



भारत सरकार - रेल मंत्रालय
अनुसंधान अभिकल्प और मानक संगठन
लखनऊ - 226011
Tele: +91 - 522 - 2459886
Fax : +91 - 522 - 2462635

Government of India - Ministry of Railways
Research Designs & Standards Organisation
LUCKNOW - 226011
Email: aamir.siddiquiner@gov.in



No.: RDSO-TELE0LKO(TECH)/8/2020-Telecom Directorate/RDSO

Date: As signed

PCSTE
All Zonal Railways

Director General
IRISET/Secunderabad

**Sub. : Revision of Technical Advisory Note (TAN) for the item
“Implementation of IP-MPLS Technology for Unified
Communication Backbone on Indian Railways.**

Ref. : i) This office letter of even no. dated 31.01.2025 & 25.04.2025.
ii) Railway Board's letter no. 2020/Tele/9(2)/1 dated 04.01.2025
regarding 42nd TCSC Meeting.
iii) Railway Board's letter no. 2024/Tele/9(3)/1/3460739 dated
23.12.2024

The revision of RDSO Technical Advisory Note (TAN) for “Implementation of IP-MPLS Technology for Unified Communication Backbone on Indian Railway” has been finalized and revised Technical Advisory Note (TAN) No. STT/TAN/IP-MPLS/2020 Ver 3.0, is issued with the approval of competent authority w.e.f. 18.06.2025.

The revised TAN alongwith PoC Guidelines is available on RDSO Website (intranet) for further necessary action.

Digitally Signed by
Mohammad Aamir Siddiqui
Date: 18-06-2025 17:34:29
Reason: Approved

मो. आमिर सिद्दिकी | **Mohd. Aamir Siddiqui**
निदेशक / दूरसंचार-II | **Director / Telecom-II**
aamir.siddiquiner@gov.in
Mob.:9794863136

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
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संकेत एवं दूरसंचार निदेशालय
अनुसंधान, अभिकल्प एवं मानक संगठन, लखनऊ-226011
SIGNAL & TELECOM DIRECTORATE
Research, Design and Standards Organization, Lucknow-226011

**IMPLEMENTATION
OF
IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION
BACKBONE ON INDIAN RAILWAY**
Document No. STT/TAN/IP-MPLS/2020
Version 3.0

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
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Amendment History:

S. No.	Date of Amendment	Version	Reason for Amendment
1	16.12.2020	1.0	First issue. TAN was issued in reference to Railway Board Letter No. 2011/Tele/9(2)/1 Dated 25.02.2020. Approved by ED/Telecom at Note#13 dated in e-Office file No. RDSO-TELE0LKO(TECH)/8/2020-Telecom Directorate/RDSO dated 16.12.2020.
2	29.03.2023	2.0	TAN was revised in compliance of Railway Board's letter No. 2020/Tele/15(18)/4(3317053) dated 22.12.2022. Approved by PED/S&T at Note # 102 dated 29.03.2023 in e-Office file No. RDSO-TELE0LKO(TECH)/8/2020-Telecom Directorate/RDSO .
3.	18.06.2025	3.0	TAN was revised in compliance of Railway Board's letter No. 2024 /Tele/9(3)/1(3460739) dated 23.12.2024 & Minutes of 42 nd TCSC. Approved by PED/S&T at Note # 357 dated 18.06.2025 in e-Office file No. RDSO-TELE0LKO(TECH)/8/2020-Telecom Directorate/RDSO .

I. DOCUMENT CONTROL SHEET

Name	Organization	Function	Level
SSE/Telecom	RDSO	Assistant	Assist/Prepare
DD/Telecom	RDSO	Member	Assist/Prepare, Check
Dir/Telecom-II	RDSO	Member Secretary	Review, Issue
ED/Telecom-I	RDSO	Reviewing Authority	Review
PED/S&T	RDSO	Approving Authority	Approve

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

(Authority-Railway Board letter No.: 2011/Tele/9(2)/1 Dated 25.02.2020)

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY

- I. Based upon the committee reports and RDSO's comments and recommendations, Railway Board vide letter no. 2011/Tele/9(2)/1 dated 25.02.2020 as Telecom Circular no. 4/2020 has approved the following:
 - 1) Use of IP-MPLS technology/standards for telecommunication backbone for Indian Railways.
 - 2) All future works/replacement of SDH/PDH, including works where tender is yet to be floated shall be with IP-MPLS standards.
 - 3) All future exchange works/replacement shall be done with IP exchanges. All exchanges can be integrated into one at the Divisional level, where feasible, with provision of suitable bandwidth and ring connectivity/protection.
 - 4) Creation of Integrated Divisional, Zonal and National level Network Management System (NMS) and these will be operated as Network Operation Centers (NOC) with relevant alerts and associated escalations. It will include integration of all such NMSs for better monitoring & proper resource utilization.
 - 5) The telecom backbone of all future works/ replacement of Data networks such as PRS/UTS/FOIS/SCADA shall be with IP-MPLS equipment by providing separate VPN network, if required.
 - 6) To optimize the cost and improve availability, same network infrastructure may be shared for number of services with required security features and with ring/protection path and VPN network, if required.
 - 7) Normally the open source software and equipment to be used for ease in integration and to optimize cost. This also includes for NMS.
 - 8) Intensive training to staff on IP-MPLS technology shall be planned immediately by IRISSET and other Zonal Training centers. IRISSET will prepare the training contents including the video clips of various modules relevant to understand various aspects of IP-MPLS.
 - 9) Zonal Railways may take 2 additional fibers (other than present 4 fibers), if required, from RailTel and the proportionate equity will be taken back from the RailTel in the same proportion as per the Railway Board's letter.
 - 10) RDSO to issue a tentative scheme and functional requirements of the system including interfaces and Network Managements Systems. RDSO will issue specifications of the equipment, if required or may adopt the TEC specifications and accordingly refer them.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
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II. Further Action:

- 1) Accordingly, a Technical Advisory Note (TAN) was issued vide documents No. STT/TAN/IP-MPLS/2020 Ver. 1.0 dated 16.12.2020 based on comments of Zonal Railways and various stake holders.
- 2) POC (Proof of Concept) guidelines and Interoperability - Integration Testing with Railtel network based on existing TAN were issued to Zonal Railways vide letter No. STT/New Trans Tech/674.dated.28.11.2022 and 14.12.2022.
- 3) Further revision of the TAN is taken up based on feedback/suggestions received from Zonal Railways and various stake holders and directives from Railway Board and revised TAN, Version 2.0 along with PoC guidelines (Annexure-1) issued w.e.f. 29.03.2023.
- 4) Further revision of the TAN is taken up based on Railway Board accepted committee report on IP-MPLS planning for core network and specification of routers and recommendations of 42nd TCSC.

A. TENTATIVE IMPLEMENTATION SCHEME AND MIGRATION PLAN

A Division is the basic operational unit of the Railways and all the activities of all departments are initiated, implemented, coordinated and monitored and hence is the basic aggregation layer for the communication bandwidth. Most circuits originate from Divisional HQ and terminate at each of the stations in the Division, adjacent Divisional HQ, Zonal HQ and the internet gateway. Also in the event of any emergency or unusual, all activities are controlled and monitored from the Divisional HQ.

Considering the various services and applications used by the Division, it is desirable that servers for running the various services and applications relevant to the Division are located in the Divisional HQs in suitable Data Centres. This will also serve to address latency and response time issues besides optimizing bandwidth utilization.

