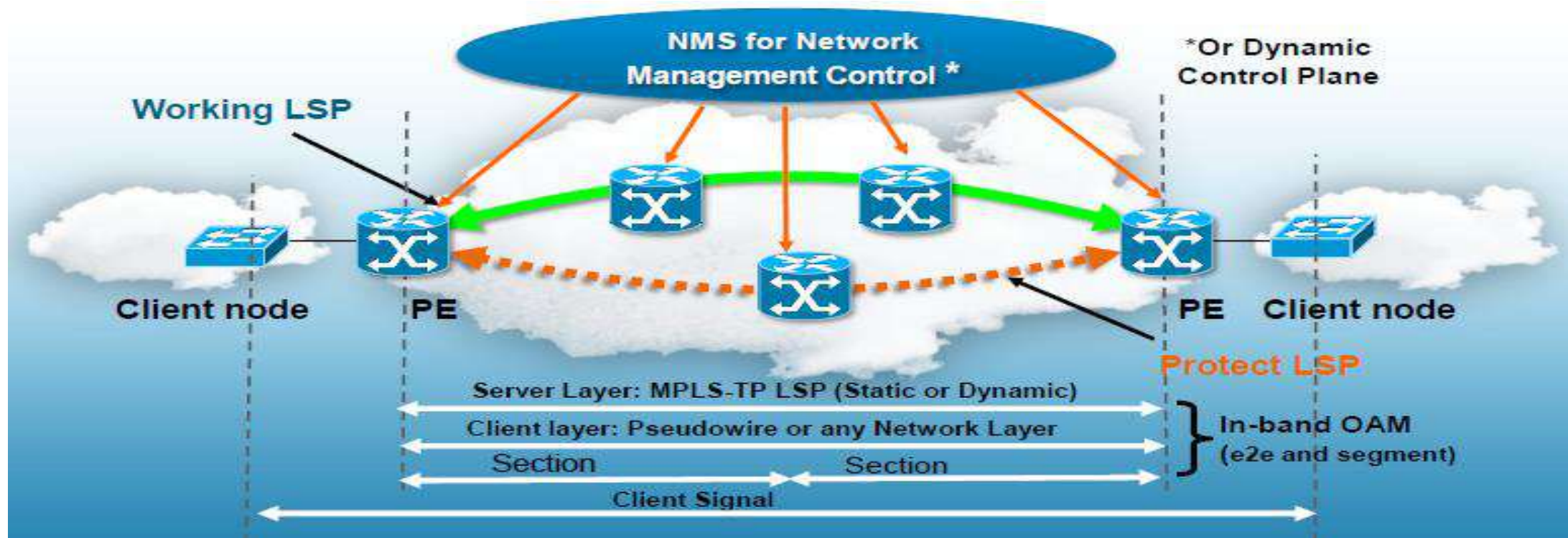
- Only 1G& 10G interface are available with similar price range as of SDH.
- Limited CES Availability
- Limited support of Legacy Interface

IPMPLS Basic Concept



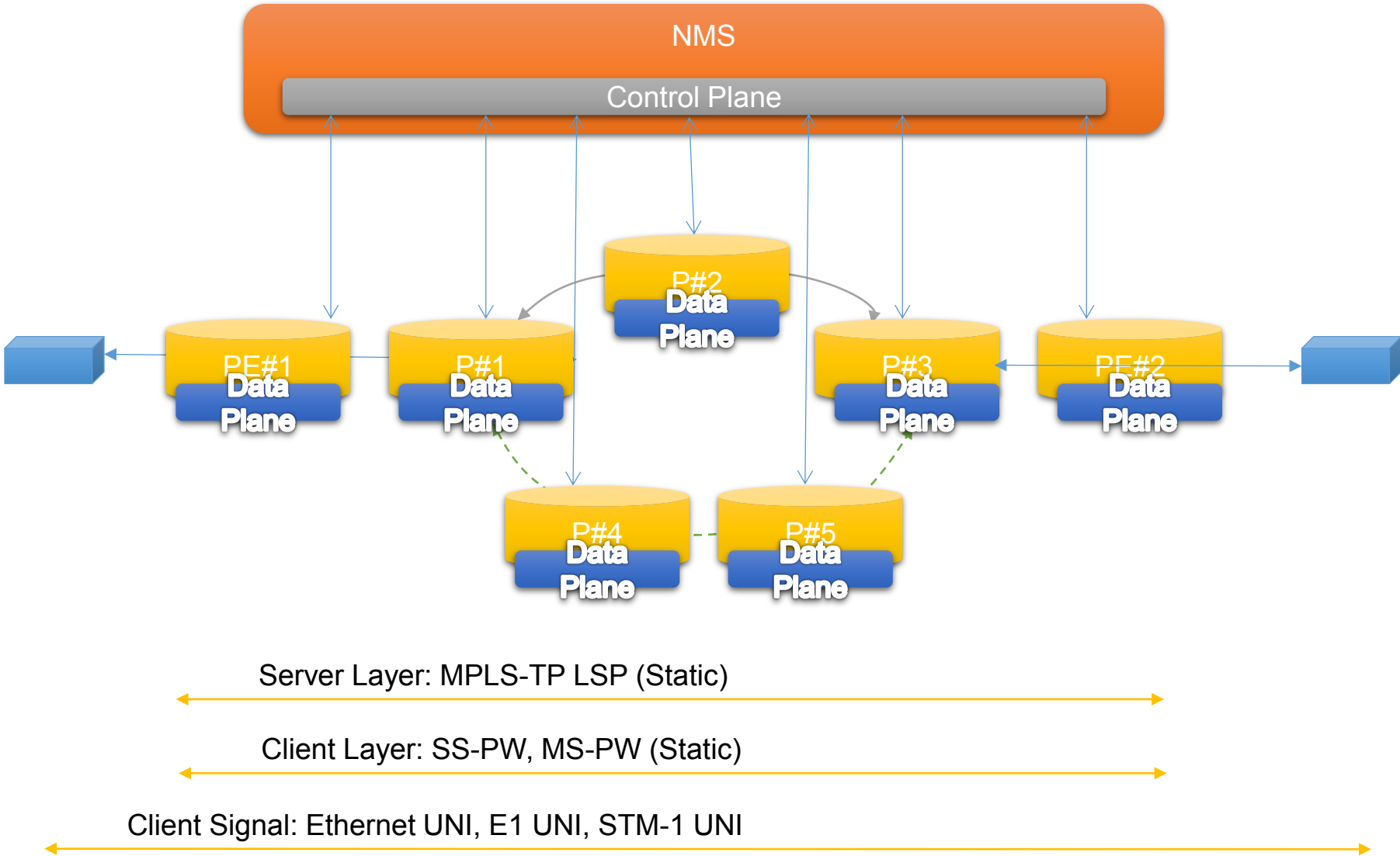
Connection-less, non pre-determined working path and protect path and high latency. Not suitable for Mission Critical Networks.

MPLS-TP Basic Concept

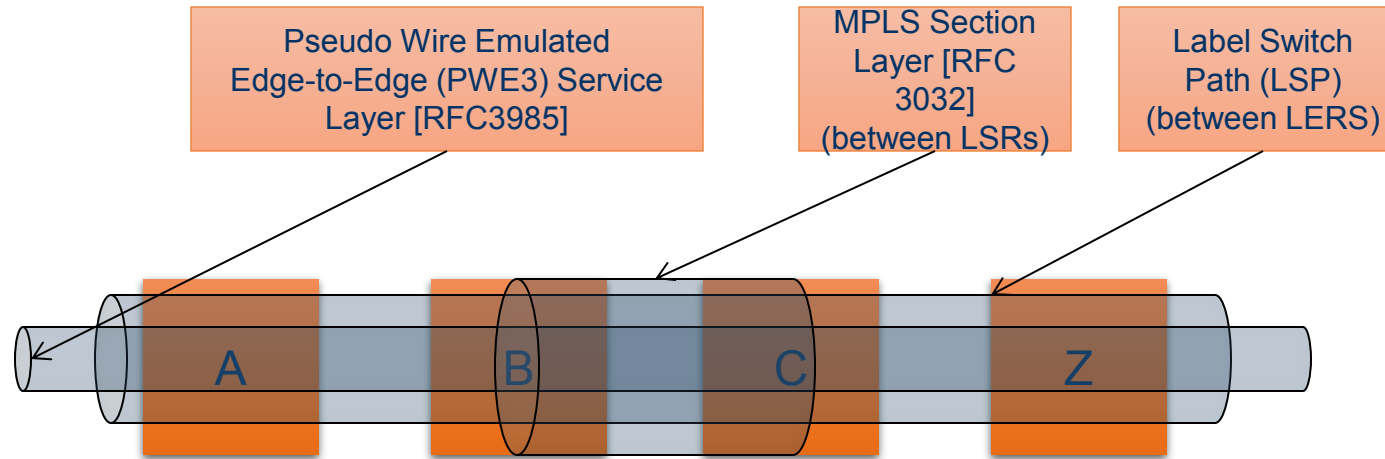


- Connection Oriented, pre-determined working path and protect path and suitable for Mission critical Networks
- Transport Tunnel 1:1 protection, switching triggered by in-band OAM, protection switch without C/P
- NMS for centralized provisioning with option for GMPLS/SDN control

MPLS-TP/PTN Architecture

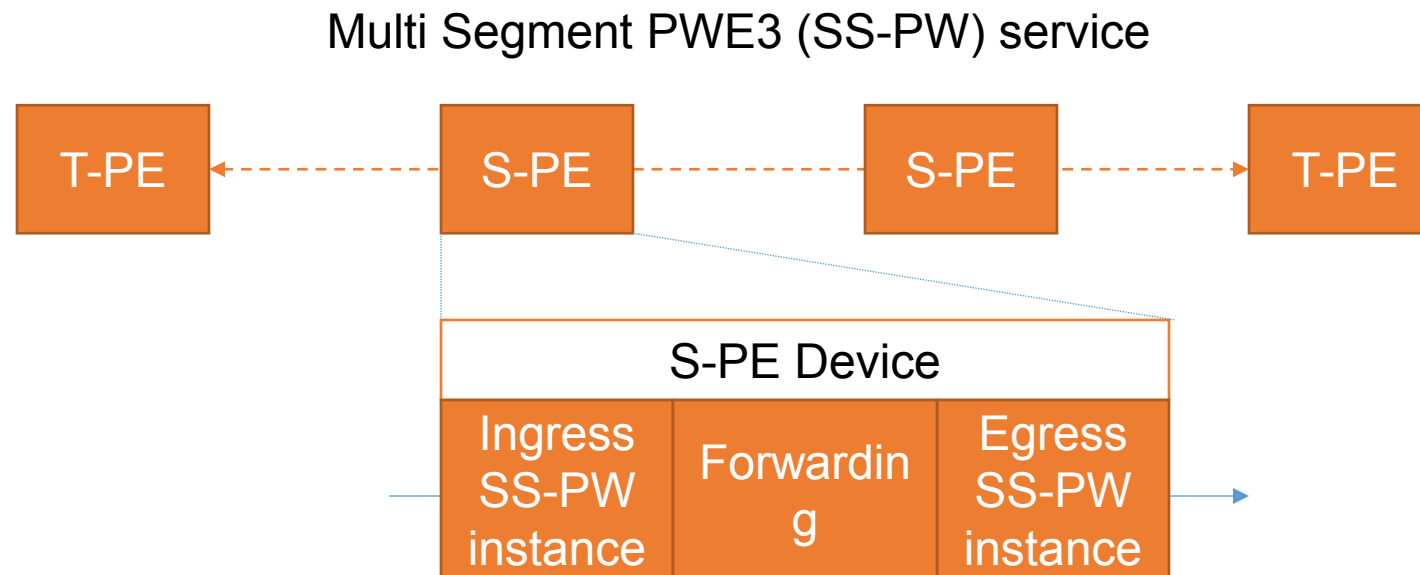
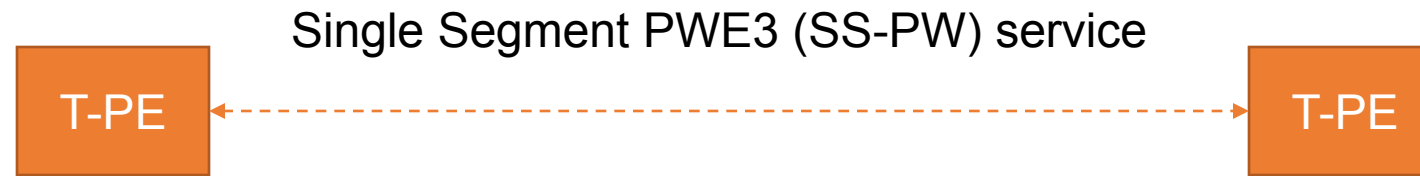


MPLS Key Terminology (RFC 3031)

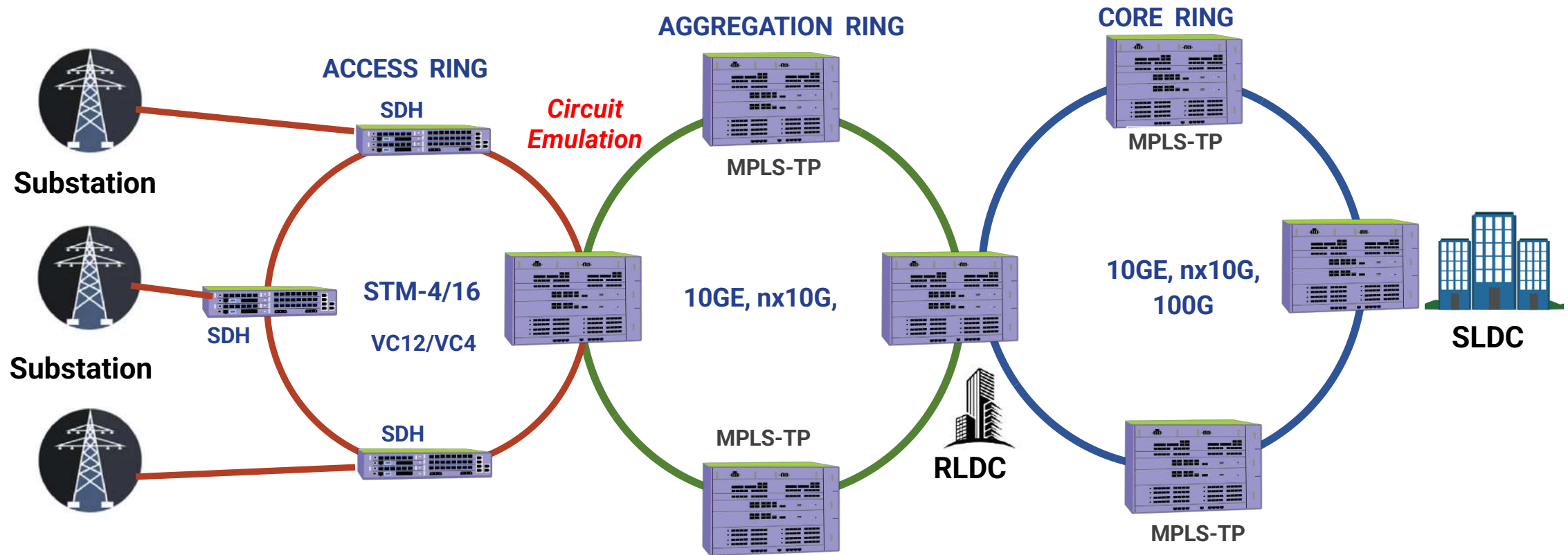


Initial version from ITU perspective will be restricted to P2P Ethernet PW over MPLS-TP LSP only

SS-PW (RFC 3985) & MS-PW (RFC 5659)



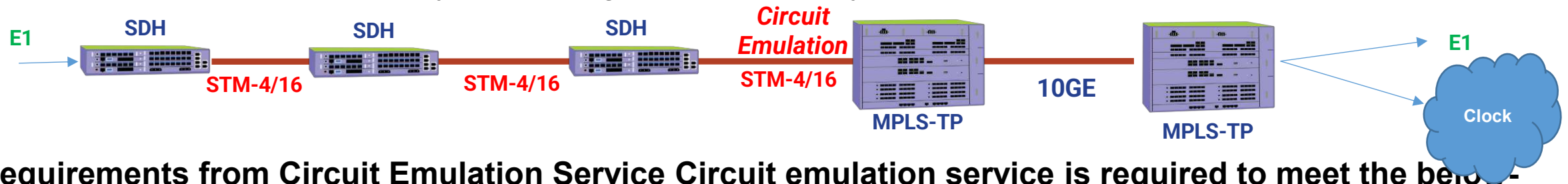
MPLS-TP Expected Network Scenario



- Theoretically, the above diagram looks practically possible by using Circuit Emulation Feature.
- Circuit emulation service is used to convert the circuit based traffic into packets which are then transported over packet networks.

Drawbacks CEM solution

- Circuit switched equipment continuously transmits and receives data bits with fixed delay.
- The continuous bit stream transmission with a fixed delay is achieved by clock synchronization between the transmitter and receiver.
- For voice-based services, this worked well as the circuit switching ensured guaranteed permanent transmission.
- The circuit emulation service must ensure that the circuit switched equipment can continue to transmit and receive data bits with fixed delay even though the connectivity happens via a packet switched network.



Requirements from Circuit Emulation Service Circuit emulation service is required to meet the below-listed requirements:

- Maintain accurate synchronization information for incoming circuit switched circuits
- Stringent latency, jitter and wander performance for end-to-end for reliable transmission
- Sub-50ms protection switching in the case of voice and other mission-critical services
- Real-time performance monitoring and fault management capabilities such as service loopbacks
- Scalability to emulate thousands of low-speed circuits for large-scale carrier networks that continue to support circuit switched interfaces.

SDH or MPLS Technologies

Despite technology progress over the past decade, packet switching also has limitations that make it unsuitable for many applications that continue to rely on SDH. Below is a summary of the primary limitations of packet switched networks compared to SDH.