The existing network carries crucial communication circuits that cover train operations and Railway working. Hence it is essential that a detailed migration plan is prepared and meticulously executed. Broad migration strategy is outlined below:

- 1) Create a Zonal NOC for provisional arrangement of NMS of the unified telecom network with its mask rights provided to Divisional Dashboard with client system for monitoring of different services at their level.
- 2) Standardize the MPLS equipment including the interfaces to be used for different categories of stations, Divisional and Zonal HQ locations including the IP numbering scheme (Uniform IP addressing scheme issued by RDSO vide letter No. STT/New Trans Tech/674 dated 27.07.2023 & 19.02.2025). Equipment with modular and hybrid interfaces are to be procured so that interfaces with legacy TDM equipment are replaced as and when needed.

- 3) The IP-MPLS routers shall be installed in existing OFC equipment rooms at all stations and should work efficiently in similar environmental conditions. These shall be called MPLS-PoPs (MPLS point of presence). In case of any feasibility issue, a separate hut/alternate room may be used. As per requirement, Rack mounted cooling system may be considered by Zonal Railways for IP-MPLS equipments.
- 4) A section wise map of available SDH networks is to be prepared specifically covering services being offered by the existing SDH network. Each of these services will be mapped to the MPLS network as an E1 circuit, MPLS VPN (L3/L2) and at MPLS boundary locations, STM-1 interface with adjacent SDH network depending upon the application.
- 5) The communication network shall consist of MPLS rings connected to every station in section terminating at a junction station. The station-to-station MPLS connectivity shall be on 10G optical interface. Suitable VPNs can be defined for segregation of the network.
- 6) The issue of fiber availability shall be dealt by Zonal Railways by implementing the network either through spare fibre or through existing fibre using WDM/DWDM multiplexing based on local condition.
- 7) **System Architecture:** Typical schematic diagram for implementation of IP-MPLS network showing required services at wayside station is given in fig.1 below. The scheme is for guideline and actual requirement may be decided by the user/purchaser.

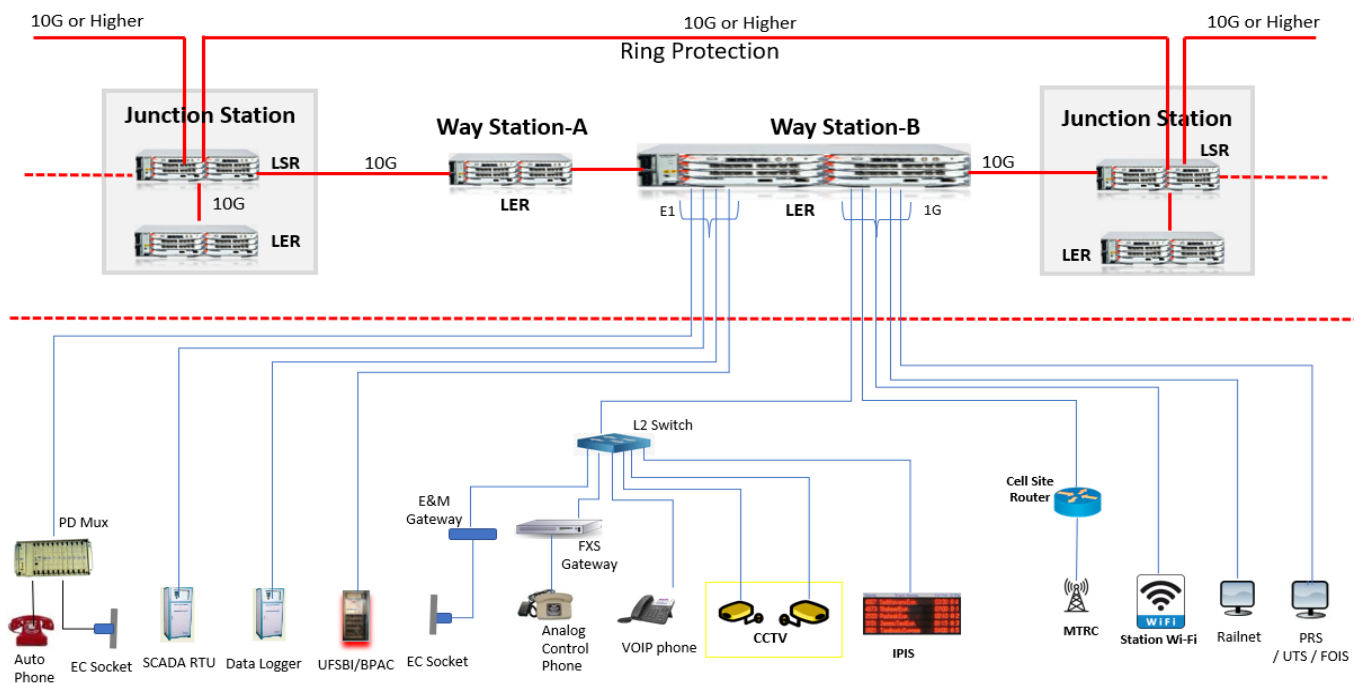


Fig. 1 Typical schematic diagram for implementation of IP-MPLS network

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

- 8) The Data networks for PRS, SCADA etc. which are still working on Statistical Mux and/or RS232 modems, will have to be migrated to full IP network and these circuits can be transferred to Ethernet interfaces right away so that their migration becomes simpler.
- 9) IP exchange installation will simplify extending Railway phones to stations. All future exchange replacement works shall include OFC and LAN cabling so as to cover the connectivity to all subordinate offices/depots etc.
- 10) At station where Railnet/Internet is being extended through Modem, the same can be migrated to Ethernet.
- 11) The IP-MPLS migration must be done control section wise.
- 12) Zonal MPLS network shall be connected with RCIL's/Other adjacent Zonal Railways/Other Service Provider's MPLS network using interface depending of traffic requirement at 2 or more locations in the Zone as per requirement.
- 13) Railways core MPLS network shall be used for inter-zonal transit traffic.
- 14) Each of the Division shall form an MPLS domain in itself and connect to RCIL/adjacent Division's MPLS network using Border Gateway Protocol. Border Gateway Protocol (BGP) is an Internet Engineering Task Force (IETF) standard, and the most scalable of all routing protocols. BGP is the routing protocol of the global Internet, as well as for Service Provider private networks.
- 15) A Uniform IP Addressing scheme has been issued by RDSO vide letter dated 27.07.2023 with further detailing issued vide letter dated 19.02.2025. Same shall be followed for the migration by all the Zonal Railways. All end equipments shall be planned on IPv6 and MPLS on IPv4/IPv6 till the finalisation of IPv6 scheme for MPLS.
- 16) At the junction/major stations or any other station as per user requirement, one LSR to be provided in addition to LER.
- 17) A high-capacity Core network will form the backbone of the Railway Network. It shall be interconnected with high-bandwidth fiber optic links in a mesh topology. High-end routers are required to aggregate data from various Divisions and provide high-speed connections to other zones via Divisions. Specification for Core routers is given in section 'F'.

B. Interfaces Configuration

- 1) The SDH equipment at all the wayside SDH equipment rooms and other Divisional and Zonal locations shall be replaced with IP-MPLS routers. These IP-MPLS routers shall be Label Edge Router (LER) with/without Label Switch Router (LSR) depending on fibre path terminations at that location.
- 2) LER shall have the provision of following interfaces or as per purchaser requirement:

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

- a) 4x10G (optical) interface equally distributed in minimum two cards, to connect to the adjacent stations.
 - b) 8x1GbE (optical) interface equally distributed in minimum two cards, to connect various networks at stations optically.
 - c) 4x1GbE (copper) to connect various networks at stations (**Optional**). This can be accommodated in 1G (Optical) Cards by addition of ports or may be provided as separate card.
 - d) 8xE1 (G.703) for working various TDM circuits of stations utilising PD Mux as well as directly (**Optional**).
 - e) 2xSTM1 (channelized, optical) ports (**Optional**).
3. LSR shall have the provision of following interfaces or as per purchaser requirement.
- a) 8x10G (optical) ports, equally distributed in minimum two cards.
 - b) Upgradable to 16 X 10 G (Optical) by way of adding/replacing the card.

Note: (i) Purchaser can decide the higher capacity interfaces (for example in case of LSR 25G/40G/50G etc.) or additional quantity of any interface (for example in case of LER 16x1GbE optical in place of 8x1GbE optical etc.) for both LER as well as LSR as per their requirement. Backplane capacity of Routers shall also be increased accordingly.

(ii) Interfaces mentioned as **optional** may be decided by Zonal Railways as per requirement.

(iii) Each type of Interfaces mentioned for LER and LSR shall be provided in separate modular cards.

C. Interoperability- Router Shall has IP-MPLS interoperability with routers of other multiple OEM's.

- 1) The interoperability of router with other OEM's routers and integration with Railtel IP-MPLS network by interconnecting with the existing infrastructure of Railtel shall be possible.
- 2) Revised PoC (Proof of Concept) guidelines including Interoperability - Integration Testing with Railtel network are enclosed as Annexure-I shall be applicable.

D. Functional and Technical requirements of Label Edge Router (LER):

1	General Specifications & Architecture
1.1	The LER shall be chassis based. Chassis shall fit into a standard sized 19 inch rack mounting.
1.2	Router shall work on -48VDC nominal power supply (with a voltage variation –40 V to –57 V DC). Router should have 1+1 redundant, field replaceable DC power supply units. In case of failure of one power supply unit/card, other power supply unit/card will take full load without any interruption of services.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

1.3	Router should be temperature hardened as it is normally placed at field locations without any air conditioning arrangement.
1.4	The router shall provide a non-blocked switching matrix-up to system capacity.
1.5	LER shall have the provision of interfaces as mentioned in para B. Optical interfaces shall be equipped with suitable optics as per purchaser requirement.
1.6	The router shall support following Timing ports– TOD in, TOD out, NTP, SYNC/BITS interface/similar timing protocol required for LTE network.
1.7	The router should have suitable onboard visual indication for various functionalities/failures.
1.8	Fan tray, controller cards, interface cards should be hot-swappable and Field Replaceable Unit (FRU).
1.9	Control plane should be redundant and should be able to take full load even with failure of one controller card.
1.10	The Router shall have provision for remote out-of-band management capability through Ethernet management port.
1.11	The Router shall have console management access, with the provision for console port.
1.12	Router shall have IP-MPLS interoperability with routers of other multiple OEMs and with RailTel IP-MPLS network by interconnecting with the existing infrastructure of Railtel.
2	Protocols supported
2.1	Router should support unicast IPv4 & IPv6 routing protocols (BGP, OSPF, IS-IS, OSPF v3, Segment Routing or similar protocol and Circuit emulation).
2.2	Router shall support LDP, MPLS-TE with FRR for sub 50 msec protection.
2.3	Router must support Traffic Engineering for node and link protection.
2.4	Router shall support aggregation of links. Minimum 8 links should be supported as part of single aggregation on a network side.
2.5	Router shall support performance monitoring for Layer-2 and layer-3 services (Y.1731, TWAMP).
2.6	Router shall support IPV4 and IPV6, MLD, and ECMP.
2.7	Router shall support 6PE and 6VPE mode for IPV6 transport over IPV4.
2.8	Router shall support BFD with interval of 10ms or less
2.9	Router should support RFC 3107 of Carrying Label Information in BGP-4.
2.10	Router should support Point to Point and Point to Multipoint LSP for Unicast and Multicast traffic.
2.11	Router shall support layer3 and layer2 MPLS VPN, VPLS and EVPN.
2.12	The router shall support Internet Group Management Protocol (IGMP) v2 and v3.
2.13	The router shall support Protocol Independent Multicast – PIM-SM and SSM.
2.14	The switch/router shall support Multicast troubleshooting tools (like Mtrace and mfib ping or equivalent).

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

2.15	IEEE 1588v2 Precision Timing Protocol (PTP) and Synchronous Ethernet support for network synchronization.
3	Quality Of Service
3.1	The switch/router shall provide per-service, per-forwarding class queuing and shaping features.
3.2	The router shall provide following QoS features: classification and hierarchical scheduling, WRR, strict priority (SP), profiled scheduling and multi-tier policing and shaping.
3.3	Router shall support 3 level HQOS on all kind of Ethernet interface with minimum 6K hardware queues.
3.4	Similar QOS shall be supported for all types of Ethernet interface including Bundled interfaces.
3.5	IP Application Mapping. The list of IP match criteria should include Source IP address and mask, Destination IP address and mask, IP protocol, UDP source port, TCP source port, UDP destination port, TCP destination port.
3.6	VLAN CoS preservation: the IEEE 802.1p priority bits.
3.7	VLAN CoS differentiation: appropriate service differentiation must be applied according to the 802.1p bits. This will require the mapping of the 802.1p bits to DSCP values and EXP-bits in the MPLS header when the service is offered over a (partially) MPLS-enabled network.
3.8	End-to-end delay budgets are strictly-enforced to support critical applications SCADA, VOICE, Video.
4	Security
4.1	Security forms an integral part of a network design to protect both the end-customers and the network infrastructure. The solution that the vendor proposes shall have the necessary provisions to implement the necessary security measures.
4.2	Support Access Control List to filter traffic based on Source & Destination IP Subnet, Source & Destination Port, Protocol Type (IP, UDP, TCP, ICMP etc) and Port Range etc. Should Support SNMP V3.
4.3	Black hole filtering or equivalent: dropping of traffic destined for a specific prefix at wire speed.
4.4	Ingress and egress packet filtering based on L2-L4 criteria at wire speed. The possibility to log the actions on individual filter rules shall be supported.
4.5	Protection of local services (http, small udp/tcp servers, DHCP, telnet, ssh) based on L2-L4 criteria.
4.6	AAA support – Accounting, Authorization and Authentication of users and commands. Support of local authentication, TACACS+ and Radius.
4.7	Authentication of routing protocol updates: IS-IS, OSPF, BGP.
4.8	SSH support.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR
UNIFIED COMMUNICATION BACKBONE ON INDIAN
RAILWAY

Document No. STT/TAN/IP-MPLS/2020
Version 3.0

5	Performance
5.1	Router shall support non-blocking throughput of 60 Gbps full duplex or higher
5.2	Router shall support 10K IPv4 & 5K Pv6 routes..
5.3	Router shall support 100 multicast groups.
5.4	Minimum 100 MPLS layer-3 VPN's.
5.5	Minimum 64 MPLS VPLS.
5.6	Minimum 500 MPLS Layer-2 PWs.
5.7	Router shall support min 64 BFD sessions.