1. **Layer 2/3 switching introduces high latency** relative to SDH that may make it unsuitable for applications that are highly latency-sensitive or have strict requirements for latency guarantees. **Latency in packet switched networks is unpredictable and cannot always be guaranteed.**
2. **CES is only an option for lower-capacity circuits**, as the technology is limited to T1/E1 and STM-1/4/16 rates **with exceptions.**
3. SDH set the gold standard in reliability with "five nines" uptime and **sub-50 millisecond recovery times.** Despite its advances, packet switching cannot match the ultra-high reliability of SDH networks.
4. Shared packet-switched networks are not private like dedicated circuit switched SDH networks, and certain operators and enterprise customers require the security of a private, **dedicated connection.**
5. Finally, some high-value end customers are simply not willing to move away from their TDM services, and forcing a migration to packet-based networks **risks losing these customers.**

Technological Feature-sets for Power Network

Attributes	SDH Attributes	Packet Attributes
Connection Type	Connection-oriented	Connection-less
Protection Type	Sub-50ms deterministic protection switching	Dependency on the Control Plane (Indeterminate)
OAM Type	In-band data-plane FM and PM (h/w based)	Out-of-band (Control plane dependent)
Automated Management	Simplicity and no dependency on control plane, allows for excellent automation.	Automation is complex and costly
BW Efficiency	Rigid : Good for CBR traffic, Bad for bursty packet traffic	Flexible : Statistical Multiplexing possible
BW Granularity	Fixed Rates Containers	Flexible : Any data rate is possible
QoS	Only one class, guaranteed class	Multiple classes of service

MPLS-TP retains the “best of both worlds”

Beyond 2.5 G or STM-16 (OTN Way Forward)

A proven mix of Technologies with dedicated OAM capabilities

Synchronous Digital Hierarchy	
Optical Signal	Bit Rate
STM-1	155 Mbps
STM- 4	622 Mbps
STM-16	2.5 Gbps
STM-64	10 Gbps

Optical Transport Network	
Optical Signal	Bit Rate (Gbps)
OTU1	2.66
OTU2	10.7
OTU3	43.01
OTU4	112

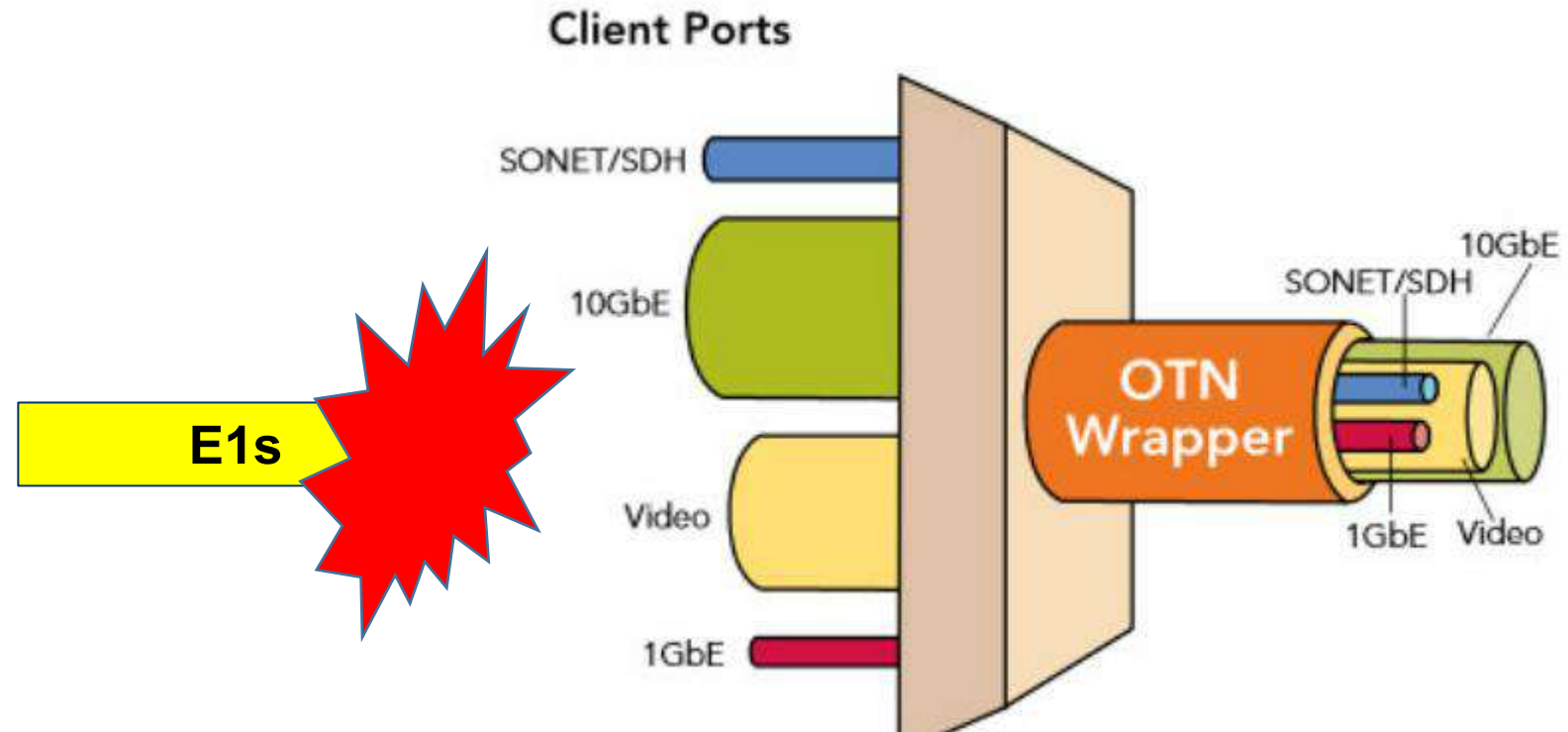
Economical & Robust Solution for Future Bandwidth Demand

OTN vs SDH/SONET

OTN	SONET/SDH
Asynchronous mapping of payloads	Synchronous mapping of payloads
Timing distribution NOT required	Requires right timing distribution across networks
Designed to operate on multiple wavelengths (DWDM)	Designed to operate on multiple wavelengths
Scales to 100Gb/s (and beyond)	Scales to a maximum of 40Gb/s
Performs single-stage multiplexing	Performs multi-stage multiplexing
Uses a fixed frame size and increases frame rate to match client rates	Uses a fixed frame rate for a given line rate and increases frame size (or uses concatenation of multiple frames) as client size increases
FEC sized for error correction to correct 16 blocks per frame	Not applicable (no standardized FEC)

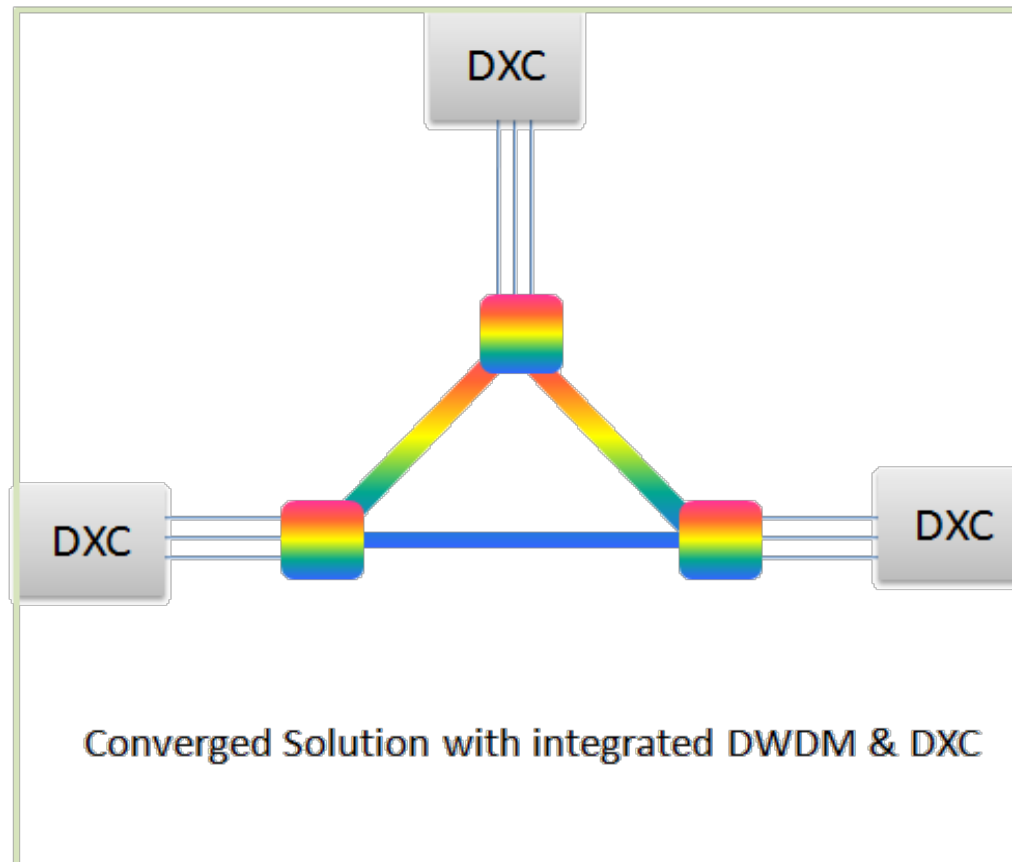
OTN: An overview

- OTN is commonly called a 'digital wrapper' as it wraps each client/service transparently into a container for transport across optical networks, preserving the client's native structure, timing information, and management information.
- The enhanced multiplexing capability of OTN allows different traffic types, including IP, Ethernet, storage, digital video, and SONET/SDH, to be carried over an OTN framing structure—a key reason for the adoption of OTN.
- **E1 support is not available on OTN.**



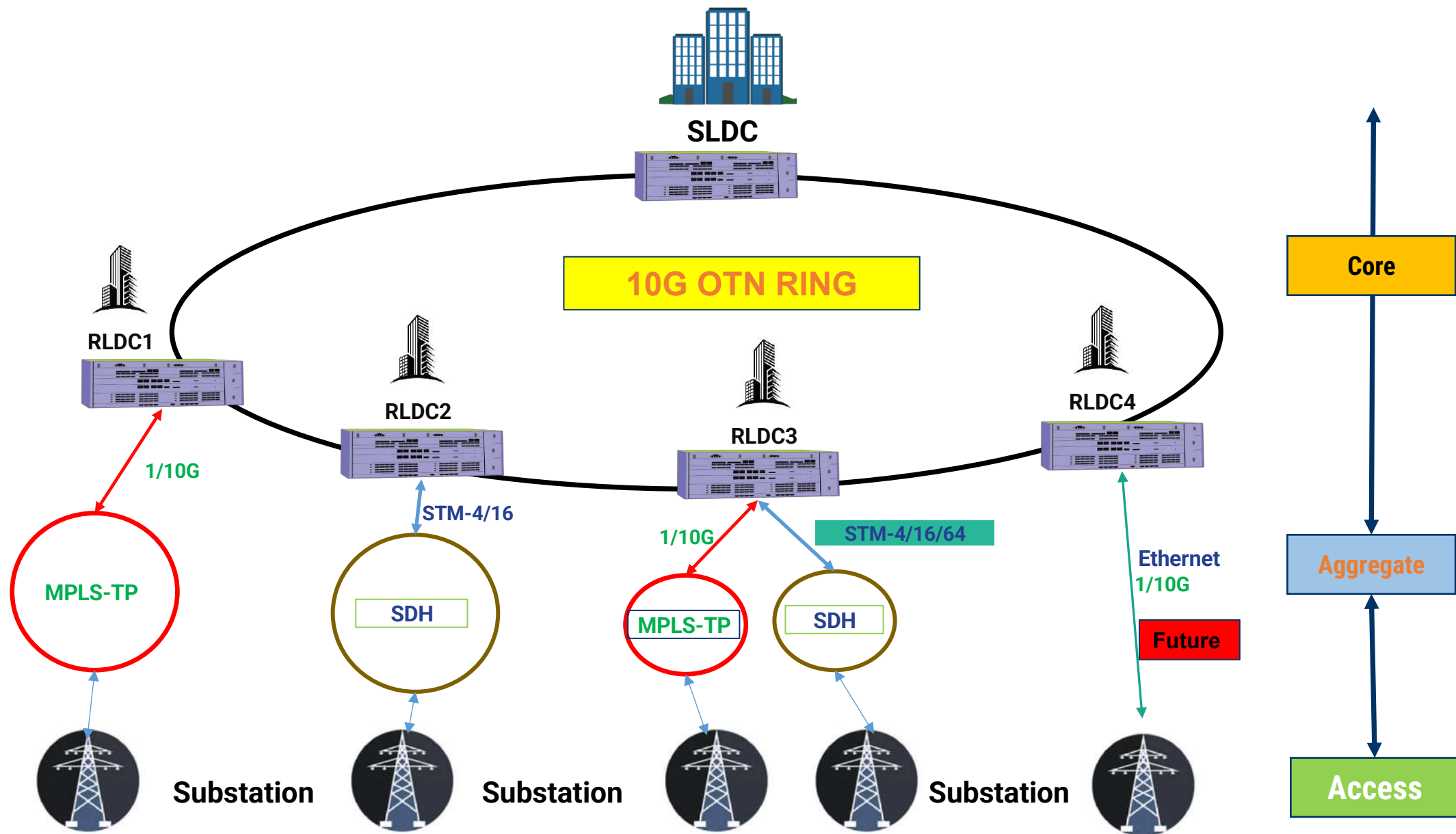
OTN for Utilities

An OTN consists of fixed OTN frame size, channelization at ODUk levels and an OTN cross-connect on top of optical layer, which can provide foundation for Legacy SDH, MPLS-TP, Carrier Ethernet and IP/MPLS services. The control plane of this network is GMPLS and/or ASON based, however, this is not exposed to the user attaching to the network, providing security.



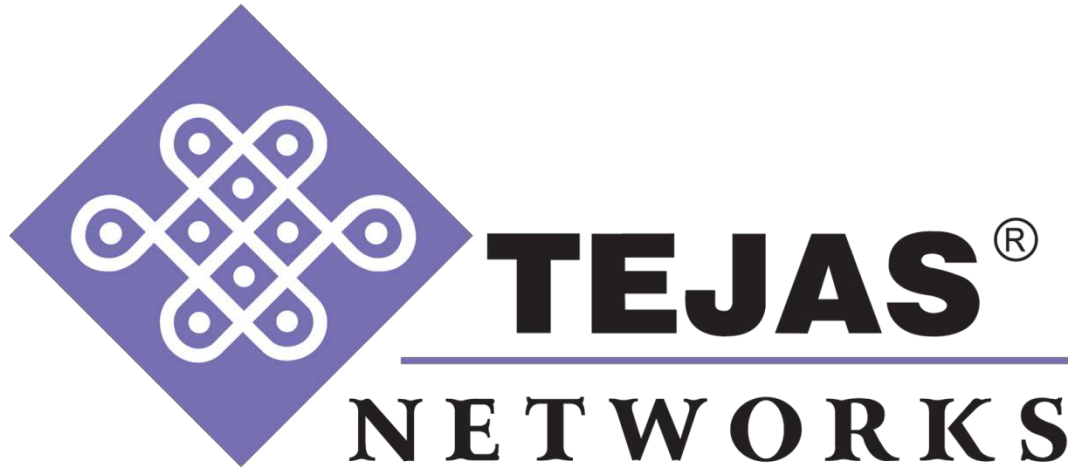
Low-cost, Coherent
DWDM and Intelligent
OTN based Network for
increased capacity,
efficient bandwidth
utilization and delivering
ultra-low latency
services

The Right Way



Conclusion

- High-profile Cyber attack in Utility/critical infrastructure sector on the rise
 - IT as well as OT system are also affected.
 - Increased vulnerability : Due to increased IP-fication, integration of IT/OT systems, machine/computer driven automation, automated back-ups, and IoT
- Connection-oriented transport technologies (DWDM, OTN, MPLS-TP) provide superior security framework for critical infrastructure
 - Authentication of Network Elements
 - Rigid path definition and universal address space reduce cyber attacks
 - No peer to peer control plane to target for DoS/DDoS attacks
 - Connection-less technologies such as IP can be overlaid on top of Connection-oriented, to provide enhanced security to IP infrastructure.
- Encryption at lower levels of OSI model preferred approach
 - Simpler to implement, have lower latency, and are more bandwidth efficient with less encryption overhead
 - Safeguards the information on the layers above - including legacy applications with no encryption capability and stringent latency requirements



Contact Us:

Thank you!



TANTRANSCO PRESENTATION OF ITS IMPLEMENTATION OF ITS MPLS-TP BASED OT COMMUNICATION SYSTEM

5th MPLSJC Meeting at Gurugram
Dt : 11-03-2024



Introduction:

* TANTRANSCO has a vast network of grid substations ranging from 110KV , 230KV , 400KV, 765KV quantifying to 200+ nodes of communication equipments.

* Comprises 100+ SDH, PDH and recently 40+ Hybrid and 10+ MPLS-TP FOTE equipments apart from Legacy PLCC equipments for voice,Data and tele-protection applications.

SDH	ABB /HITACHI/TEJAS/COMTEL
HYBRID	ABB /HITACHI (FOX615)
MPLS-TP	ABB/HITACHI (FOX 605)



Adoption of modern tech:

- * Adoption of modern technology is to be exercised with caution and at the same time seamless migration to modern technologies avoiding major risks in migration process.
- * Security, reliability, maintainability of communication network is of importance.
- * Hence the adoption of MPLS-TP technology is by gradual basis by deploying hybrid equipments that support concurrent communications over MPL-TP and SDH network.
- * MPLS-TP is more characteristic of the Transmission utility applications in terms of network design, deterministic communication, N/W management etc.



TANTRANS CO- Key Reasons for Adoption of MPLS-TP

Aspects/ Criteria	SDH	Modern technology (MPLS-TP)
Technology	Obseleteness	Investment protection necessitates to adopt modern technology instead of obsolete technology. At the same time suitable for power utility application.
Bandwidth Efficiency	Not optimised as TDM based	Optimised as packet based
Product and service support	Waning availability of vendors.	Growing availability of vendors.
Inventory	Inventory of hardware is high leading to higher cost of inventory due to various types of legacy interfaces for voice, tele-protection, Data applications.	Inventory of hardware is optimised since most of applications are migrating to ethernet based interface Tele-protection : External / Builtin are ethernet based Data : Ethernet based protocols such as 104, C37.94 etc., Voice comm.: VoIP is ethernet based CCTV : Video (Future) PoE+ based
Other features	-	QoS,Priority tagging of traffic data etc. Retains SDH flavour suited for power utilities in respect of Deterministic time for Tele-prot, User defined network path definition BFD prot switching < 50ms etc.

TANTRANSCO - MIGRATION FROM SDH NETWORK TO MPLS-TP NETWORK USING HYBRID NODES & STANDALONE MPLS-TP NODES

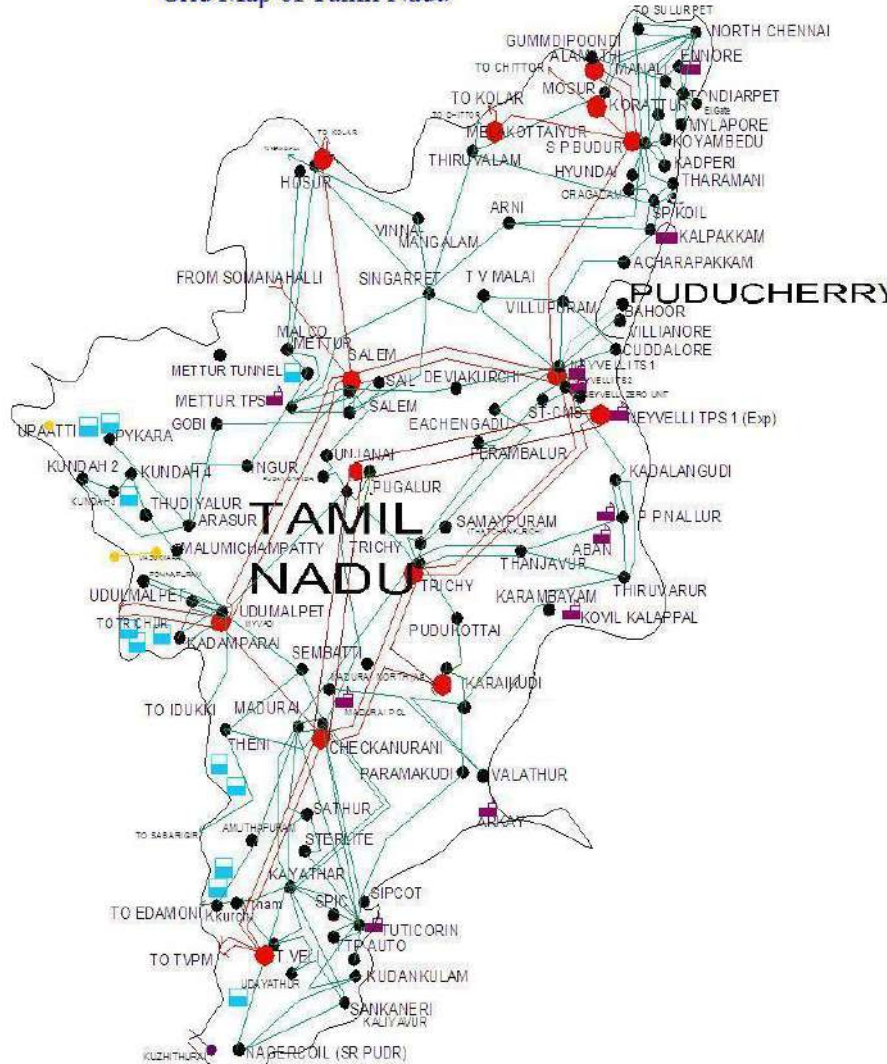


Tantransco, India

Hybrid FOTE solution is implemented in our mission critical communication network migrating the legacy Time-Division Multiplexing (TDM) method of transferring signals like **Ethernet (IEC 60870-5-104), RTU/SAS on Serial V.24/V.28, Distance & Differential Protection** & to a **packet-switched (MPLS-TP) technology** at Tamil Nadu Transmission Corporation.



Grid Map of Tamil Nadu



The Project – 400 Kv Ottapidaram

- Migration of TDM based legacy application for OT network with Hybrid FOTE over 230 KV above and MPLS-TP for 110 KV S/S
- Converge multiple applications, Data (IEC 60870-5-104 & 101) Differential & Distance Teleprotection on the same infrastructure
- Simplify management of legacy and packet networks

Proposed solution

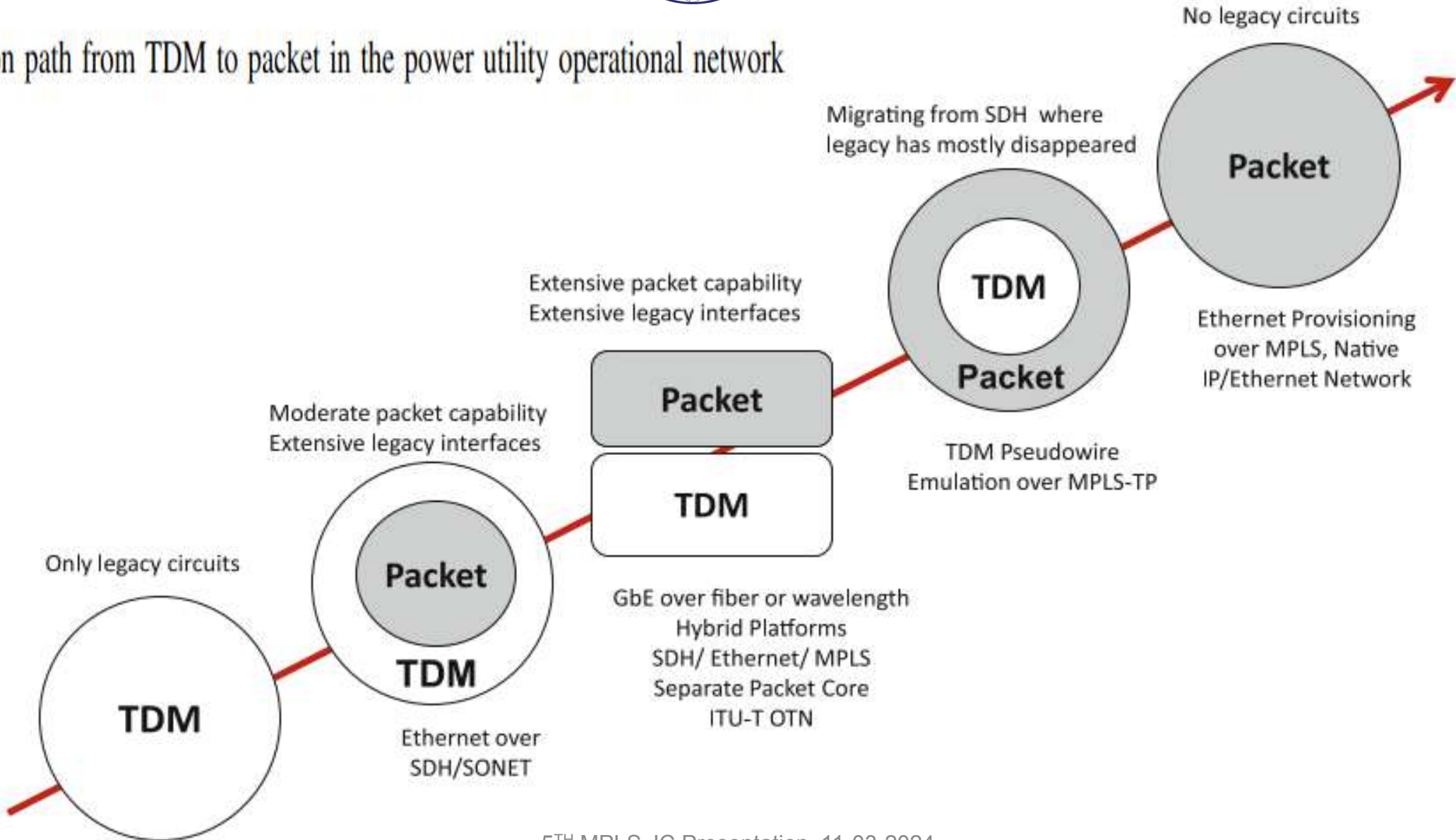
- FOX615 Hybrid Multiservice platform Transport: 1G/10GbE Hybrid & MPLS-TP- capable
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Benefits

- Increased efficiency with a single packet-switched OT network
- Single NMS for overall network with all application including teleprotection.
- Ensured high availability during a complex migration



Migration path from TDM to packet in the power utility operational network





TANTRANSOCO : Product Details for Hybrid Equipments

Hybrid Equipment : (Typical Configuration details)

HITACHI (Formerly ABB) FOX 615 with cross connect multiplexer, dual power supply cards & control cards, 4 port circuit emulation card to support min. 16 E1s, tributary cards & other hardware accessories including subracks, patch cords,DDFetc.,

For SDH Interface:

(i) 4 port STM1/4/16 I/F card- 2nos. (with min.2 STM1/4 & 2 STM4/16 per card)

For MPLS-TP Interface:

- (ii) 4 port x 1G MPLS-TP opt. I/F card-1 no.
- (iii) 4 port x10G MPLS-TP opt.I/F card-1no.

Legacy interfaces:

- (iv) 2/4W, 8 channel E&M card - 1no.
- (v) 8 channel FXO card - 1no.
- (vi) 8 channel FXS card - 1 no.
- (vii) 4 port serial data I/F card -1 no. (V.11,V.24,V.35 etc.,)
- (viii) 8 ch. E1(framed/unframed)card- 2nos.
- (ix) 4 ch. Diff. protn interface card-(C37.94 compatible) (Where ever required)

Ethernet ports:

- 8 port 10/100/1000 Mbps ethernet I/F card with L2 switching capacity- 1no.



TANTRANSKO : Product Details for MPLS-TP Equipments

MPLS-TP Equipment :

HITACHI (Formerly ABB) FOX 605 with redundant supply cards, all cablings, circuit emulation card & other hardware accessories including subracks, patch cords,DDF etc.

- (i) 4 port GE electrical ethernet card (POE/ PoE+ capable) 1 Gb capacity/port- 1 no.
- (ii) 4 port optical SFP interface card ,each port supporting E/FE/GE/STM1 - 1 no.
- (iii) 4 ports interface card for E1 framed/ unframed channels -1no.
- (iv) 4 port interface card for V.11, V.24, RS 485/ RS 232 etc.,) - 1no.

NMS: HITACHI (Formerly ABB) FOX MAN

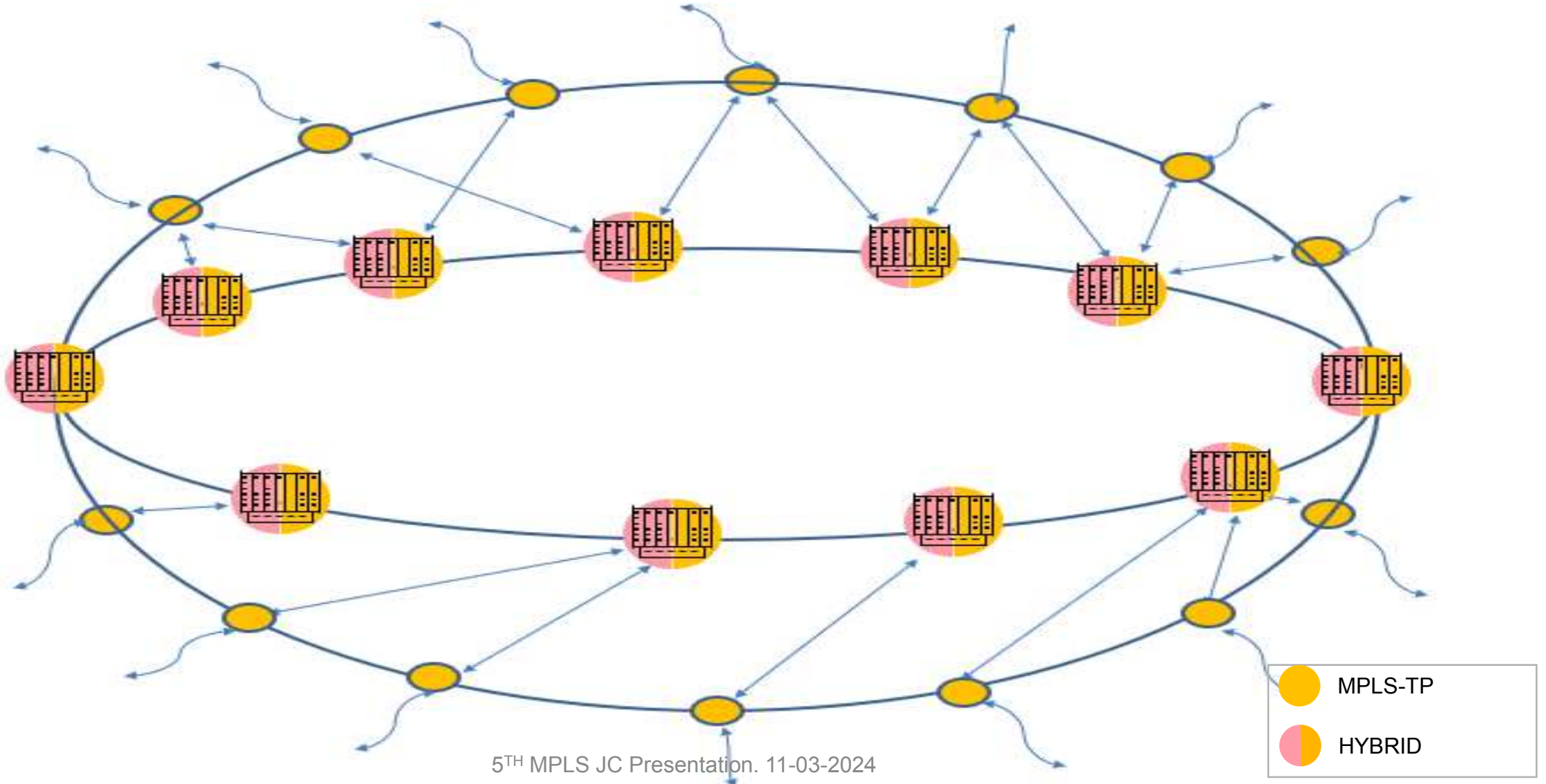
NMS main servers at Chennai LDC,

Client machines at Madurai Backup LDC and at Erode Sub-LDC

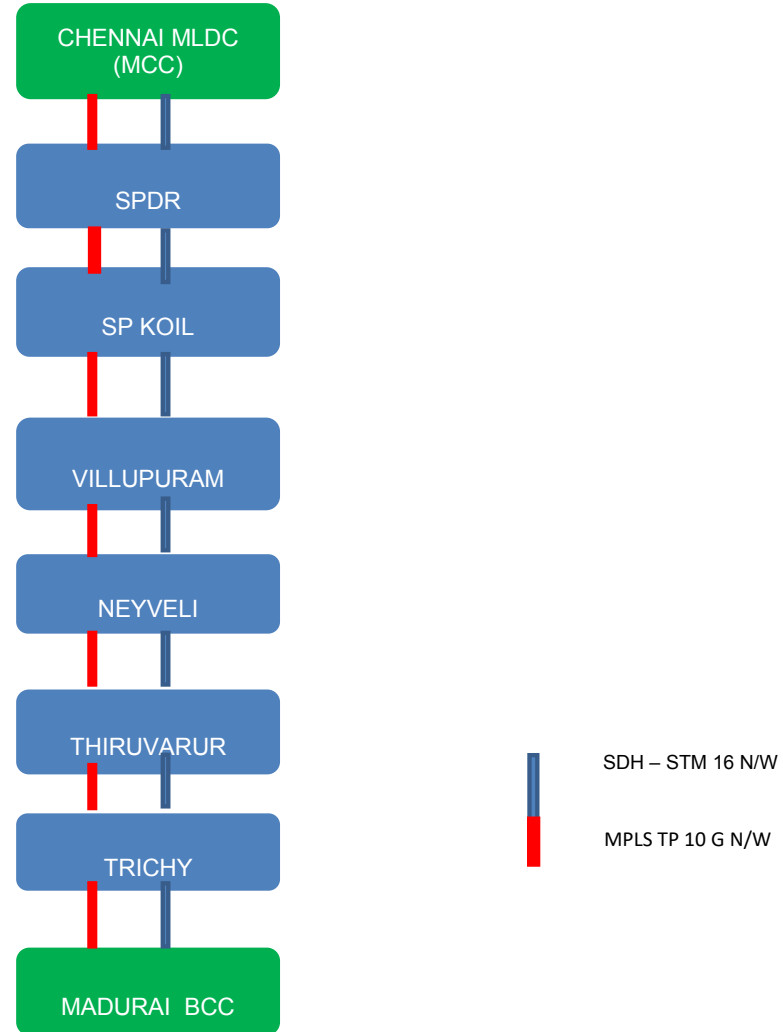
Visualized Archiecture



MPLS_TP Main Ring via Hybrid Nodes & Protection Ring via Standalone MPLS_TP Nodes



TANTRANSCO- BACKBONE NETWORK FORMATION USING MPLS-TP AND SDH LINKS

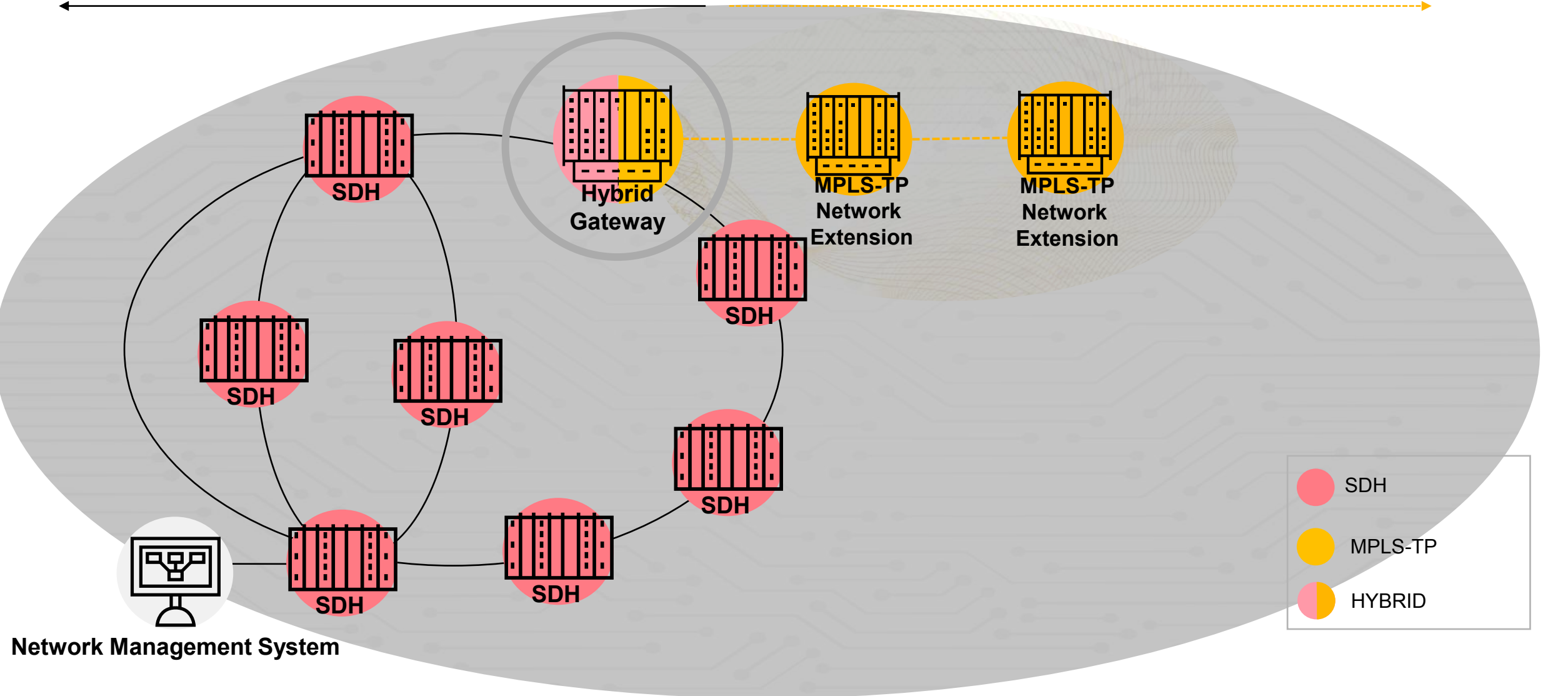




Present Case: MPLS-TP extension via Hybrid gateway node

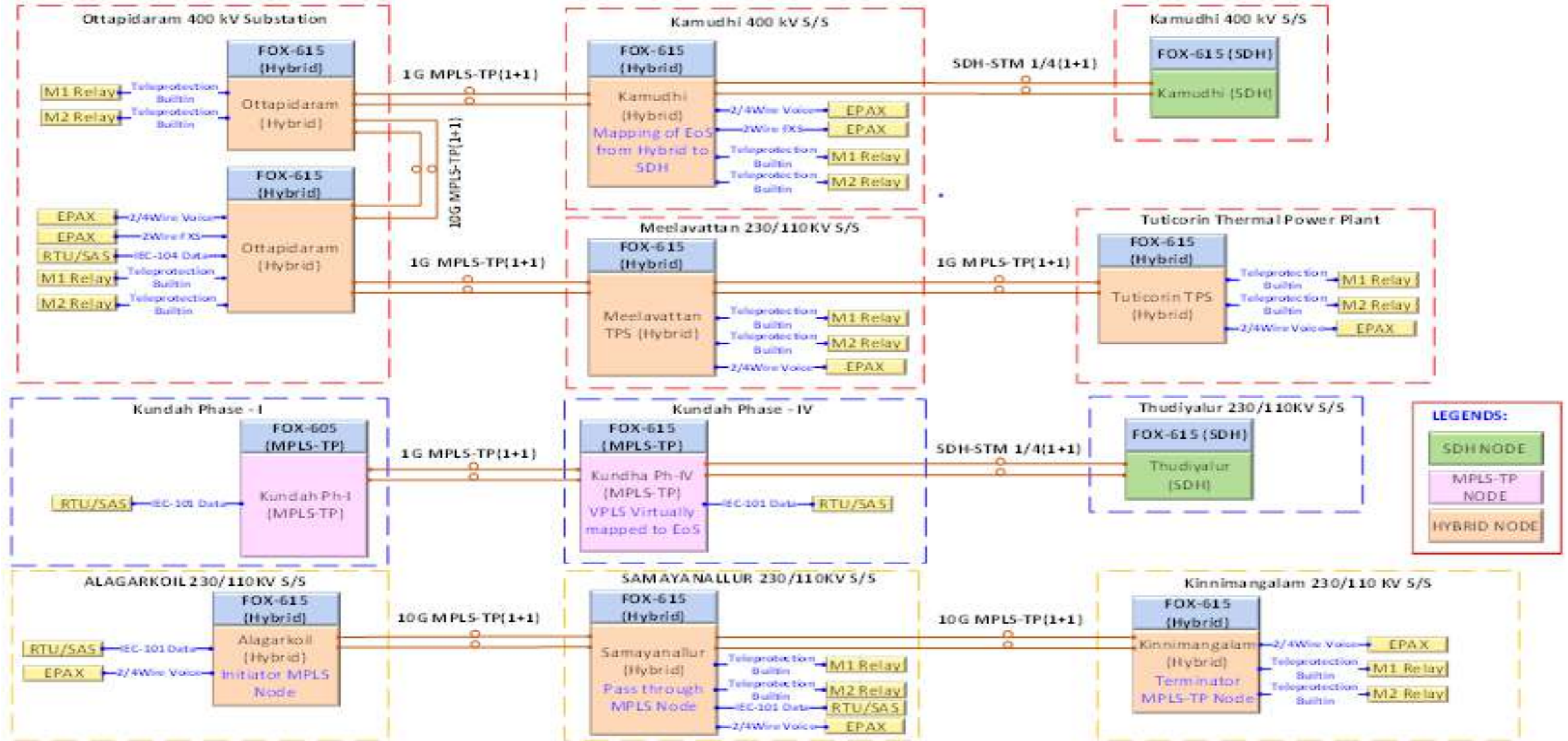
EXISTING SDH NETWORK

MPLS-TP



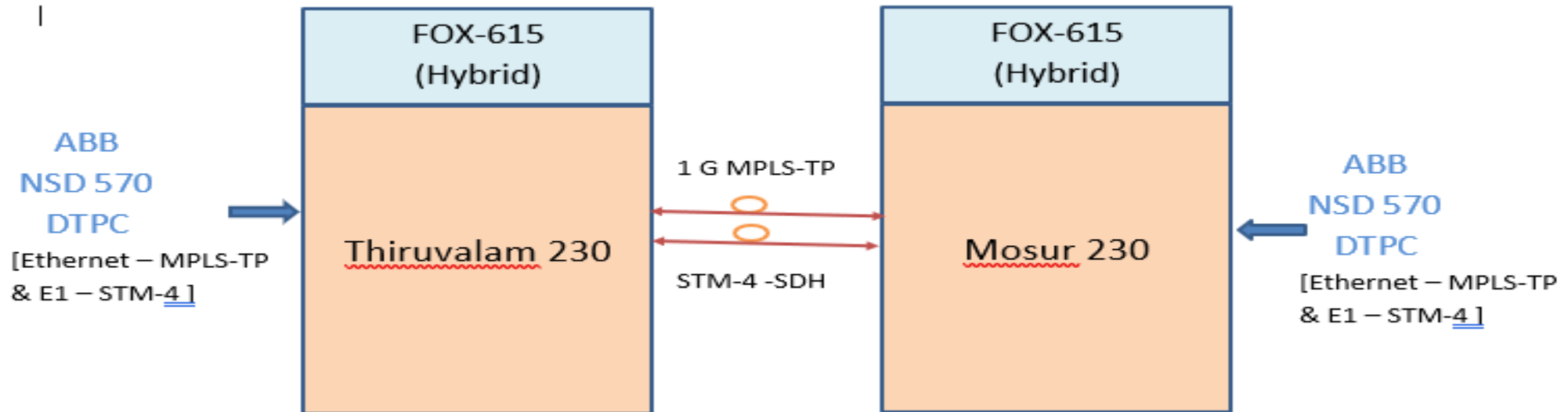


Implementation of Distance Teleprotection Scheme & RTU/SAS Data Communication via MPLS TP of Hybrid Nodes