E. Functional and Technical requirements of Label Switch Router (LSR):

1	General Specifications & Architecture
1.1	The LSR shall be chassis based. Chassis shall fit into a standard sized 19 inch rack mounting.
1.2	Router shall work on -48VDC nominal power supply (with a voltage variation –40 V to –57 V DC). Router should have 1+1 redundant, field replaceable DC power supply units. In case of failure of one power supply unit/card, other power supply unit/card will take full load without any interruption of services.
1.3	Router should be temperature hardened as it is placed at field locations
1.4	The router shall provide a non-blocked switching matrix upto system capacity.
1.5	Switching and packet routing (L2 and L3) shall be wire speed on all interfaces. Performance shall not be decreased at maximum traffic load.
1.6	LSR shall have the provision of interfaces as mentioned in para B. Optical interfaces shall be equipped with suitable optics as per purchaser requirement.
1.7	The router shall support following Timing ports– TOD in, TOD out, NTP, SYNC/BITS interface /similar timing protocol required for LTE network
1.8	The router should have suitable on-board visual indication for various functionalities/failures.
1.9	Fan tray, controller cards, interface cards should be hot-swappable and Field Replaceable Unit (FRU).
1.10	Control plane should be redundant and should be able to take full load even with failure of one controller card.
1.11	The Router shall have provision for remote out-of-band management capability through Ethernet management port.
1.12	The Router shall have console management access, with the provision for console port.
1.13	Router shall have IP-MPLS interoperability with routers of other multiple OEMs and with RailTel IP-MPLS network by interconnecting with the existing infrastructure of Railtel.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

2	Protocols supported
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2.2	Router shall support LDP, MPLS-TE with FRR for sub 50 msec protection.
2.3	Router must support Traffic Engineering for node and link protection.
2.4	Router shall support aggregation of links. Minimum 8 links should be supported as part of single aggregation on a network side.
2.5	Router shall support performance monitoring for Layer-2 and layer-3 services (Y.1731, TWAMP).
2.6	Router shall support IPV4 and IPV6, MLD, and ECMP.
2.7	Router shall support 6PE and 6VPE mode for IPV6 transport over IPV4.
2.8	Router shall support BFD with interval of 10ms or less.
2.9	Router should support RFC 3107 of Carrying Label Information in BGP-4.
2.10	Router should support Point to Point and Point to Multipoint LSP for Unicast and Multicast traffic.
2.11	Router shall support layer3 and layer2 MPLS VPN, VPLS and EVPN.
2.12	The router shall support Internet Group Management Protocol (IGMP) v2 and v3.
2.13	The router shall support Protocol Independent Multicast – PIM-SM and SSM.
2.14	The switch/router shall support Multicast troubleshooting tools (like Mtrace and mfib ping or equivalent).
2.15	IEEE 1588v2 Precision Timing Protocol (PTP) and Synchronous Ethernet support for network synchronization.
3	Quality Of Service
3.1	The switch/router shall provide per-service, per-forwarding class queuing and shaping features.
3.2	The router shall provide following QoS features: classification and hierarchical scheduling, WRR, strict priority (SP), profiled scheduling and multi-tier policing and shaping.
3.3	Router shall support 3 level HQOS on all kind of Ethernet interface with minimum 6K hardware queues.
3.4	Similar QOS shall be supported for all type of interface including Bundled interfaces.
3.5	IP Application Mapping. The list of IP match criteria should include Source IP address and mask, Destination IP address and mask, IP protocol, UDP source port, TCP source port, UDP destination port, TCP destination port.
3.6	VLAN CoS preservation: the IEEE 802.1p priority bits.
3.7	VLAN CoS differentiation: appropriate service differentiation must be applied according to the 802.1p bits. This will require the mapping of the 802.1p bits to DSCP values and EXP-bits in the MPLS header when the service is offered over a (partially) MPLS-enabled network.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR
UNIFIED COMMUNICATION BACKBONE ON INDIAN
RAILWAY

Document No. STT/TAN/IP-MPLS/2020
Version 3.0

3.8	End-to-end delay budgets are a strictly-enforced to support critical applications SCADA, VOICE, Video.
4	Security
4.1	Security forms an integral part of a network design to protect both the end-customers and the network infrastructure. The solution that vendor proposes shall have the necessary provisions to implement the necessary security measures.
4.2	Support Access Control List to filter traffic based on Source & Destination IP Subnet, Source & Destination Port, Protocol Type (IP, UDP, TCP, ICMP etc) and Port Range etc. Should Support SNMP V3.
4.3	Black hole filtering or equivalent: dropping of traffic destined for a specific prefix at wire speed.
4.4	Ingress and egress packet filtering based on L2-L4 criteria at wire speed. The possibility to log the actions on individual filter rules shall be supported.
4.5	Protection of local services (http, small udp/tcp servers, dhcp, telnet, ssh) based on L2-L4 criteria.
4.6	AAA support – Accounting, Authorization and Authentication of users and commands. Support of local authentication, TACACS+ and Radius.
4.7	Authentication of routing protocol updates: IS-IS, OSPF, BGP.
4.8	SSH support.
5	Performance
5.1	Router shall support non-blocking throughput capacity of 200 Gbps full duplex or higher.
5.2	Router shall support 64k IPv4 & 16k IPv6 routes Multicast routes 1K
5.3	Router shall support 100 multicast groups.
5.4	Minimum 500 MPLS layer-3 VPN's.
5.5	Minimum 500 MPLS VPLS.
5.6	Minimum 500 MPLS Layer-2 PWs.
5.7	Router shall support min 64 BFD sessions.

F. Functional and Technical requirements of Core Routers

1	General Specifications & Architecture
1.1	Router shall be chassis based & shall have modular architecture for scalability. Chassis shall be 19" rack mountable type.
1.2	Router shall work on -48VDC nominal power supply (with a voltage variation –40 V to –57 V DC). Router shall have 1+1 redundant, field replaceable DC power supply units. In case of failure of one power supply unit/card, other power supply unit/card will take full load without any interruption of services.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