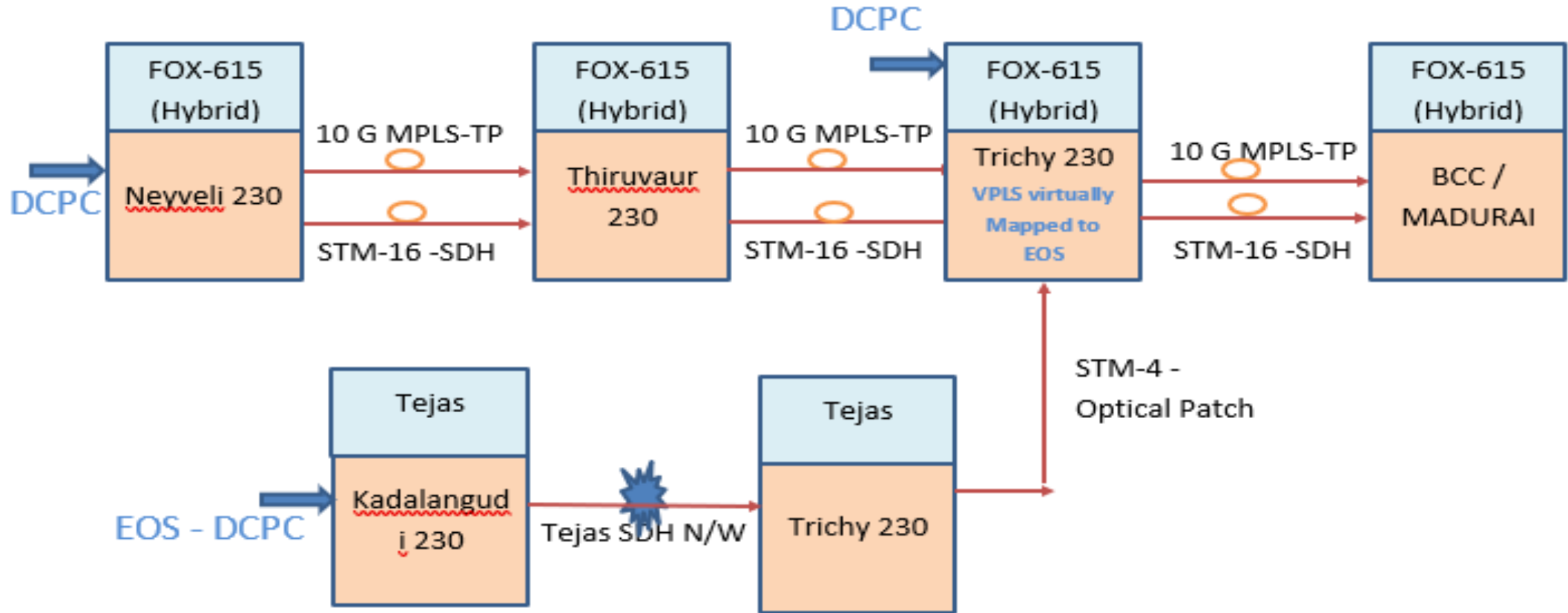
Implementation of Distance Protection Scheme via Standalone DTPC interfaced in Hybrid Node with MPLS_TP Main Channel & SDH Redundant Channel



E1 Channel Loop Test Time is 5.9 ms
Ethernet Channel Loop Test Time is 3.1 ms

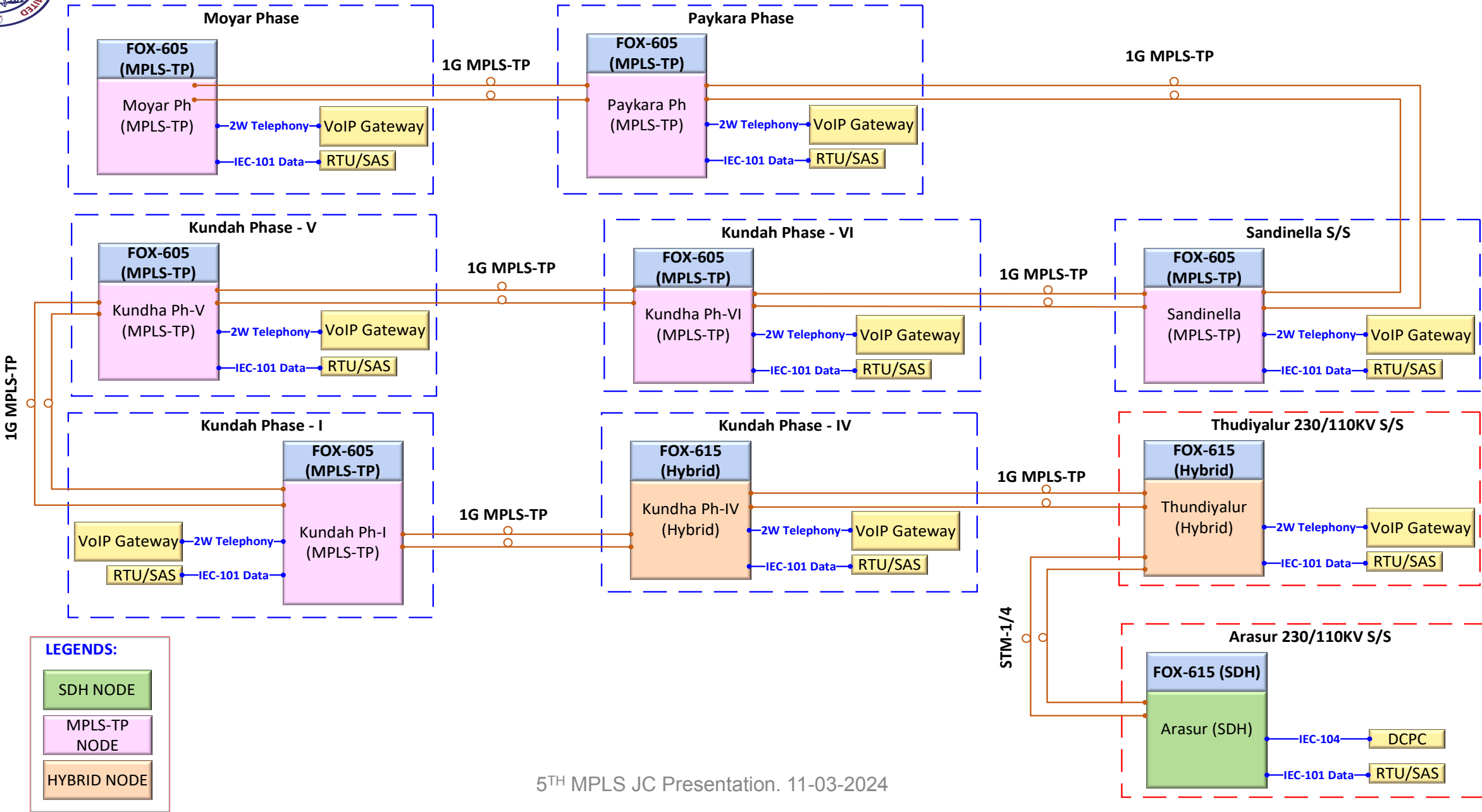


Integrability of Hybrid Node with other SDH Equipment



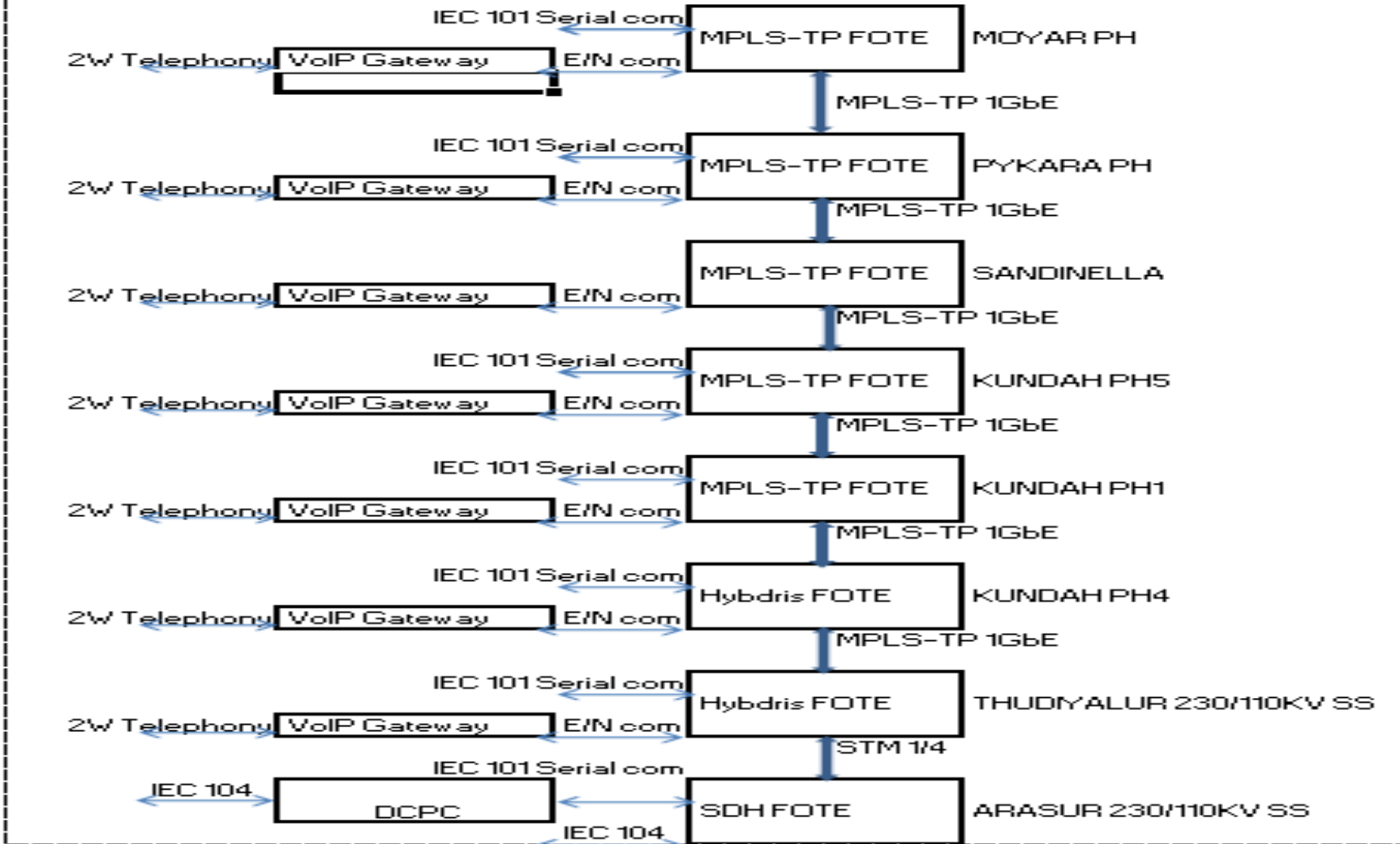


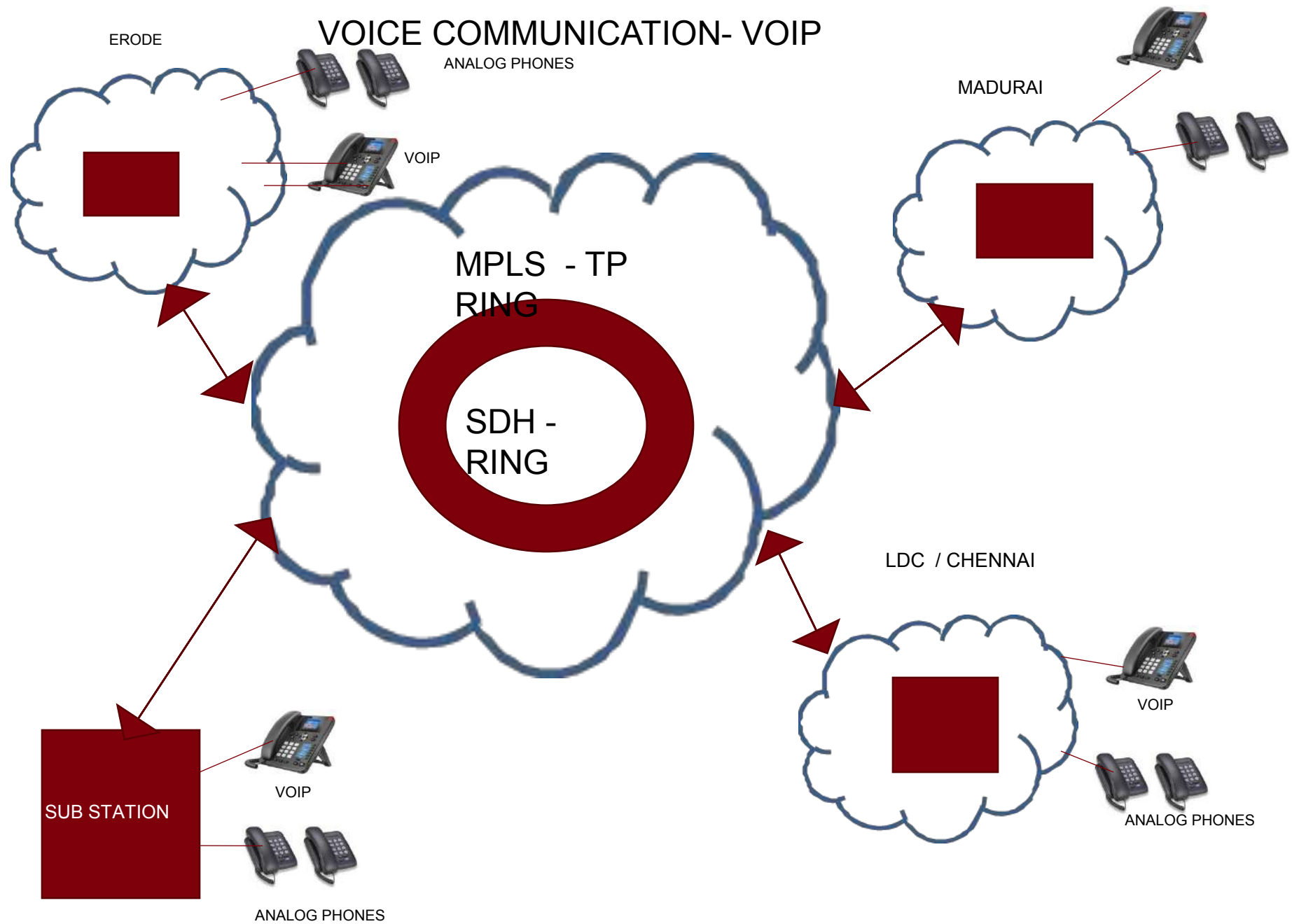
VOICE Communication based on VOIP between
MPLS-TP connected stations





VOICE Communication based on VOIP between MPLS-TP connected stations







Thank you



TANTRANS CO. : EMERGING TRENDS –TECH SPEC -MPLS-TP Equipments

Power utility Applications	MPLS-TP interface
Network management	Ethernet based interface
Tele-protection interface	Ethernet based interface between DTPC and FOTE
Voice communication Interface	Ethernet interface based VoIP supports: - VoIP phone - VoIP gateway for analog phone interface
Data communication:	Ethernet interface based SCADA : IEC 104 protocol PMU Data : IEEE C37.94 Protocols TWFL : Ethernet based exchange of fault data DR & RAS : Ethernet based DR acquisition and File transfer
CCTV System	PoE+ based interface

Significance: The ethernet based power utility applications interface facilitates MPL-TP suitable interface without the need of legacy interfaces / circuit emulation hardware.

E/N based interface facilitates scope for interoperability with other make MPLS-TP subject to POC verification.



TANTRANSCO : EMERGING TRENDS –TECH SPEC –Grid substations

	Hybrid Equipment	MPLS-TP Equipment
Redundancy:	CPU Modules Link : 1G/10G MPLS-TP i/f & STM-4/16 i/f SFP module for 1+1 redundancy Power supply sources nxE1 ports Module and E/N port for Tele-prot signalling	CPU Modules Link : 1G/10G MPLS-TP i/f modules SFP module for 1+1 redundancy Power supply sources Or Device complete replication.
Tele-protection	Main-1 ch through E1-SDH Main-2 ch through E/N MPLS-TP	Main-1,Main-2 ch through E/N MPLS-TP
Voice	Legacy 2W/4W FXS,FXO,E&M interface – SDH/ MPLS-TP. VoIP- MPLS-TP	VoIP- MPLS-TP Including hotline applications.
Data	E/N based protocols – EoS over SDH, E/N – MPLS-TP	E/N based protocols – MPLS-TP
Line diff Prot comm.	E1/C37.94 over SDH C37.94/ E/N - MPLS-TP	C37.94 Ckt emulation module –MPLS-TP
Cyber security	Encryption to support standard algorithm like AES 256	

Pl.Note: Hardware to be specified for redundancy and for provision for future expansion, cross connect capacity.



Thank you



RRVPNL

Rajasthan Rajya Vidyut Prasaran Nigam Ltd.

“Design, Supply and Implementation of Information and Communication Technology Infrastructure under Package-B of Smart Transmission Network and Asset Management System (STNAMS)”



**Rajasthan Rajya Vidyut Prasaran Nigam Limited
(RRVPNL)**

SCOPE OF WORK

- Planning, Design
- Methodology

Site Survey



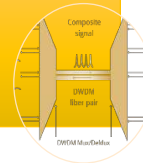
- MCCC at 400kV Heerapura GSS
- Back up and Sub-Control Center at Jodhpur & Ajmer

Establishment of MCC



- Structural cabling with IP-MPLS Node 552 RPF-POP EHV Substations

Establishment of DWDM/IP-MPLS



- NMS Application Software
- NMS Hardware with Accessories

NMS



- IP Surveillance Cameras
- POE Switches

VMS



- 500 Mbps – ISP link for all 552 GSS location

ISP Bandwidth



- Voice Gateway
- IP Phone
- Firewall
- IPS & ATP

UCM & Cyber Security



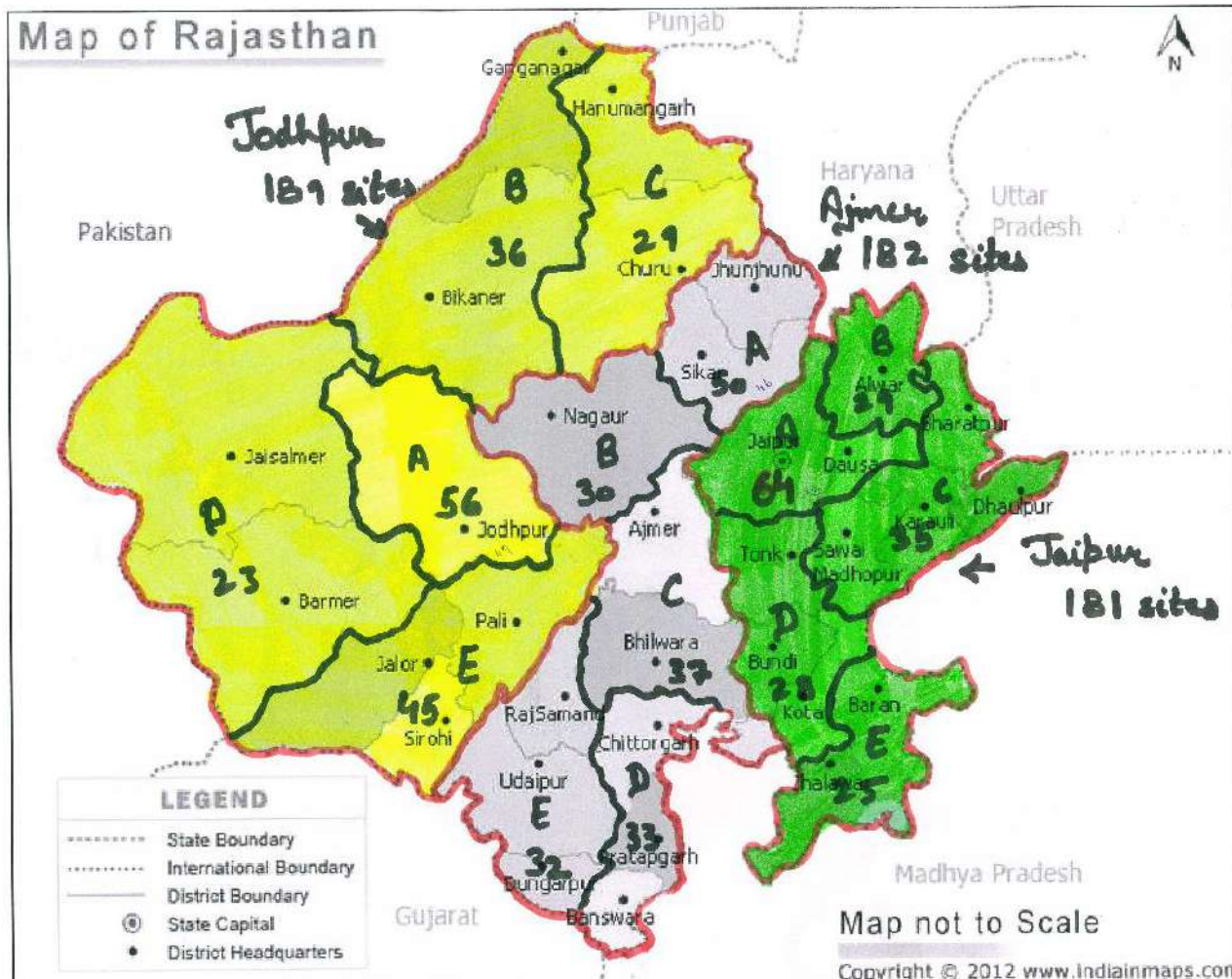
- Maintenance Training on implementation, customization, utilization and maintenance

Training



GEOGRAPHICAL FOOT PRINT OF GSS POP LOCATIONS

Geographical representation of all 552 GSS POP locations spread across whole Rajasthan and 3 Command Control Centres



SS Category	No. of sites
765kV	2
400kV	15
220kV	121
132kV	414
Total	552

Zones	No. of sites
UOM	Nos.
Jaipur	181
Jodhpur	189
Ajmer	182
Total	552

LOCATION-WISE INFRASTRUCTURE

Sl.No	Locations	Qty	Remarks
1	Main Control centre at Jaipur	1	
2	Backup Control centre at Jodhpur	1	
3	Sub Control centre at Ajmer	1	
4	Total Substations	552	
4 (a)	Substations with only MPLS router	480	Earlier proposed to be connected on ISP Network, later changed to be connected on OPGW Network
4 (b)	Substations with MPLS router and DWDM	72	To be connected on OPGW network from the beginning
5	Data connectivity to Field Offices	87	Outside building via fiber; remaining connected in Substation's switch
8	UCM with Phones	206	138 GSS Locations + 45 locations in VB+ 23 in Command centres
9	Video Surveillance	261	(138 +3)FC at GSS+ 36 FC at CC + 84 PTZ ; 42 Switches, 84 Poles

Smart Transmission Network and Asset Management System (STNAMS)

Project Objective



Operations management for efficient, safe & stable grid via Wide Area Network.

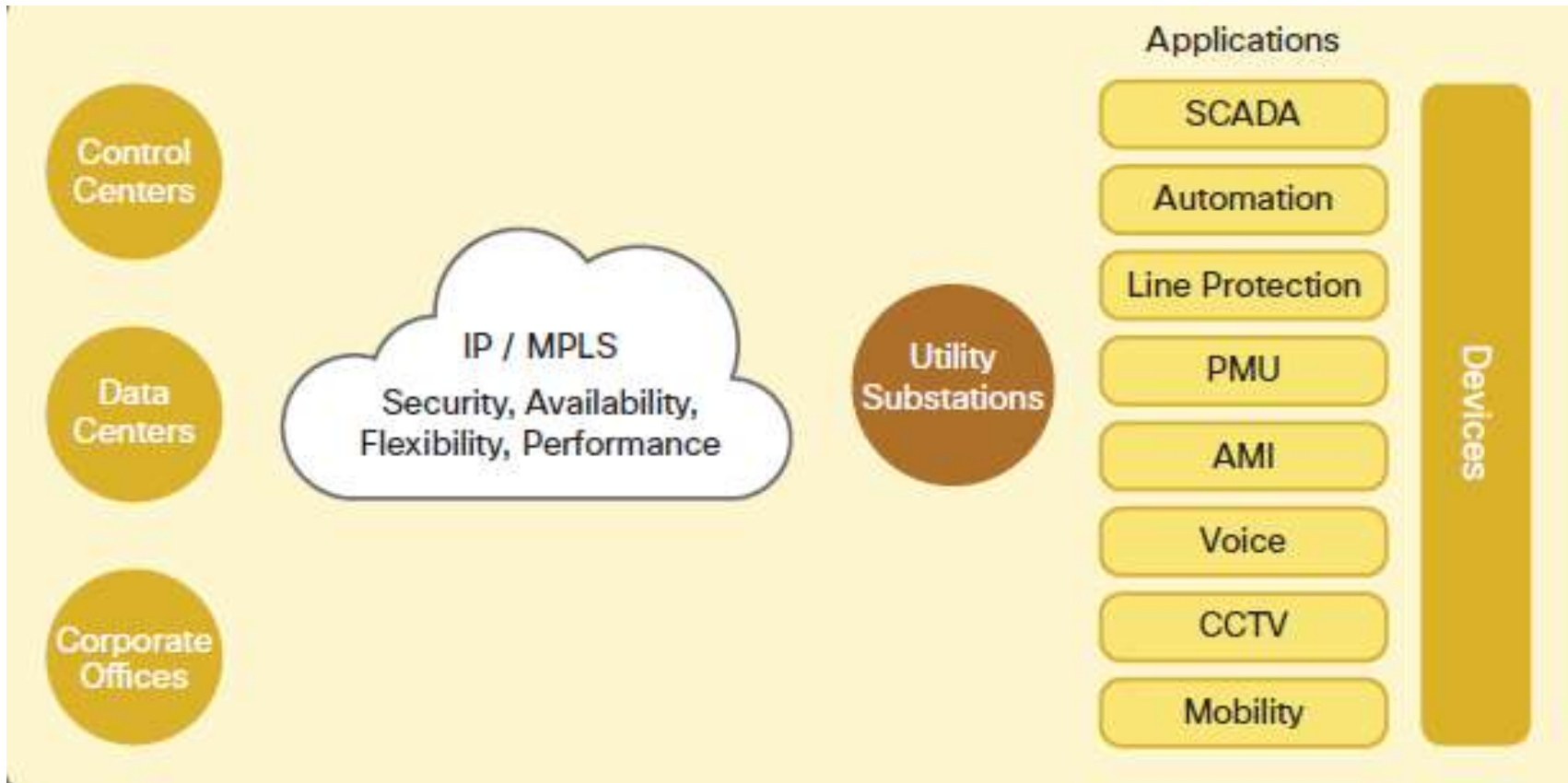
Monitoring, Control of the Transmission Grid and substations from Control centre through real time data transfer with reliability, speed and geo-referenced localization of faults

Quality management of Power flow through maintaining the Voltage and Frequency under prescribed limits by effective monitoring and utilizing the reactive elements.

Asset Management at Substations via Dynamic GIS Maps.

The accurate data and estimations for future **Planning** and studies.

SMART GRID Architecture



Real time monitoring

Better Control

Data Acquisition
for Planning

Integration with
GIS for asset
tracking and
localization of
fault.

INTRODUCTION

- RRVPNL has decided to implement Cisco IP/MPLS (Multi-Protocol Label Switching) WAN (Wide Area Network) solution for its various utility applications and services including Supervisory Control and Data Acquisition (SCADA) systems, Tele-Protection, Phasor measurement unit (PMU) data, IP Voice/Video and IP Camera for Surveillance.
- The RRVPNL IP/MPLS WAN solution is designed to build a common fast convergent IP/MPLS platform for 552 sites.
- The RRVPNL IP/MPLS WAN solution that connects Operational Technology (OT) endpoints over an IP packet-based infrastructure will allow RRVPNL to form the core of an advanced communications solution for implementing intelligent network services that facilitate new business requirements now and into the future.

OBJECTIVES

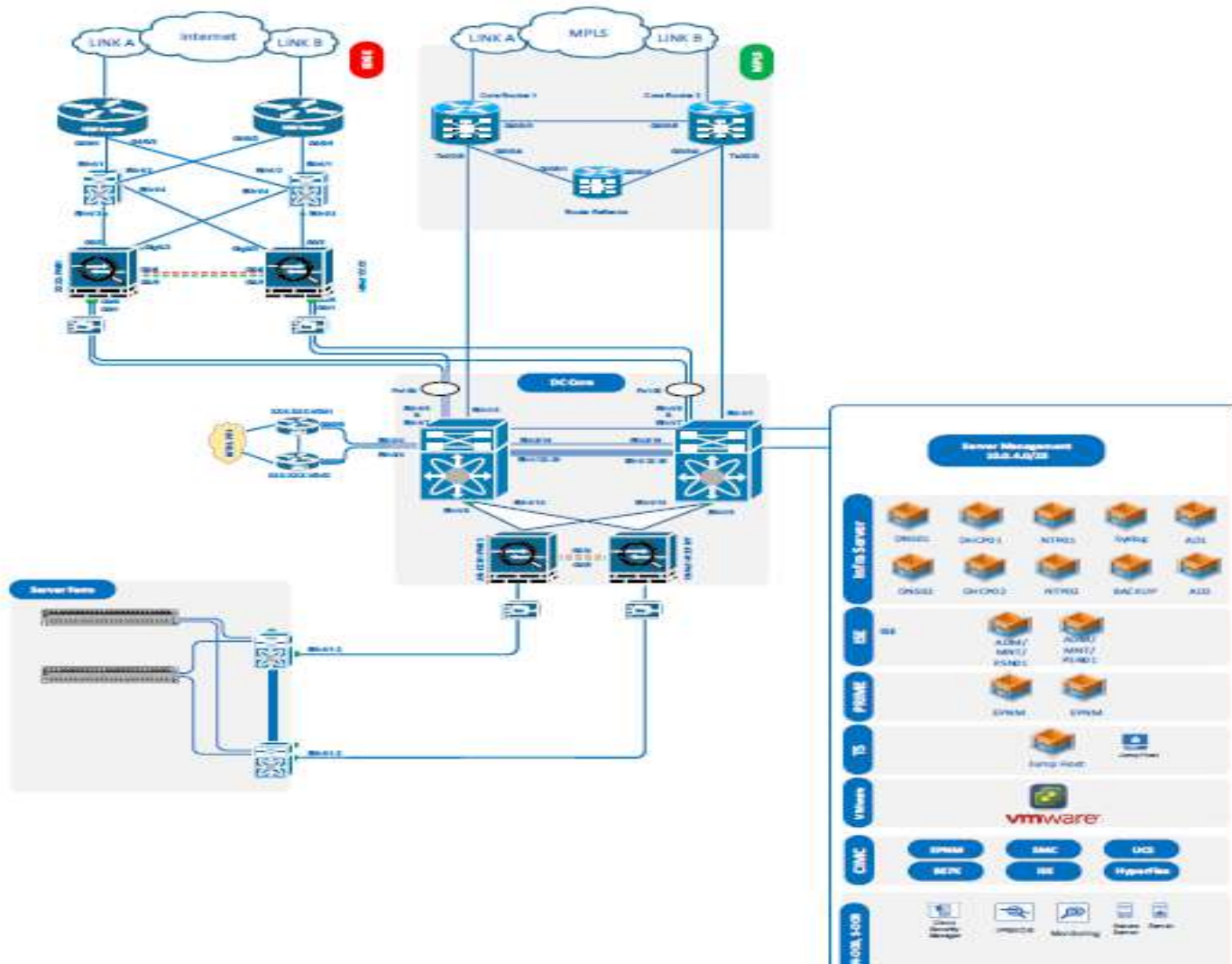
- The objective of project is to provide the Information and Communication Technology Infrastructure for the proposed Smart Transmission Network and Asset Management (STNAMS) system. The reliable, efficient and scalable communication backbone as proposed under this project shall enable the achievement of following wider objectives under proposed STNAMS.
- The IP/MPLS WAN will provide the following functions and capabilities to RRVPNL.
 - Implementation of a network architecture based on IP standards
 - Deployment of a multiservice network
 - Integration of equipment from multiple vendors across a common communications solution.
 - A tailored approach for meeting the requirements of RRVPNL's defined services.

- **DATA CENTER DESIGN**

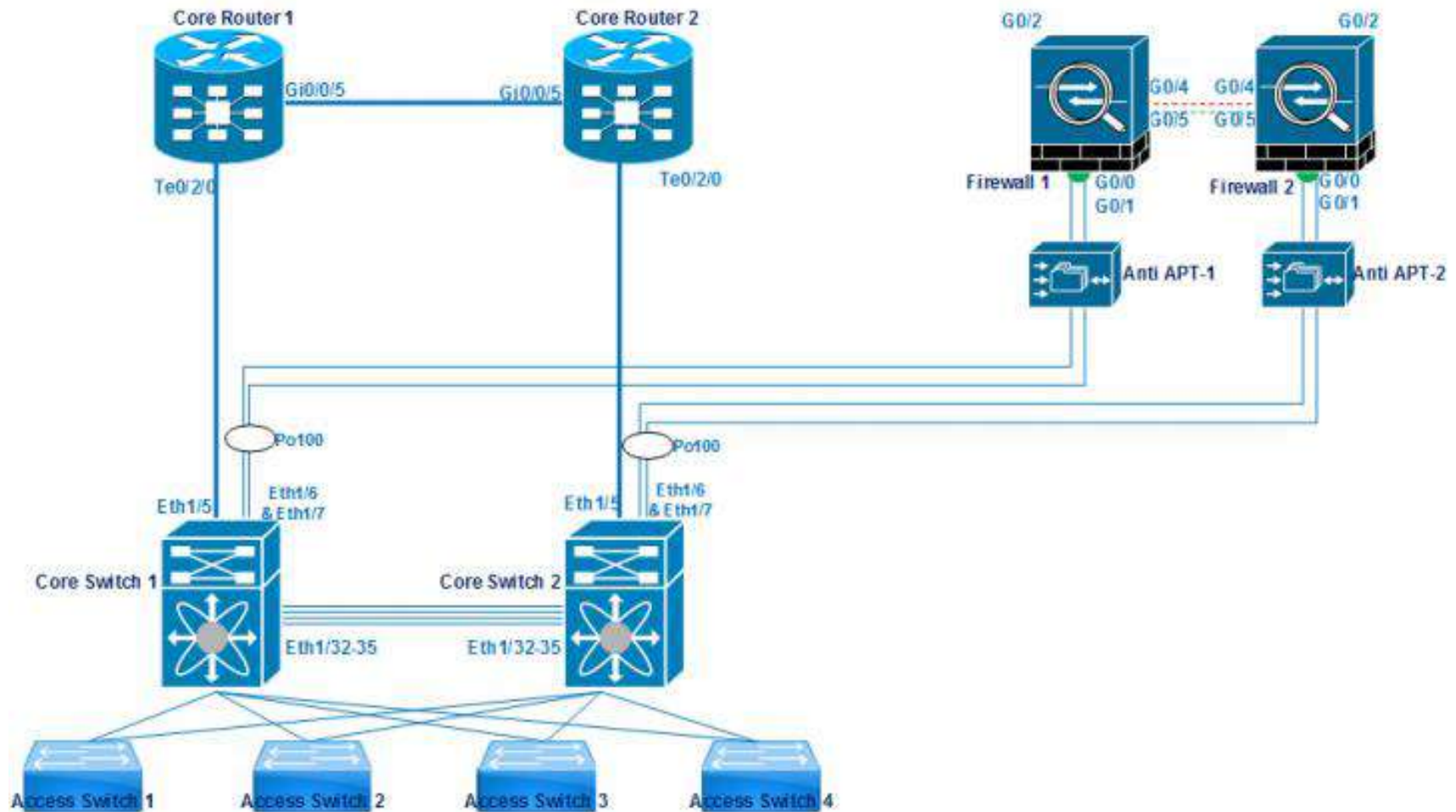
- RRVPNL Campus is based on a 2-level hierarchical design, including the levels of Access and Core.
- The Access level provides end-users connectivity, along with Access Points connectivity.
- The Core level, at the top of the hierarchy, aggregates all traffic coming from Access switches and connects the LAN Campus to the other Campus blocks.