1.3	The Mission Critical IP-MPLS Network shall be based on highly resilient, multiservice technology to provide traffic engineered service assurance and bandwidth guaranteed behaviour for mission critical, delay sensitive and bandwidth intensive services & applications.
1.4	The network design shall cater for capability to engineer traffic links between nodes with user defined bandwidth guarantee and QoS profile. Allocation of user configurable queues shall be supported for differentiated treatment to traffic for speed and reliability. It shall be possible to re-route traffic from failed routes to protected routes with no impact on active sessions.
1.5	The modular operating system shall run all critical functions like various routing protocol, forwarding plane and management functions in separate memory protected modules. Failure of one module shall not impact operations of rest of the OS.
1.6	The router shall provide a non-blocked switching matrix upto system capacity.
1.7	Shall support online insertion and removal (OIR) of line cards that is non-disruptive in nature for fast reboot, minimum network downtime etc. Online insertion and removal of one-line card shall not lead to any packet loss for traffic flowing through other line cards for both unicast and multicast traffic.
1.8	Router shall support System & Event logging functions as well as forwarding of these logs onto a separate Server for log management. Event and system logging history functions shall be available. The Router shall generate system alarms on events. Facility to put selective logging of events onto a separate hardware for the analysis of log shall be available.
1.9	The Router shall support various software models/sensors for capturing different health parameters from the devices.
1.10	The router shall have suitable onboard visual indication for various functionalities/failures.
1.11	The Router shall have console management access, with the provision for remote out-of-band management capability.
1.12	Shall able to support multiple VPN's for different services with traffic engineering defined.
1.13	The routers shall support both L2 and L3 services on all interfaces.
1.14	The router shall have the ability to interact with open standard based tools.
1.15	All the routers, Routing EMS/SDN controller shall be capable for seamless integration and interworking. Routing EMS/SDN Controller or Manager or features required of SDN controller/manager can be of same or different OEMs, however it should support standard interfaces like NETCONF/YANG/BGP-LS/PCEP/RESTCONF etc. to interoperate with routers of multiple OEMs in the network.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
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	NMS must be capable to support/integrate/manage multi OEM devices (Routers and Switches).
1.16	Shall have provision for display of input and output error statistics on all interfaces.
1.17	Shall have provision for display of Input and Output data rate statistics on all interfaces.
1.18	After fulfilling minimum interface requirements, the Router shall have minimum of 2 interface slots vacant for future expansion.
1.19	Router shall support minimum non-blocking capacity of 4 Tbps full-duplex or higher at full services scales. It shall have support Minimum 400 Gbps full-duplex per slot capacity.
1.20	Shall have redundant controller and Switch fabric cards (1+1) for high availability. There shall not be any degradation of performance in case of failure of the redundant module.
1.21	Router shall have hot-swappable/ pluggable redundant (1+1) hot standby fans/fan units.
1.22	All line cards, Power Supply Cards, Fan Tray & Controller Cards shall be hot swappable and field replaceable unit (FRU) for high availability.
1.23	All interfaces on the routers shall provide wire-rate throughput.
1.24	The router shall support 10GE, 25GE, 40/50GE, 100GE, interface.
1.25	The router shall support multi-rate interfaces: 10/25GE, 40/50/100GE.
1.26	<p>The Core Router shall have the provision of following interfaces or as per purchaser requirement:</p> <ul style="list-style-type: none"> (i) 8 x 100GE interfaces equally distributed in minimum two-line cards with 100G with suitable optics. (ii) 8 x 40/50GE interfaces equally distributed in minimum two-line cards with 40/50GE with suitable Optics. (iii) 8x10/25GE interfaces, equally distributed in minimum two-line cards with suitable Optics. <p>Note:</p> <ul style="list-style-type: none"> (1) Purchaser can decide the type of interfaces, its capacity and quantity as per their requirement. (2) Each type of Interfaces mentioned above shall be provided in separate modular cards.
2.	Protocol Supported:
2.1	The network shall be implemented with standard based protocols as defined by IETF, IEEE, ITU-T, etc.
2.2	All the network equipment shall be IPv4 and IPv6 fully capable and shall fully support IPv4 and IPv6.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

2.3	Router shall support, Border Gateway Protocol, Intermediate System- to-Intermediate System [IS-IS], Open Shortest Path First [OSPF], Virtual Router Redundancy Protocol (VRRP) or equivalent, BGP Prefix Independent Convergence, Segment Routing and LDP.
2.4	Shall support link aggregation using LACP as per IEEE 802.3ad and MC-LAG or EVPN Multihoming.
2.5	Shall support MPLS Provider/Provider Edge functionality. MPLS VPN, MPLS mVPN (Multicast VPN), AS VPN, DiffServ Tunnel Modes, MPLS TE (Fast re-route), DiffServ- Aware TE, Inter-AS VPN, Resource Reservation Protocol (RSVP), VPLS, VPWS, Ethernet over MPLS, EVPN, Segment routing and Segment routing Traffic engineering.
2.6	The router shall support BGP link-state (BGP-LS).
2.7	The router shall support Netconf, YANG and other modern system management protocols.
2.8	It shall Support SNMP V3.
2.9	Router shall support performance monitoring for Layer-2 and layer-3 services (like Y.1731, TWAMP or others).
2.10	Router shall support layer-3 and layer-2 MPLS VPN, VPLS and EVPN.
2.11	Router shall support BFD with interval of 100 ms or better for routing engine based session and 10 ms or better and distributed sessions.
2.12	Router shall support Point to Point and Point to Multipoint LSP for Unicast and Multicast traffic.
2.13	The router shall support Internet Group Management Protocol (IGMP) v2 and v3.
2.14	The router shall support IEEE 1588v2 Precision Timing Protocol (PTP) and Synchronous Ethernet (SyncE) for network synchronization. The Router Shall support GNSS.
2.15	It shall support Multicast troubleshooting tools (like Mtrace and mfib ping or equivalent).
2.16	It shall support FRR & BFD.
2.17	The Router shall support Equal Cost Multi Path (ECMP) routing for load-balancing.
2.18	The router shall support Protocol Independent Multicast-PIM-SM & SSM.
3.0	Quality of Service
3.1	It shall provide per-service, per-forwarding class queuing and shaping features.
3.2	Ability to configure hierarchical queues in hardware for IP QoS at the egress to the edge.
3.3	Platform shall support Classification, hierarchical shaping, scheduling, and policing for the control upstream and downstream traffic.
3.4	Router shall have min 3 level of scheduling for HQOS, per VLAN QoS. Shall support at least 8 hardware queues to be available for each GE interface on the router.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

3.5	Shall support Traffic Classification using various parameters like source physical interfaces, source/destination IP subnet, protocol types (IP/TCP/UDP), source/destination ports, IP Precedence, 802.1p, MPLS EXP, DSCP.
3.6	Shall support Strict Priority Queuing or Low Latency Queuing to support real time application like Voice and Video with minimum delay and jitter.
3.7	Similar QOS shall be supported for all types of Ethernet interface including Bundled interfaces.
3.8	The list of IP match criteria should include Source IP address and mask, Destination IP address and mask, IP protocol, UDP source port, TCP source port, UDP destination port, TCP destination port.
3.9	The Router shall support VLAN CoS preservation. Shall support the IEEE 802.1p priority bits.
3.10	Appropriate service differentiation must be applied according to the 802.1p bits. This will require the mapping of the 802.1p bits to DSCP values and EXP-bits in the MPLS header when the service is offered over a (partially) MPLS-enabled network.
3.11	End-to-end delay budgets are strictly-enforced to support critical applications SCADA, VOICE, Video.
3.12	It shall support Priority queuing, Class based weighted fair queuing Congestion Management or equivalent.
3.13	Traffic Conditioning: Committed Access Rate/Rate limiting.
4.0	Security
4.1	Security forms an integral part of a network design to protect both the end-customers and the network infrastructure. The solution that vendor proposes shall have the necessary provisions to implement the necessary security measures.
4.2	Shall support Access Control List to filter traffic based on Source & Destination IP Subnet, Source & Destination Port, Protocol Type (IP, UDP, TCP, ICMP etc) and Port Range etc.
4.3	Shall support per-user Authentication, Authorization and Accounting through RADIUS or TACACS+.
4.4	Multiple privilege level authentications for console and telnet access through Local database or through an external AAA Server.
4.5	Support for monitoring of Traffic flows for Network planning and Security purposes.
4.6	High Availability features like node protection, path protection, link protection as per media availability.
4.7	Router shall have Debugging features to display and analyse various types of packets.
4.8	Ingress and egress packet filtering based on L2-L4 criteria at wire speed. The possibility to log the actions on individual filter rules shall be supported.
4.9	Authentication of routing protocol updates: IS-IS, OSPF, BGP.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

4.10	It shall support SSH (Secure Shell).
5.0	Performance
5.1	Router shall support minimum non-blocking capacity of 4 Tbps full-duplex or higher at full services scales.
5.2	The router shall have capability of minimum 2 Million IPv4, 500K IPv6 routes.
5.3	The router shall support minimum 128K MAC address.
5.4	Router shall support 16k multicast routes.
5.5	It shall support 2K Multicast group.
5.6	Router shall support minimum 8K MPLS PWE3.
5.7	Router shall support minimum 8K VPLS.
5.8	Router shall support minimum 1K MPLS L3 VPN.
5.9	The router shall support minimum 10K labels and 10 label stacks.
5.10	Shall support 64 ECMP (equal cost multipath).

G. Network monitoring and provisioning system at Division and Zonal HQ

As with any network, once deployed and running, we must continue to monitor and manage the network while supporting new service loads and demands. An advantage MPLS provides above and beyond IP is its capability to traffic engineer based upon utilization and application demands as the business evolves. With MPLS traffic engineering, we can adjust primary paths and alternate paths in the network for supporting traffic. Split traffic over multiple paths, and optimize network resources for the virtualized networks being supported. Upon occasion, as network traffic grows, it may be necessary to add transport capacity and upgrade router interfaces to support new services as well as to deploy new routers to extend the reach of the network.

i. Operations

After discovery of network devices (MPLS Routers) with help of standard protocols, start monitoring various assets for complete visibility and control over existing IT infrastructure with proactive network monitoring. The discovery process immediately provides details and health of nodes.

Proactively manage, monitor and control overall network health, availability and performance by collecting network information on various parameters such as temperature, power, packet loss, throughput, response time, utilization, error rates, downtime/uptime, etc., collected mostly using SNMP.

ii. Service Provisioning:

Provisioning and management require visibility and control. Management Information Bases (MIBs) are significant to provide standardized visibility into the network. MIBs are available for all protocols and applications developed by the IETF and are used to manage the network. Service provisioning will be done quicker whether the service provision required one location

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

or multiple locations. This will minimize the chance for errors, provide corrective actions and assist in detecting, troubleshooting, and resolving failures during the provisioning itself.

iii. **NMS & NOC Architecture**

a) **NMS**

Unified Network monitoring and provisioning system Hardware and Software will be deployed at Zonal HQ locations. Divisional HQ, and Sectional HQ will Manage the network of their own area through workstation terminal from the same NMS.

b) **Network Operations Center (NOC)**

NOC to be Centralized to manage the whole Indian Railway Network.

It shall be manned round the clock on 24X7 basis.

The NOC is the heart of the network management strategy. This NOC is responsible for monitoring, managing, and maintaining all Railway communication networks—IP/MPLS, MTRC, OFC, CCTV, VoIP etc. from a single location. Three Tiered structure for NOC of IR is proposed, it includes:

- **Central NOC:** Manages the overall architecture and handles inter-zonal connectivity issues and major incidents. It shall be located strategically in DC-DR configuration.
- **Zonal NOCs:** The Zonal NOCs are higher-level operational canter responsible for overseeing and coordinating the network's performance across their respective zones. Each zone comprises several Divisions, and the Zonal NOC plays a critical role in supervising the Divisional NOCs while ensuring alignment with broader network policies and goals.
- **Divisional Dashboard:** Handle day-to-day local network management, fault resolution and incident response within the Division.
 1. **Zonal NOC capabilities:** Zonal NOC shall have following minimum capabilities for management of IP-MPLS network however detail responsibilities of Zonal NOC shall be decided by the Zonal Railway.
 - a. Single point of contact for the inter-divisional and inter-zonal issues.
 - b. Node installations, troubleshooting and updating for Zonal nodes.
 - c. Service provisioning for Zonal nodes.
 - d. Overall Performance reporting and improvement recommendations.
 - e. Patch management and whitelisting.
 - f. Backup management
 2. **Divisional Dashboard capabilities:** Divisional Dashboard shall have following minimum capabilities for management of IP-MPLS network however detail responsibilities of shall be decided by the Zonal Railway.
 - a. Troubleshooting and updating.
 - b. Field support.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
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- c. Node installations, troubleshooting and updating.
- d. Service provisioning.
- e. Performance reporting and improvement recommendations.
- f. Patch management and whitelisting.
- g. Backup management.

H. Functional and Technical requirements of eMS/Network monitoring and provisioning system at Division and Zonal HQ :

The role of element Management System (eMS) is to control and manage all aspects of the domain such as Fault, Configuration, Accounting, Performance and Security (FCAPS) as defined by ITU-T and to ensure maximum usage of the devices resources. The eMS performs the following functions:

(i) Service Delivery:

- a) Inventory Management Support: It involves maintaining a record of all the NE resources that are installed in the sub network to support the provisioning of services; it includes collection of locations, quantities of equipment, model numbers, serial numbers, versions, installation dates, etc. To ensure ongoing operational integrity, the eMS periodically resynchronizes its database with the NE using the auto discovery mechanism. It also auto discovers equipment-provisioning parameters that are stored in the eMS database for use in other service-provisioning, service-assurance operations.
- b) Configuration Management Support: It involves complete control of sub network resources, topologies, and redundancies and includes the installation and turn-up of new equipment resources; it may include the assignment of resources to trunk routes or service areas, the control of equipment, and network protection switching.
- c) Provisioning Support: It involves the creation of specific connections or the enabling of specific sub network features and the assignment of these to a specific subscriber for an extended period; the connections and features may take into account or be determined by a QoS level that is guaranteed to the subscriber.
- d) Service Usage Support: It involves the measurement of the usage of the sub network resources by the various subscribers; this is the basis for billing.

(ii) Service Assurance:

- a) Fault Management Support: It involves the monitoring of the network resources to detect malfunction, preempt failures, and detect faults. After faults are discovered, the user/operator can troubleshoot, repair, and restore the network as quickly as possible. Fault management ensures that service remains available.
- b) Performance Data Collection Support: It involves the periodic collection of quality metrics that characterize the performance of the network resources over service intervals. It also

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
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facilitates the visualization of trends that can indicate periodic or gradual degradation of physical resources.

- c) Resource Utilization data Collection Support: It involves the collection of data on the level of utilization of network resources assigned to subscribers. This data can be used to determine whether the service product is appropriately matched to the subscribers' usage characteristics. It can also be used to forecast demand and suggest service upgrades before QoS suffers.
- d) QoS Assurance Support: It involves ensuring that the quality metrics characterizing network performance remain within the agreed limits. It requires proactive monitoring of the network fault, performance, and utilization parameters to preempt any degradation in service quality.
- e) The eMS provides the North bound interface to integrate NMS.
- f) The System allows to assign following categories of users
 - a. Helpdesk User
 - b. Operation and Maintenance User
 - c. System Administrator
- g) The application provides the control of access right of users in respect of function menu and geographical area of interest.

Basic requirements of eMS/Network monitoring and provisioning system is given below. However detailed requirement of eMS/Network monitoring and provisioning system shall be in accordance with Part III (eMS/NMS requirement) of TEC GR 48050: 2024 or latest.