JAIPUR DATA CENTRE ARCHITECTURE

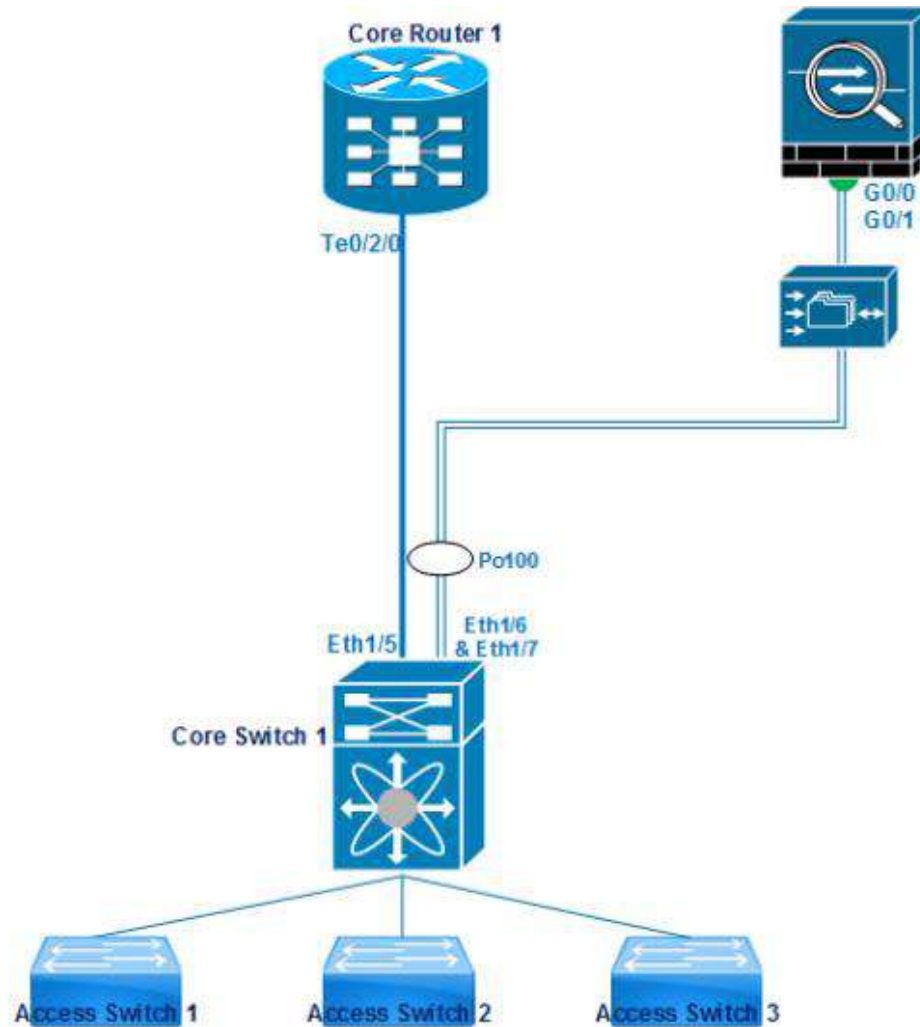
Figure 3-1 Jaipur Datacenter



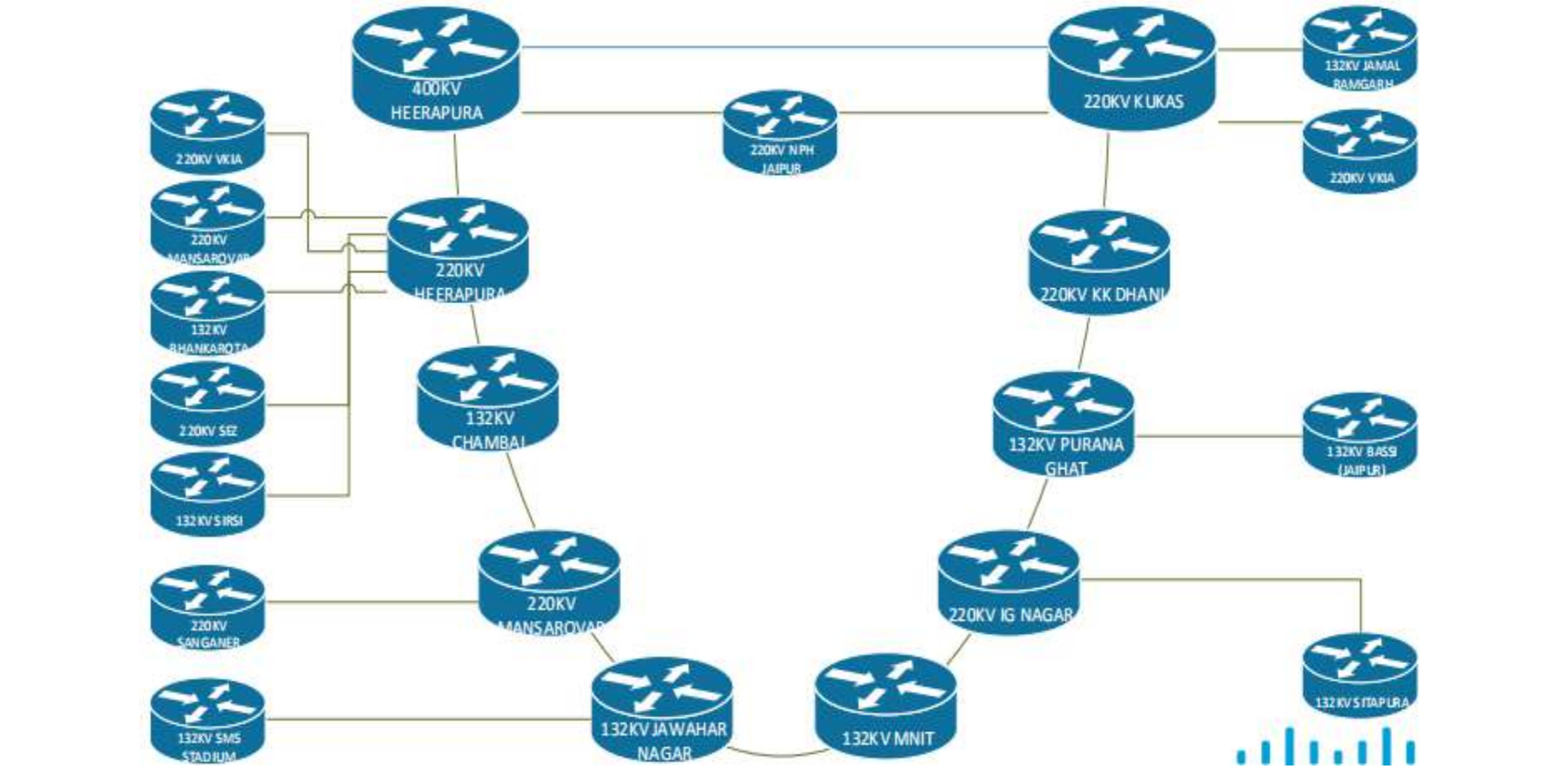
JODHPUR DATA CENTRE ARCHITECTURE



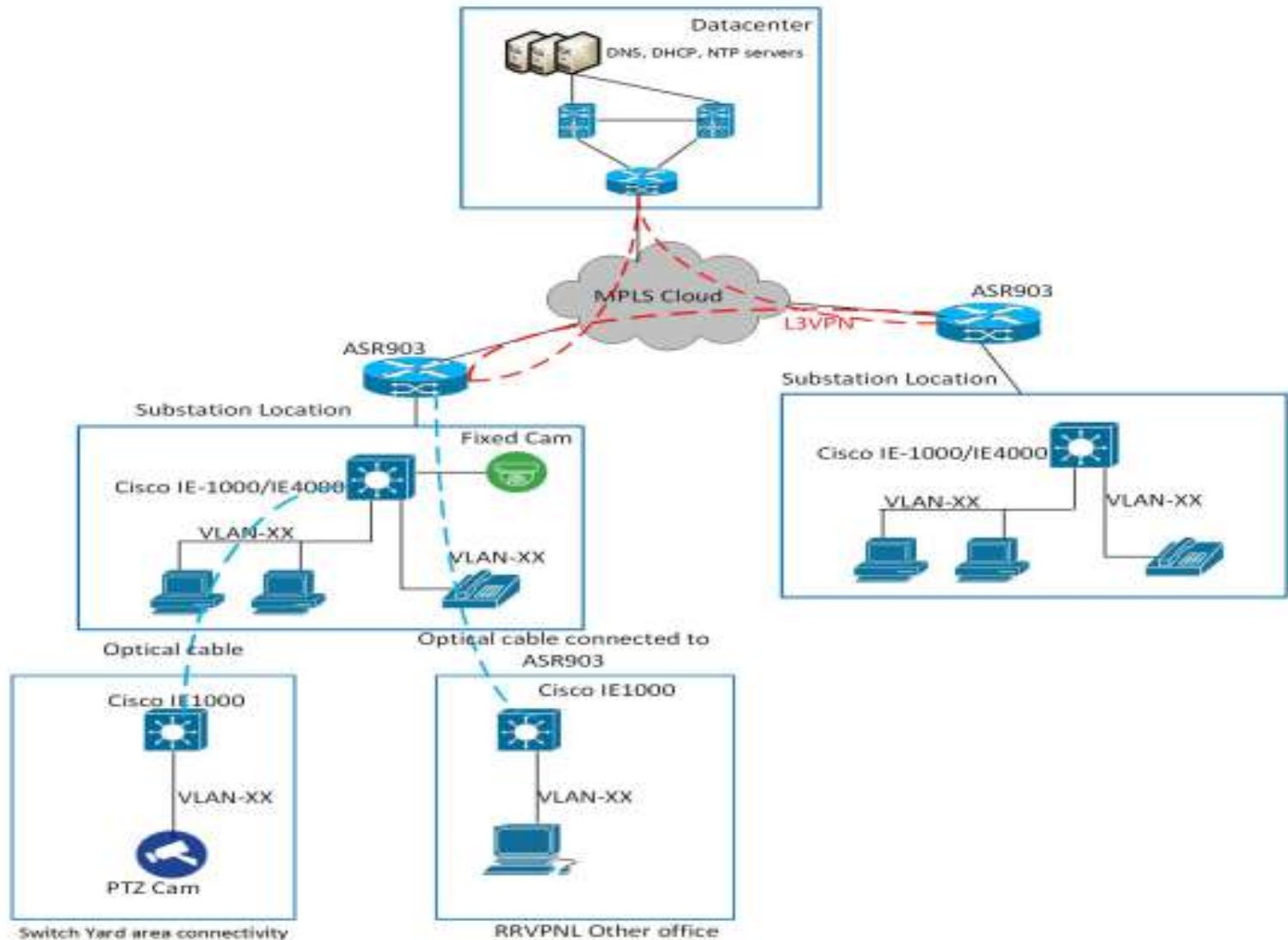
AJMER DATA CENTRE ARCHITECTURE



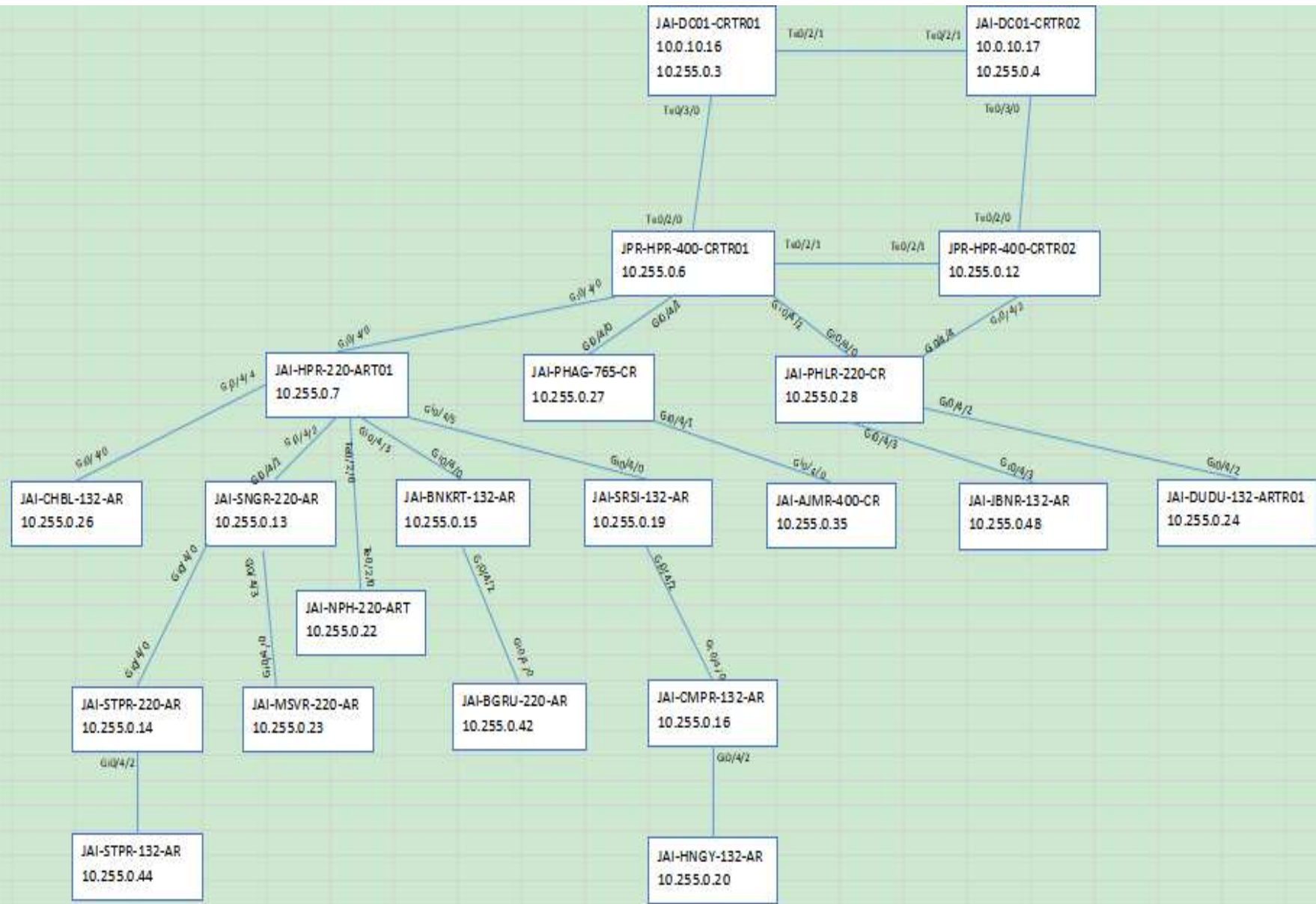
MPLS RING DIAGRAM



RRVPNL IP MPLS network architecture for substation location



MPLS POP CONNECTIVITY



TELE-PROTECTION CONNECTIVITY

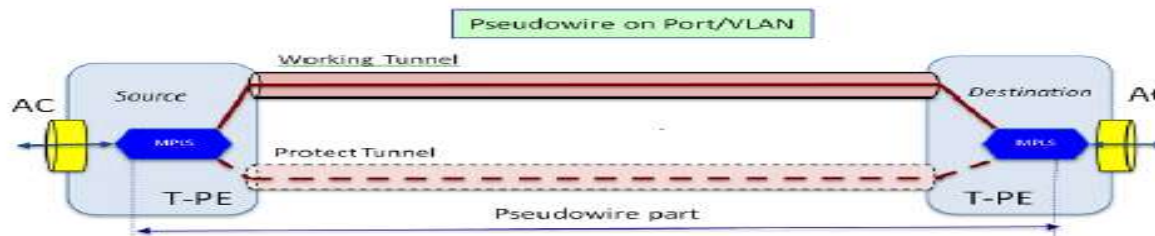
13.2 EoMPLS Terminologies

Pseudowires: Pseudowires(PW) are used to provide end-to-end services across an MPLS network. They are the basic building blocks that can provide a point-to-point service as well as a multipoint service such as VPLS, which is practically a mesh of PWs used to create the bridge domain across which the packets flow.

The end-to-end service is composed of 2 parts. The Attachment Circuit (AC) part and the Pseudowire part. The whole circuit end-to-end is still referred to as Pseudowire in Cisco Transport Controller(CTC), but bear in mind the two part distinction exhibited here for the troubleshooting that follows.

Pseudowire part practically starts and stops at the tunnel end points (if you exclude the MPLS encapsulation block shown here).

Figure 13-3. Pseudowire



Attachment Circuit (AC): The AC carries the customer traffic in its native form, i.e. Ethernet frames with or without VLAN tagging depending on whether we are creating a VLAN based Pseudowire or Ethernet Based Pseudowire (AC Type box in the PW creation wizard). The MPLS labels for the specific PW service as well as for the tunnel over which it is riding are then added. Packets are then sent across the Pseudowire part of the circuit into the MPLS cloud. This process is called Label Imposition in MPLS terminology. On the far end, the reverse process occurs, i.e. the labels are removed or the Label Disposition occurs, and the packets, which are now back to native Ethernet frames, are then delivered to the other end through the far end AC part of the Pseudowire circuit.

13.3 EoMPLS Forwarding

When the ingress PE router receives the Ethernet frame, it strips off the preamble, Start of Frame Delimiter (SFD), and FCS fields, adds a control word, labels the frame, and forwards it across the MPLS network. If the Ethernet frame is tagged with an 802.1Q tag, this tag is kept, too. On the egress PE router, the VC label is stripped off, the control word is removed, the Ethernet FCS is added, and the frame is sent toward the CE router or switch.

13.3.1 VLAN ID Rewrite

VLAN ID Rewrite is the feature whereby the 802.1Q tag might be rewritten in Ethernet VLAN mode if the 802.1Q VLAN ID is different at both sides of the ATM network. You might have VLAN 100 on the ingress PE router and VLAN 200 on the egress PE router, for example. The VLAN ID rewrite happens either on the imposition side or on the disposition side. The VLAN ID Rewrite is an automatically enabled feature, so no configuration is needed to enable it.

13.3.2 EoMPLS carrying one VLAN

In RRVPNL's network, in the scenario of EoMPLS carrying one VLAN, you have an 802.1Q trunk between the CE and the PE routers. Each VLAN is mapped to one pseudowire. The advantage of this scenario compared to non-vlan tagged scenario is that each VLAN has its own pseudowire and can be routed differently through the MPLS network, or the different pseudowires can be between different CE routers.

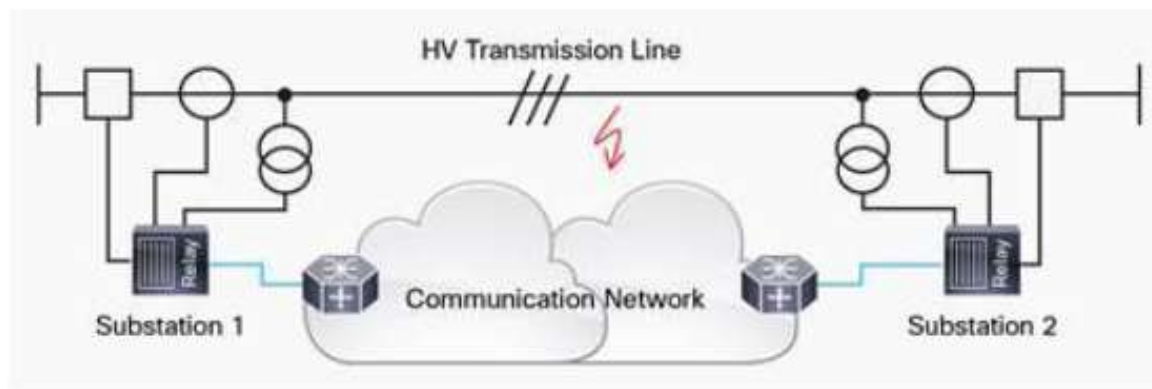
TELE-PROTECTION CONNECTIVITY

14.4 Teleprotection

A secure and uninterrupted supply of electricity is only possible with the help of comprehensive protection and control functions, which ensure the reliable operation of the power system. To prevent the system from failure and damage, the Teleprotection system has to selectively disconnect the faulty part by transferring command signals within the shortest possible time.

Tele-protection schemes employ protection relays that sense anomalies in power line current, phase or voltage, and signal between geographically separate substations to protect grid infrastructure such as transformers and circuit breakers, as depicted in the below Figure.

Figure 14-9: Smart Grid Tele-protection



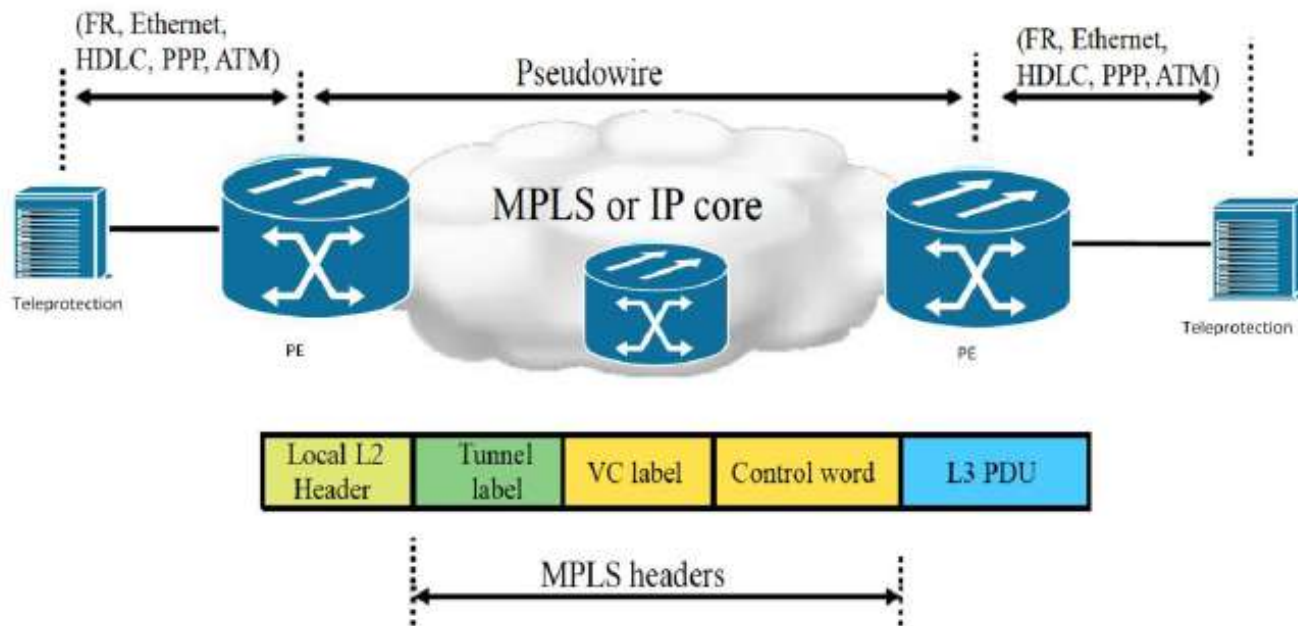
Cisco ASR903 has a interface module that delivers 6 ports of Ear and Mouth (E&M) interfaces. The design emphasizes Smart-Grid and low-latency applications environments. Typical uses cases for this module are Teleprotection and Land Mobile Radio applications. The module supports E&M type I, II, III, and V on 2 or 4 wire modes with selectable 600 or 900 ohm impedances. The physical connectivity

TELE-PROTECTION CONNECTIVITY

on the interface module is using standards based RJ-45 connectors. The E&M signals and voice data can be transported using CESoPSN with and without Channel Attached Signalling (CAS) over MPLS.

Over the IP/MPLS network the Teleprotection data frame will be transported between two Substations with P2P L2VPN. The L2VPN technique we will be using is called EoMPLS as explained L2VPN section. There was a requirement, that if point to point link fails, the L2VPN tunnel should be redirected through alternate path. This will be done by using MPLS targeted LDP sessions. This concept has already been explained in MPLS LDP session protection.