1	General Requirements
1.1	Support for multiple service types including VPLS, H-VPLS, VLL, RFC2547 VPNs and Internet Access.
1.2	Rapid service turn-up via end-to-end, point & click service provisioning.
1.3	Easy-to-use GUI-based user interface with pre-defined "service templates".
1.4	Full FCAPS support.
1.5	SNMP V3 support.
1.6	Remote Configuration back up shall be possible.
1.7	Remote software upgrades up shall be possible.
1.8	Automatic discovery of network elements.
2	Configuration Management
2.1	It is required to enable gross control of Network resources and topologies to the extent that each network device is configurable.
2.2	It shall be possible to generate a configuration file / template for a remote station from NMS and load the same onto the equipment so that installation of equipment at remote site does not require expert.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

2.3	The proposed management system shall offers 100% reliable mechanisms to create links (including, but not limited to, LLDP protocol, MAC learning mechanism, BGP/LDP/OSPF).
2.4	The proposed management system shall provide tools for point-and-click or templates (masks) for the creation of services between two or more items, and then applies the physical or logical ports (VLAN, IT, VC/VP) and QoS attributes.
3	Performance Management
3.1	The System shall provide end-to-end visibility of network operations in order to have SLA monitoring as well as Performance Reporting.
4	Topology Management
4.1	The System shall provide physical map views of network equipment, Links and MPLS tunnels.
4.2	The System shall provide end to end service topology views with association of services with logical and physical entities.
5	Inventory Management
5.1	The Inventory Management system should manage and track the end-to-end physical information.
6	High Availability
6.1	Support high availability by utilising geographical redundancy of platforms.
6.2	Redundancy shall be automatic. In the event of a failure the management system should revert to the standby system without the need for user intervention.
6.3	In the event of a failure of the active management system, client platforms should automatically connect to the standby system without the need for user intervention.
6.4	Active and standby system to be provisioned at 2 different locations/stations for main and standby NMS. One NMS should be supplied as active system in main location/station and another as standby system in physically separated another location/station.
7	Network Management Security
7.1	The proposed management system must have user account access control.
7.2	The proposed management system must integrate with existing RADIUS/TACACS+ AAA systems.
7.3	The proposed management system must have ability to log all user access and user actions.
7.4	The proposed management system should use standard non-proprietary protocol such as Netconf / SNMP / SSH etc. to access the device under monitoring.
8	Alarm Management
8.1	The proposed management system shall support real time alarm display on the GUI.
8.2	The proposed management system shall support color coding active alarms to identify major and minor.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

8.3	The proposed management system shall support easy alarm filtering based on a number of options such as, but not limited to, severity.
8.4	The proposed management system shall support alarm correlation, whereby lower level alarms are correlated to the top-level most significant alarm.
8.5	The proposed management system shall support the escalation and de-escalation of alarm severity based on threshold crossing settings.
8.6	The proposed management system shall allow operators to acknowledge, clear, append free text notes to individual alarms.
8.7	The proposed management system shall allow individual alarms to be filtered/ignored.
8.8	The proposed management system shall allow default severity settings to be changed.
8.9	The proposed management system shall support an historical alarm database of all alarms that have been cleared / deleted. The size of this database must be configurable.
9	North Bound Interface
9.1	The proposed management system shall support a northbound interface (NBI) for interfacing to OSS using XML/SOAP/ RESTCONF/ Rest API/CORBA or equivalent / similar standard interfaces

I. PC Workstation

1. The PC Workstation shall have the following minimum specifications:

S. No.	Parameter	:	Specification
i.	Processor	:	Intel Core i5 or equivalent AMD processor
ii.	No. of Cores	:	6 Core or higher
iii.	Frequency	:	1.8 GHz or higher
iv.	Memory	:	32 GB or higher
v.	Operating System	:	Open-source Operation System like Linux-based distributions like Ubuntu and Fedora, as well as BSD based system like FreeBSD and OpenBSD
vi.	LAN/ Ethernet	:	10/100/1000 base T, Onboard/ on slot Gigabit Ethernet (RJ45), IPv6 compliant.
vii.	Hard Disk Drive	:	2 x 500GB SSD
viii.	USB Ports	:	USB 3.0 min. 2 Nos.
ix	USB/ PS/2 mouse and keyboard	:	USB wireless keyboard and mouse
x	Monitor	:	24-inch LED Color Monitor

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
---	--

J 1. Environmental Conditions:

The equipment (LER & LSR) shall be designed to comply with environmental conditions as per SD-QM-333 in category B2, issued by TEC, Department of Telecommunication, Gol (or Equivalent IS/IEC/EN). Details of the tests to be conducted are as below;

1.1 Climatic Test

The recommended sequence for climatic testing shall consist of the following tests as applicable in the order given below;

- 1.1.1 Cold (Low Temperature)
- 1.1.2 Dry Heat (High Temperature)
- 1.1.3 Damp Heat cyclic (Tropical exposure)
- 1.1.4 Rapid Temperature Cyclic
- 1.1.5 Damp Heat Steady State

1.2 Vibration**1.3 Bump/Roadability Test**

1.4 In addition to above, following specific test as per environmental conditions may be specified by the purchaser:

- 1.4.1 **Corrosion Test:** The test shall be necessary where equipment is to operate in salt laden atmosphere (sea cost areas, saline soil and islands)
- 1.4.2 **Dust Test:** The test shall be necessary only when equipment is exposed to desert environment

2. Safety: As per IS 13252-1 or IEC: 60950-1 or IEC 62368-1.

3. EMI/EMC:

S. No.	Parameter	Standard Name
1.	Conducted And Radiated Emission - Class B	EMI EMC Standard CISPR 22/32 EN55022/32. Annex-B
2.	Immunity to AC Voltage Dips and Short Interruptions	EMI EMC Standard EN/IEC: 61000-4-11. Annex-B
3.	Immunity to DC Voltage Dips and Short Interruptions	EN/IEC: 61000-4-29. Annex-B
4.	Immunity to Electrostatic Discharge	EMI EMC Standard EN/IEC: 61000-4-2. Annex-B
5.	Immunity to Fast Transients (Burst)	EMI EMC Standard EN/IEC: 61000-4-4. Annex-B
6.	Immunity to Radiated RF	EMI EMC Standard EN/IEC: 61000-4-3. Annex-B
7.	Immunity to RF Field Induced Conducted Disturbance	EMI EMC Standard EN/IEC: 61000-4-6. Annex-B

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
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8.	Immunity to Surges	EMI EMC Standard EN/IEC:61000-4-5. Annex-B
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Note: For details of **Annex-B**, refer Document No.: TEC/SD/DD/TCP-222/2.11/September 2022 of TEC or latest.

4. MTCTE Certification:

Vendor shall have integrated MTCTE certification for the product as per relevant TEC ER & ITSAR (Indian Telecom Security Assurance Requirements).

5. Trusted Telecom Portal (TTP) Clearance:

IPMPLS Router shall be cleared through the Trusted Telecom Portal (TTP) of National Security Council Secretariat (NSCS).

K. TRAINING:

1. Onsite training shall be provided to the Railway officials as nominated by purchaser. The training shall include Network configuration of the system through use of various modules, integration of hardware with software and complete operation of the system.
2. Two Sets of training manual hard copies & soft copies containing details of technical specifications, installation and commissioning, troubleshooting & maintenance schedule etc. shall be supplied along with the equipment.