Figure 14-10: L2VPN packet flow



TELE-PROTECTION TEST CASES

16.7 L2VPN config test

Test No:	16.7	Revision:	1.0	Author:	Advanced Services	Date:	
Test Category:	L2VPN			Standard/Optional:	Standard		
Product Chassis ID:	Cisco ASR 903			Product Card ID:	N/A		

Test No:	16.7	Revision:	1.0	Author:	Advanced Services	Date:								
Technology:	MPLS	(Conformance Tests)	Standard:	N/A										
Hostname:														
Elements Managed (NMS Tests):	N/A													
Test Title:	L2VPN													
Test Purpose:	Verify MPLS L2 VPN Config on ASR903													
Test Setup:	Tests will be carried out on fully implemented network topology build out as described in the LLD.													
Procedure:	1. Verify L2VPN and Pseudowire Config show xconnect all													
Checks:														
1. Verify L2VPN configs							Pass: ☒ Fail: ☐							
2. Verify Pseudowire configs.							Pass: ☒ Fail: ☐							
Expected Results:	L2VPN should be configured as per NIP and LLD design.													
mpls ldp neighbor 10.4.32.13 targeted ldp mpls ldp discovery targeted-hello accept JAI-HPR-CRTR01#sh xconnect all Legend: XC ST=Xconnect State S1=Segment1 State S2=Segment2 State UP=Up DN=Down AD=Admin Down IA=Inactive SB=Standby HS=Hot Standby RV=Recovering NH=No Hardware														
XC ST Segment 1 S1 Segment 2 S2 +-----+-----+-----+ UP pri ac CE0/3/0:0(CESoPSN Basic) UP mpls 10.4.32.13:100 UP														
Passed: (Initial)														
Failed: (Initial)														
Reason for Failure:														
Remarks:														

Generally Approved

Generally Approved

TELE-PROTECTION TEST CASES

16.8 L2VPN test

Test Case ID	Test Case Name	Author	Advanced Services	Date
Test Category:	L2VPN		Standard/Optional:	Standard
Product Channel ID:	Class ASR 903		Product Card ID:	N/A
Feature Set:	MPLS	(Conformance Tests)	Standard Test:	N/A
Test Case ID:				
Elements Tested (NMS Tests):		N/A		
Test File:	L2VPN			
Test Purpose:	Verify MPLS L2 VPN status			
Test Scope:	Tests will be carried out on fully implemented network topology build out as described in the LLD.			
Procedure:	1. Verify L2VPN and Pseudowire status show mpls l2transport vc detail			
Checks:	show mpls l2transport vc 100 detail Local interface: 10.4.32.10 up, line protocol up, CE3oPSN Basic 0 up destination address: 10.4.32.13, VC ID: 100, VC status: up transport label: 100, proposed label stack (0 20) Preferred path: 0, send peer Default path: none Next hop: 10.4.32.13 Create time: 1w4d, last state change time: 1d00h Last LDP FIB install change time: 1w2d Signalling peer: 10.4.32.13, peer 10.4.32.13:0 up Targeted label: 10.4.32.13 (LDP Id) > 10.4.32.13, LDP is UP Graceful restart: not configured and enabled Non-stop routing: not configured and not enabled Status FIB export (local/remote) : enabled/supported LDP route status : enabled Label status: 0x0 machine : established, LruRru Last local FIB install status rcvd: No fault Last RPD install status rcvd: Not sent Last RPD install status rcvd: No fault			

Generally Approved

TELE-PROTECTION TEST CASES

Test No.	16.8	Revision:	1.0	Author:	Advanced Services	Date:	
Last local AC circuit status sent: No fault Last local PW l/f circ status rcvd: No fault Last local LDP TLV status sent: No fault Last remote LDP TLV status rcvd: No fault Last remote LDP ADJ status rcvd: No fault MPLS VC labels: local 16, remote 20 Group ID: local 39, remote 51 MTU: local 0, remote 0 Remote interface description: Sequencing: receive disabled, send disabled Control Word: On (configured: autosense) SSO Descriptor: 10.4.32.13/100, local label: 16 Dataplane: SSM segment/switch IDs: 8197/4097 (used), PWID: 1 VC statistics: transit packet totals: receive 87397025, send 87397043 transit byte totals: receive 4369851250, send 3670675806							
1. Verify L2VPN configs						Pass: ☒ Fail: ☐	
2. Verify Pseudowire configs						Pass: ☒ Fail: ☐	
Expected Results:	VC(Virtual circuit) status should be "UP"						
Passed: (Initial)							
Failed: (Initial)							
Reason for Failure:							
Remarks:							

LOW LATENCY IN NETWORK

```
Administrator: C:\WINDOWS\system32\cmd.exe
Control-C
^C
C:\Users\administrator>ping 10.255.1.95 -t

Pinging 10.255.1.95 with 32 bytes of data:
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=15ms TTL=249
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=37ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=13ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=17ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249
Reply from 10.255.1.95: bytes=32 time=14ms TTL=249

Ping statistics for 10.255.1.95:
    Packets: Sent = 21, Received = 21, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 13ms, Maximum = 37ms, Average = 15ms
Control-C
^C
C:\Users\administrator>_
```

Contd..

LOW LATENCY IN NETWORK

```
Administrator: C:\WINDOWS\system32\cmd.exe
    Minimum = 13ms, Maximum = 37ms, Average = 15ms
Control-C
^C
C:\Users\administrator>ping 10.255.0.7 -t

Pinging 10.255.0.7 with 32 bytes of data:
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=50ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=4ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=3ms TTL=251
Reply from 10.255.0.7: bytes=32 time=2ms TTL=251

Ping statistics for 10.255.0.7:
    Packets: Sent = 20, Received = 20, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 2ms, Maximum = 50ms, Average = 4ms
Control-C
^C
C:\Users\administrator>
```


JAIPUR DATA CENTRE CONTROL ROOM VIEW



JAIPUR DATA CENTRE EQUIPMENT ROOM VIEW



JAIPUR DATA CENTRE EQUIPMENT ROOM VIEW



JODHPUR DATA CENTRE VIEW

Jodhpur DC
All Zone Wise



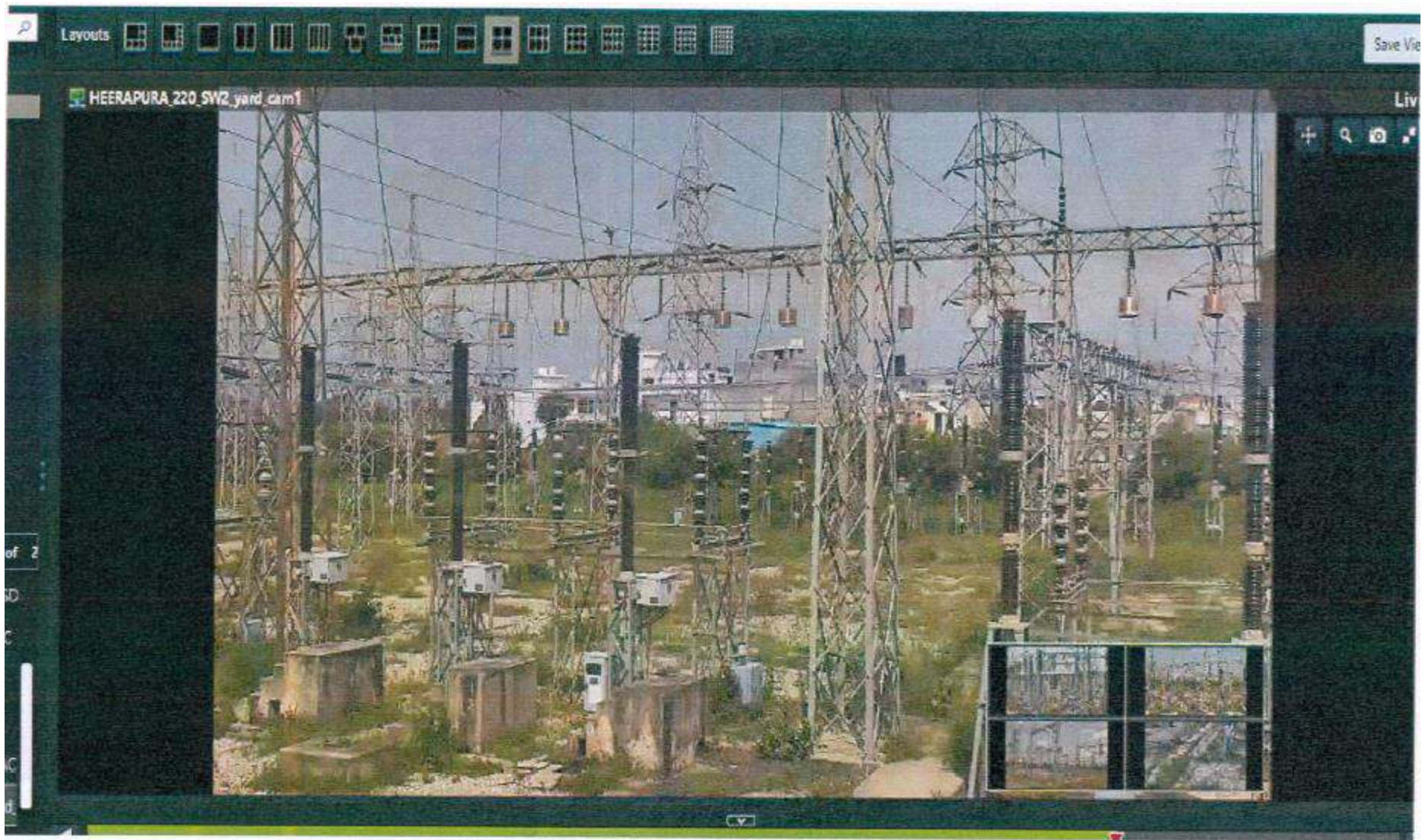
AJMER DATA CENTRE VIEW



PTZ CAMERA VIEW-1



PTZ CAMERA VIEW-2



GSS LOCATION CONTROL ROOM FIXED CAMERA VIEW



THANK YOU



Annexure-XXI

TEST PLAN for Interoperability Test between different MPLS OEM Equipment

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1 General

1.1 Purpose

The purpose of this document is to test and witness the interoperability between different make MPLS IP/TP make equipment for Power System applications .

This document contains the Acceptance Test procedure under for the following OEMs:

- Belden MPLS-TP)
- Cisco IP/MPLS
- GE MPLS-TP
- Nokia IP/MPLS
- Hitachi MPLS-TP

1.2 Location

- Hitachi: Korattur 230/110 Kv S/S
- GE & Belden: Sriperambuthur 400/230/100 Kv S/S
- Cisco & Nokia: Kanchipuram 230 Kv S/S

1.3 Test Pass/Fail Criteria

The specific test will be considered as completed successful as per this procedure after it meets the acceptance criteria mentioned in the test.

1.4 Presumptions

Acceptance Test and Test Configuration will be carried with following test setup: -

- The links used in the test setup is almost representing real links and network as in the field network.
- Availability of services of network will be tested by test equipment or instrument as described in the specific test.

1.5 Acceptance of Test

After the completion of each test , the test report is to be signed by witnessing team members of JC & respective OEMs .

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2 Inventory detail of Nodes for POC

2.1 Korattur 230/110 Kv S/S

Hitachi Equipment

Slot No.	Card Model	Description	Serial Numbers
	CESM2	Control Unit ; MPLS-TP Interface	
	SAM02	SDH Interface card + PDH card	
	CEPI 1	Circuit Emulation Card	
	LEDET	E1 Interface Card	
	OPIC1	Differential protection	
	CEP1	FXO Communication	
	LEDA	ESM communication	
	EP011	Ethernet Interface	
TRIB14	FXS	12 Port FXS Board	
TRIB15	----	-----	
TRIB6	----	-----	

2.2 Sriperambuthur 400/230/100 Kv S/S

GE Equipment *Chazh Dxc*

Slot No.	Card	Description	Serial Numbers
01	PSUXM	48V Power Supply Main	
02	PSUXS	48V Power Supply Standby	
03	E1	E1/T1 - Interface card	
04	8GE	8 Gigabit Interface card	
05	PTN-10G	PTN-10G (MPLS Interf. Card) - Main	
06	PTN-10G	PTN-10G (MPLS Interf. Card) - Protected	
XCU1		XCU - controller card (Main)	
XCU2		XCU - controller card (Standby)	
11	E4M	8 Port E4M card	
12	RS232	8 Port RS232 card	
14	L.S. optical	4 Port C.37.94 Interface card	
16	FXS	12 Port FXS card	
17	C		

12/09/2024

Belden Equipment Chassis XT2210

Slot No.	Card Model	Description	Serial Numbers
1	AC PSU	AC Power Supply	
2	DC PSU	DC Power Supply	
3	NSM	Node Support Module	
4	4GCLW	Interface Card - WAN/LAN-1G	
5	6GELW	Interface Card - LAN-1G	
6	4G0-LW	Interface Card - WAN/LAN	
7	4G0-LW	—u—	
8	C5M310	CPU	
9	C5M310	CPU	
10	110G1W	Interface Card - 10G LAN/WAN	
11	110G1W	—u—	
12	C37.94	Interface card - C37.94 & E1	
13	C37.94	—L—	
14	90LW	Interface Card - WAN/LAN-1G	

2.3 Kanchipuram 230 Kv S/S

Cisco Equipment

Slot No.	Card Model	Description	Serial Numbers
	NCS540-1	Network core Router MPLS LSP	
	NCS540-2	MPLS / IP Router	
	SEL-1	Power - blades	
	SEL-2	Power - blades	
	C37.94	Interface module	
	Ether NL-	1G Copper	
	Fiber FM	1G	
	Fiber - 2m	10G module	
	G703 -	E1 Interface	
	GPs - 1	SyncE Port / FOD / GPs Port	
	GPs - 2	SyncE Port / FOD	

12/09/2024

Nokia Equipment

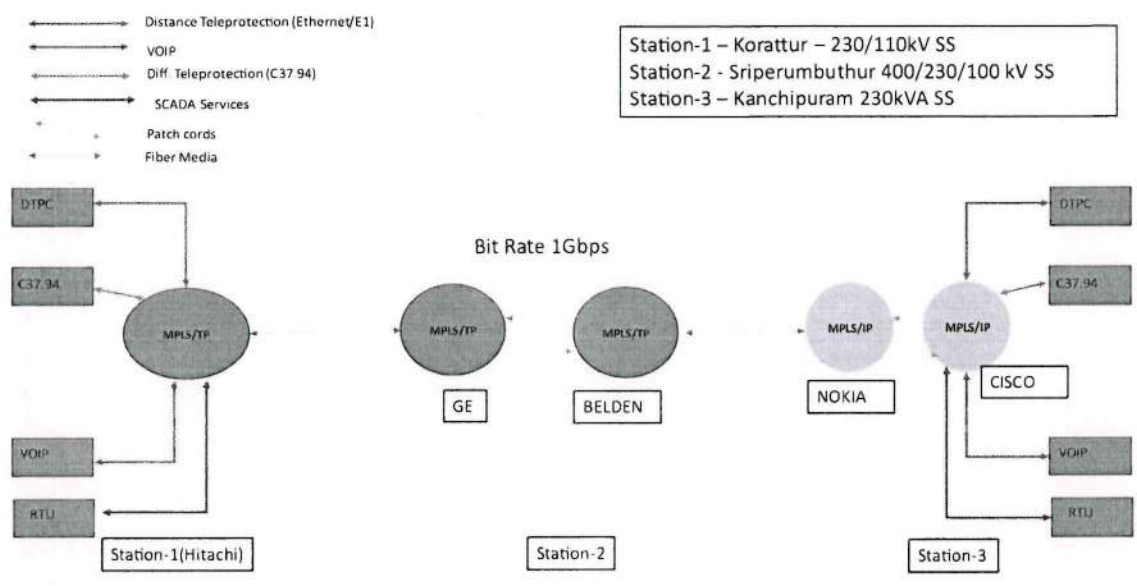
Slot No.	Card Model	Description	Serial Numbers
1	CPM-A	Control Card	
2	-		
3	a8-1gb-v3-sfp	1G/10G Comba Card ethernet-	
4	a6-em-10g	10 card ethernet	
5	a8-C3794	C3794 teleprotection Card	
6	a8-v1	Comba Card FxS, FxO teleprotection	
		Card	
	10G-ZR	10G-80km sfp	
	10G-ER	10G-40km sfp	
	10G optical cables.		
	2x 1G Copper	RJ45 sfp, Copper	

3 Test setup

Operational set up of TANTRANSCO shall not be disturbed. Hitachi hybrid equipment present at Node 1 shall be connected to GE/BELDEN equipment present at Node 2 as shown in the figure below.

12/09/2024

TEST Setup



4 Service Testing

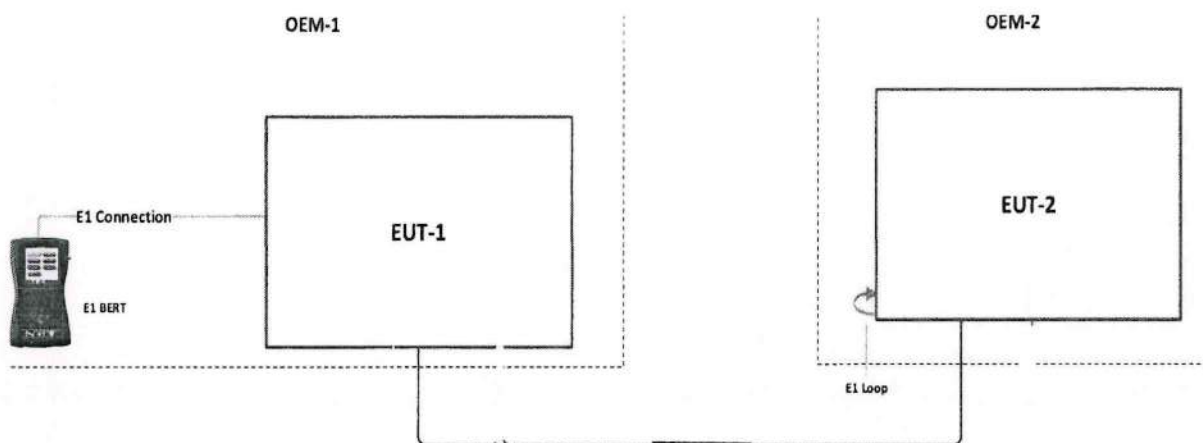
4.1 Test Scenario's

All Tests shall be done end to end test setup link as shown above

4.2 Integration at MPLS Level & ~~Testing of E1 over MPLS path~~ Ethernet

Purpose: Testing of Distance Protection through E1 over MPLS path.

Test Setup: Arrange the test setup as shown below diagram.



- Create Tunnels over 1G links as described below:-
 - Tunnel between Stations
- Configure one E1 circuit in both equipment, connect the E1 Tester on E1 Port of Station – 2 and provide loop on E1 Port of Station – 3
- Run E1 BERT on E1 tester and check that no errors appearing on the tester.
- Observe 0 BER (as per ITU-T standard).
- Measure Latency with the tester also and observe for CEA acceptance criteria.

12/09/2024

Results

OEM-1	OEM-2	Technology	Pass	Fail	Comments
GE	Hitachi	Mpls-Tp	✓		
	Belden	Mpls-Tp	✓		
	Cisco	Mpls-Ip	✓		
	Nokia	Mpls-Ip	✓		
Hitachi	Belden	Mpls-Tp	✓		
	Cisco	Mpls-Ip	✓		
	Nokia	Mpls-Ip	✓		
Belden	Cisco	Mpls-Ip	✓		
	Nokia	Mpls-Ip	✓		
Cisco	Nokia	Mpls-Ip	✓		

Cheng
DBMECTU

2/12/2024

Amf
ABE, SRPC

DD(PCD), CEA

KEEL
EEI

Cheng
(Grainger Assoc)
Chief Manager, POWERGRID

Amf
(ABE, SRPC)

12/09/24
Sety andy Kndok
Dne. for, CEA

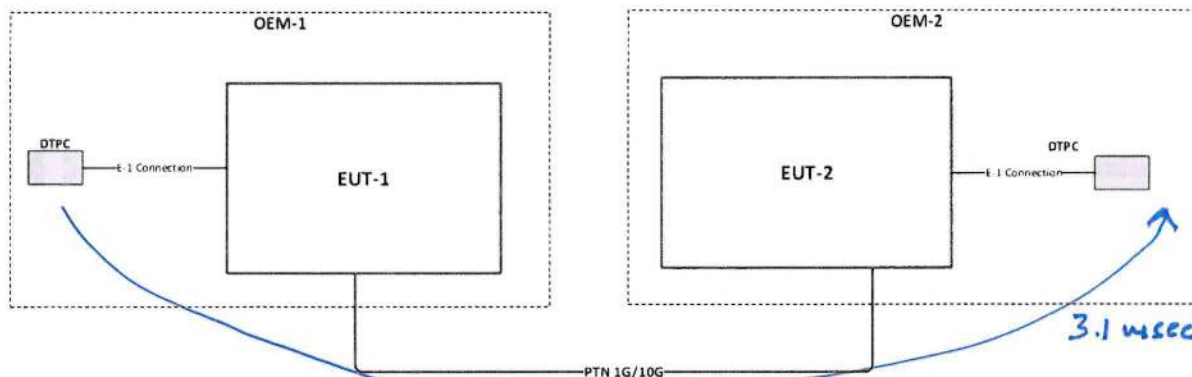
12/09/2020

4.3 Distance Tele protection Testing of ~~E1~~ over MPLS path (This test can be done with 4.2)

ETHERNET

Purpose: Testing of Command Transfer for Distance Teleprotection (E1) over MPLS path.

Test Setup: Arrange the test setup as shown below diagram.

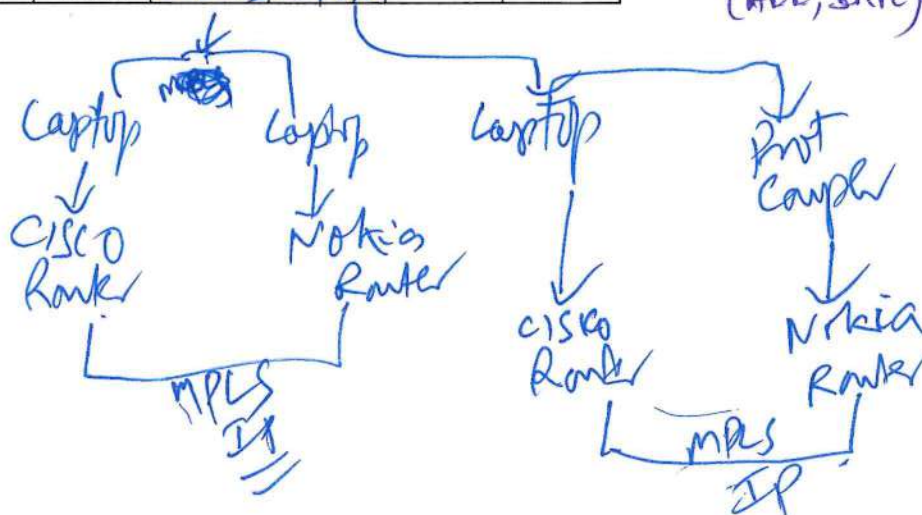


DTPC at both ends shall be same as different OEM DTPC will not communicate with each other

- Use Set up as per section 4.2 for ~~E1~~ Testing.
- Replace BERT with DTPC of same OEM at both Sides
- Initiate commands from One DTPC (Through LCT or contacts) and check same are received at other DTPC on LCT or DTPC Counter.

Results

OEM-1	OEM-2	Result (Pass/Fail)			
		CMD-1	CMD-2	CMD-3	CMD-4
GE	Hitachi	3.1 msec	3.1 msec	3.1 ms	
	Belden	NA	NA		
	Cisco	NA	NA	3.56	
	Nokia	NA	NA		
Hitachi	Belden	3.11 msec	3.09 msec	3.6 ms	
	Cisco	NA	NA		
	Nokia	NA	NA		
Belden	Cisco	NA	NA		
	Nokia				
Cisco	Nokia	< 1 ms	< 1 ms		



For Signature of
either team

[Signature]
DGA(CTU)

[Signature]
DD (PCD), CEA

[Signature]
Amp
(ABR, SRPC)

[Signature]
Rog
KSEK

EE1

[Signature]
CM, Powergrid

[Signature]
Satyendra
Dobu
Director, CM

12/09/2014

Not on CMT OEM

4.4 Testing of C37.94 Differential Protection on MPLS

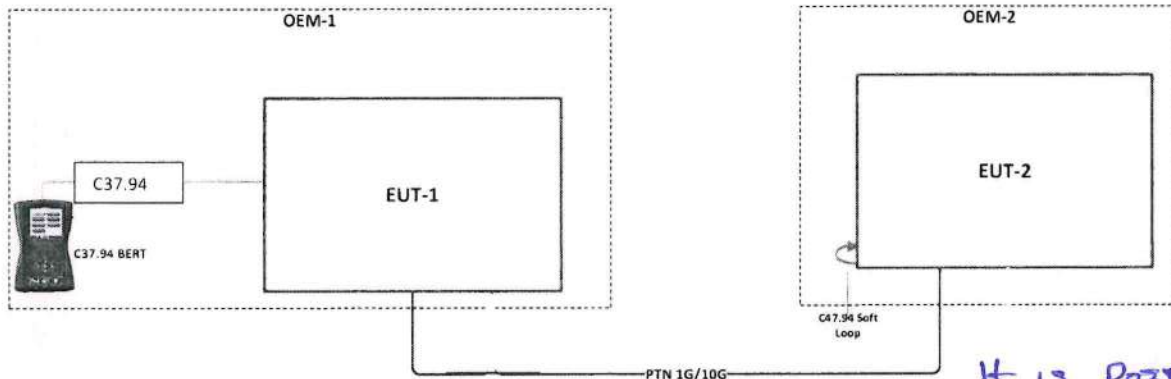
~~NOT~~ (both IP & TP)

Purpose: Testing of C37.94 Differential Protection through Mpls

NOT POSSIBLE

Test Setup: Arrange the test setup as shown below diagram.

Different OEM's use different protocol settings



It is possible between

- Create Tunnels over 1G links as described below:-
 - Tunnel between Stations
- Configure one suitable circuit in both equipment.
- Testing to be done on 1G link
- Run C37.94 BERT on C37.94 tester and check that no errors appearing on the tester.
- Observe 0 BER.
- Measure Latency with the tester also and observe for CEA acceptance criteria.

Same OEM in MPLS-TP

It is possible

between same OEM

on MPLS-TP.

Results

OEM-1	OEM-2	Result		
		Pass	Fail	Comments
GE	Hitachi			
	Belden			
	Cisco			
	Nokia			
Hitachi	Belden			
	Cisco			
	Nokia			
Belden	Cisco			
	Nokia			
Cisco	Nokia			

Tested Between OEM MPLS-TP to MPLS-TP in same OEM Equipment
Belden - Belden

DGM(CTO)

Asim Singh

g. V. V.
CM (Powercat)

Reg. EEP/REGAL

DD (PCO), CEA

ABR, SRP

12/09/14
Subj: MPLS-TP
Dir: CEA

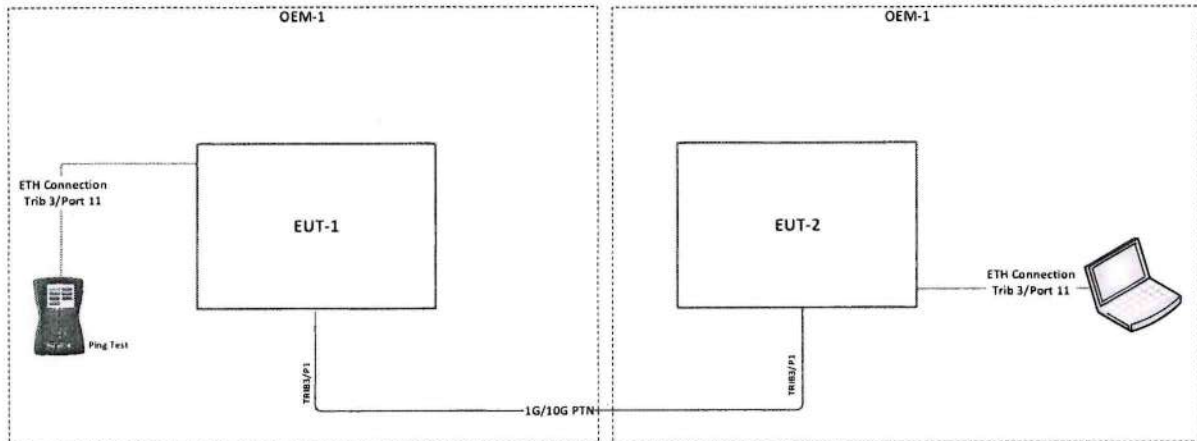
14/09/2024

4.5 Testing of Point to Point Ethernet Circuit over MPLS path

Creating IP to SDC channel IP server

Purpose: Testing of Point to Point Ethernet Circuit between EUT1 & EUT2

Test Setup: Arrange the test setup as shown below diagram.



- Create Tunnels over 1G/10G links as described below:-
 - Tunnel between Stations
 - Configure a Point to Point Ethernet circuit between EUT1 Slot-X/Port-Y and EUT2 Slot-A/Port-B
 - Connect Ethernet tester for ping test at EUT1 Slot-X/Port-Y and a laptop at EUT2 Slot-A/Port-B
 - Check that Ethernet tester & laptop are pinging each other.
 - No loss of ping on MPLS path.

Results

OEM-1	OEM-2	Result		
		Pass	Fail	Comments
GE	Hitachi	✓		
	Belden	✓		
	Cisco	✓		
	Nokia	✓		
Hitachi	Belden	✓		
	Cisco	✓		
	Nokia	✓		
Belden	Cisco	✓		
	Nokia	✓		
Cisco	Nokia	✓		

Measured time : 10 msec

43m sec

500ms
DGN(CTU)

Run
DD(PUD), CEA

ABP
ABP, SPDC

CM, POWERAD

Reg
KSEHL
EEI

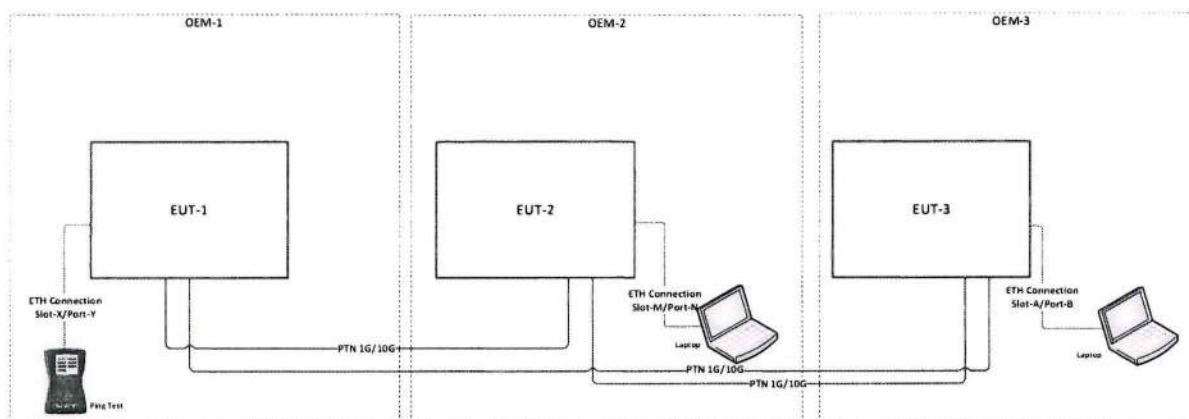
12/09/24
Sachin K. Datta
Nokia CEA

12/09/2024

4.6 Testing of Point to Multi Point Ethernet Circuit over MPLS path

Purpose: Testing of Ethernet through Point to Multi Point Ethernet Circuit in Mpls between EUT1 & EUT2

Test Setup: Arrange the test setup as shown below diagram.



- Create Tunnels over 1G/10G links as described below:-
 - Tunnel between Stations
 - Configure a Point to Multi Point Ethernet Circuit between EUT1 Slot-X/Port-Y to EUT3 Slot-A/Port-B via EUT2 Slot-M/Port-N
 - Connect Ethernet tester for ping test at EUT1 Slot-X/Port-Y and a laptops at EUT2 Slot-M/Port-N and EUT3 Slot-A/Port-B
 - Check that both laptops are pinging with each other.
 - No loss of ping.

Results

OEM-1	OEM-2	Result		
		Pass	Fail	Comments
GE	Hitachi	✓		
	Belden	✓		
	Cisco	✓		
	Nokia	✓		
Hitachi	Belden	✓		
	Cisco	✓		
	Nokia	✓		
Belden	Cisco	✓		
	Nokia	✓		
Cisco	Nokia	✓		

CHYU
DGM(CTU)
DD(PLD), CEA

Measured Latency: 10msec
2/5/2024

ABP
ABP, SRPC

John
GAT, Powertrain

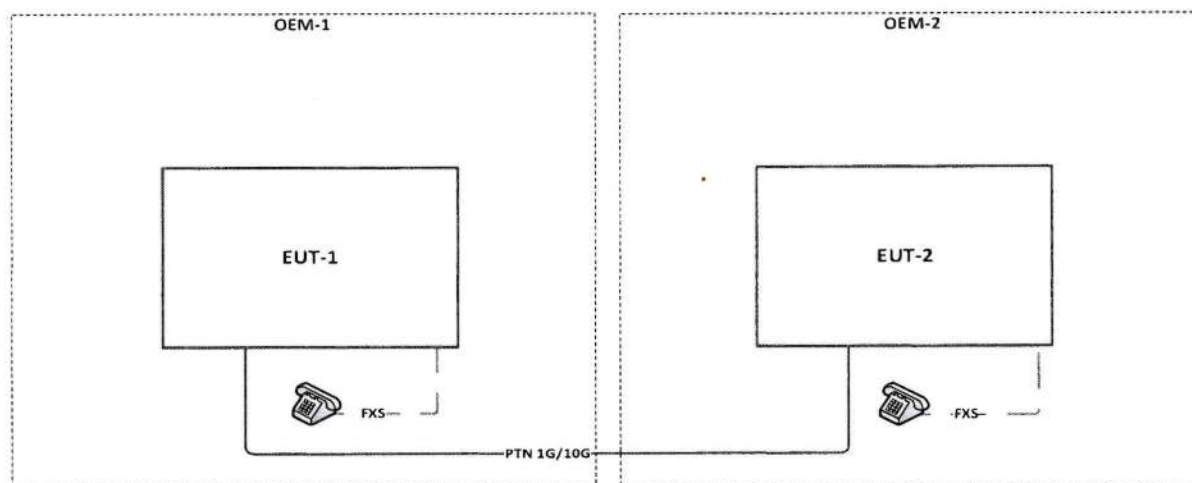
Reg
EE, KSEK
12/09/24
Satyendra Kumar Datta
Mumbai, India

12/09/2024

4.7 Testing of FXS – FXS (Hotline) Communication through MPLS path *NOT REQUIRED*

Purpose: Testing of FXS (Hotline) – FXS (Hotline) Communication as Main & MPLS as Protected path.

Test Setup: Arrange the test setup as shown below diagram.



- Create Tunnels over 1G/10G links as described below:-
 - Tunnel between Stations
- Configure a FXS circuit between EUT's
- Connect a phone to Port1 of EUT1 and another phone to Port 1 of EUT2.
- Check that voice communication between each site is working.

Results

OEM-1	OEM-2	Pass	Fail
GE	Hitachi		
	Belden		
	Cisco		
	Nokia		
Hitachi	Belden		
	Cisco		
	Nokia		
Belden	Cisco		
	Nokia		
Cisco	Nokia		

12/09/2024

4.8 Testing of E1 for drop/Insert Functionality

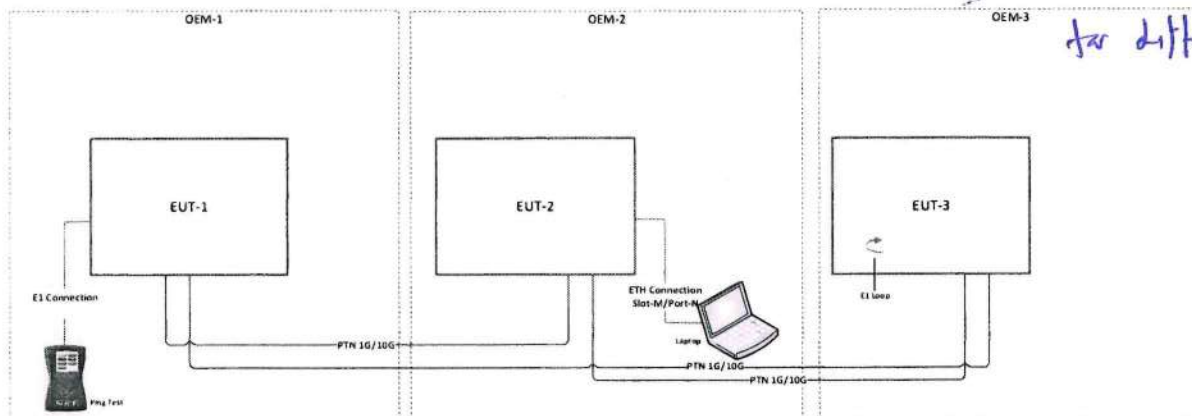
WORK IN PROGRESS

Purpose: Testing of E1 from dropped in Equipment

Test Setup: Arrange the test setup as shown below diagram.

WORKING WITH SAME OEM EQUIPMENT
Configuration need to be set-

for different make
OEM'S



- Create connections 1G/10G links as described below:-
 - Configure & map 01 E1 in EUT1 and Map this E-1 to EUT1 Mpls Port going to EUT2.
 - By-pass this E1 from EUT2 to MPLS port of EUT2 and further drop this E1 at EUT3
- Provide E1 loop in EUT3
- Run E1 BERT on E1 tester and check that no errors appearing on the tester.

Results

OEM-1	OEM-2	OEM-3	Pass	Fail
GE	Hitachi	Belden		
	Cisco	Nokia		
Hitachi	Belden	GE		
	Nokia	Cisco		
Belden	Cisco	Hitachi		

~~NOT TESTED~~

Tested in same make mpls-TP
OEM equipments.

2/3/2025

2/3/2025

CM (Power & ARIS)

Reg. 22/09/24

DD (PCD), (EA)

ABBSRPA

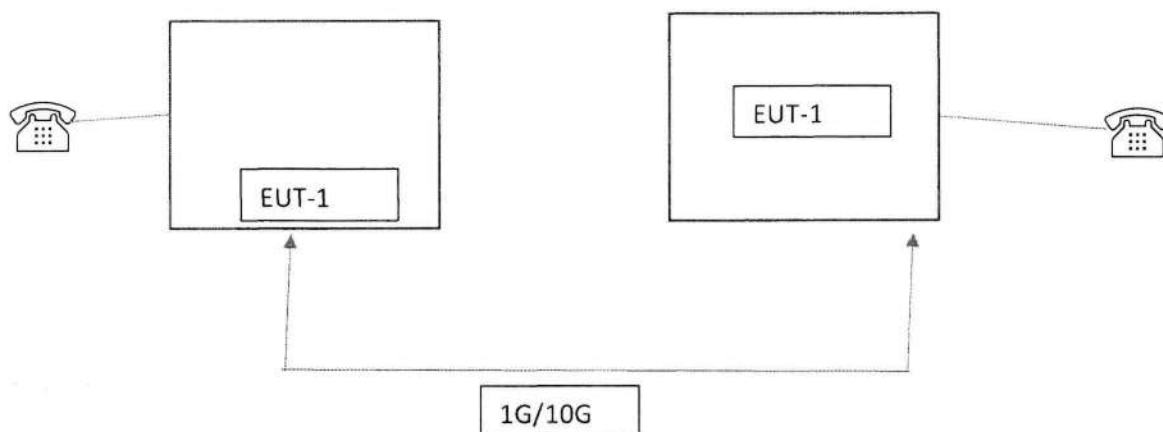
2/3/2025
12/09/24

Safety and for. Dots -
Hacker, com

4.9 Testing of VOIP channel

Purpose: Testing of VOIP functionality

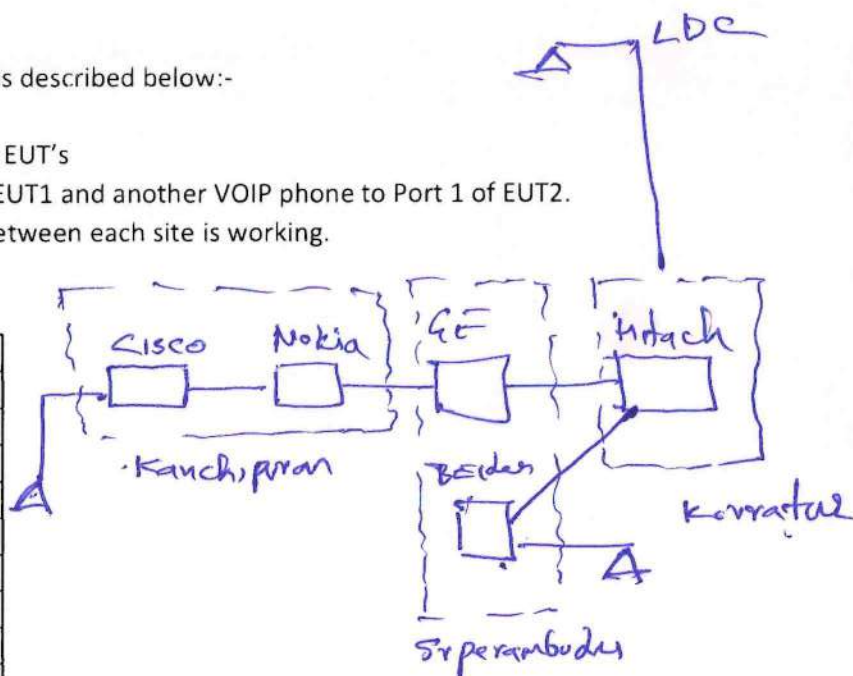
Test Setup: Arrange the test setup as shown below diagram.



- Create Tunnels over 1G/10G links as described below:-
 - Tunnel between Stations
- Configure a VOIP channel between EUT's
- Connect a VOIP phone to Port1 of EUT1 and another VOIP phone to Port 1 of EUT2.
- Check that voice communication between each site is working.

Results

OEM-1	OEM-2	Pass	Fail
GE	Hitachi	✓	
	Belden	✓	
	Cisco	✓	
	Nokia	✓	
Hitachi	Belden	✓	
	Cisco	✓	
	Nokia	✓	
Belden	Cisco	✓	
	Nokia	✓	
Cisco	Nokia	✓	



12/09/24
DGM(CTV)
Ravi Shakti

12/09/24
DD(PLD), LEA
Ah
(ABE, SRP)

12/09/24
Direct, con

12/09/24
Ch, Bannu