IMPLEMENTATION OF IP-MPLS TECHNOLOGY FOR UNIFIED COMMUNICATION BACKBONE ON INDIAN RAILWAY	Document No. STT/TAN/IP-MPLS/2020 Version 3.0
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L. GUIDELINES FOR TENDERING AUTHORITY

The tendering authority shall specify the following parameters:

S.N.	Clause Number	Item to be specified by tendering authority
1.	D 5.1	Non-blocking throughput capacity of the LER. (As per clause, default is 60 Gbps full duplex or higher)
2.	E 5.1	Non-blocking throughput capacity of the LSR. (As per clause, default is 200 Gbps full duplex or higher)
3.	B	Type & Quantity of each Type of Interface for LER & LSR.
4.	D.1.5	Various types of Optics for LER. As per clause, suitable Optics shall be specified as per requirements)
5.	E.1.6	Various types of Optics for LSR. (As per clause, suitable Optics shall be specified as per requirements)
6.	F 1.26	Type & Quantity of each Type of Interface for Core Routers.
7.	F 1.26	Various types of Optics for Core Router. (As per clause, suitable Optics shall be specified as per requirements)
8.	F 1.19 & F 5.1	Non-blocking throughput capacity of the Core Router. (As per clause, default is 4 Tbps full duplex or higher)

POC Guidelines
for
Implementation of IP-MPLS Technology for Unified Communication Backbone on Indian Railway

SIGNAL AND TELECOM DIRECTORATE
RESEARCH, DESIGNS & STANDARDS ORGANISATION
MINISTRY OF RAILWAYS
MANAK NAGAR
LUCKNOW – 226 011

Test Definitions			
Sl.No	Test Case ID	Test Case	Description
1.	Ser_01	Service Requirement	System (LER, LSR, NMS and application softwares etc.) shall be configured as per field requirements including components to be used for Railway Services intended to Run on the System.
2.	Gen_02	General requirement	General requirement of LER and LSR
3.	FRS_ 03	Functional and Technical requirements of Label Edge Router (LER)	Functionality of LER along with the integrated components for all the services used by Railways.
4.	FRS_ 04	Functional and Technical requirements of Label Switching Router (LSR)	Functionality of LSR along with the integrated components for all the services used by Railways.
5.	Per_05	Performance of LER/LSR	Performance of LER/LSR as per TAN.
6.	INT_06	Interoperability	Integration Of Divisional IP-MPLS Network With Railtel Network

1. Service Requirement:

- 1.1 **System Architecture:** Typical schematic diagram is given in fig.1 below. However, actual architecture shall be as per purchaser requirements.

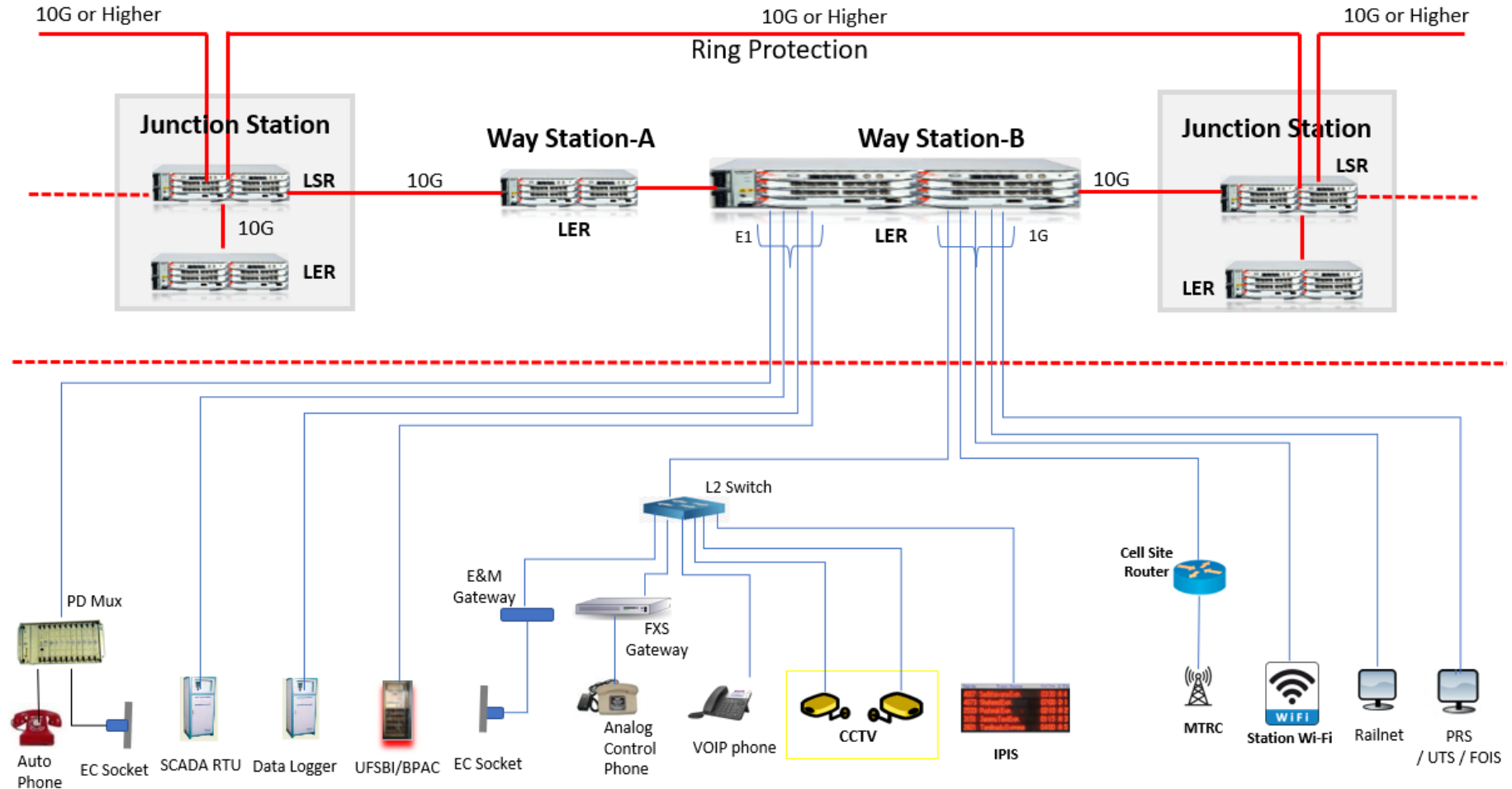


Fig. 1: Typical schematic diagram for implementation of IP-MPLS network

- 1.2 **Services Proposed to be used:** Typically, following services are being used over IR. However, any additional services shall be connected & tested as per purchaser requirements.

Ser_01: Service Requirement Test Cases			
S.No.	Services	Test Scenario/Procedure	Expected result
1.	VoIP Based TCCS	Connect with Railway network through required port of LER	Successful communication shall be established between controller and way station.
2.	Railnet		Demonstrate the availability of Railnet.
3.	PRS/UTS/FOIS		Demonstrate the availability of PRS/UTS/FOIS connection.
4.	CCTV		Demonstrate the CCTV connectivity.
5.	Station Wi-Fi		Demonstrate the availability Wi-Fi network at Station.
6.	IP Based IPIS		Demonstrate the availability of IP Based IPIS connectivity.
7.	PDMux		Demonstrate the typical services running through PDMux.
8.	STM-1		Demonstrate the typical services running through STM1.
9.	SCADA		Demonstrate the availability of SCADA network.
10.	Data Logger		Demonstrate the availability of Data Logger connectivity.
11.	UFSBI		Demonstrate the availability of UFSBI connectivity.
12.	BPAC		Demonstrate the availability of BPAC connectivity.
13.	Any Other Services	As per purchaser requirements.	

2.0	Gen_02: General requirement of LER and LSR		
S. No.	Test Scenario	Input Specification	Expected Output/Values
2.1	Design	The LER and LSR shall be chassis based. Chassis shall fit into a standard sized 19 inch rack mounting.	Verify the LER and LSR shall be chassis based. Chassis shall fit into a standard sized 19 inch rack mounting.
2.2	Manufacturing details	Details of card configuration of LER and LSR Routers	Verify the following details in LER and LSR: (i) Make (ii) Model Number (iii) Chassis serial number (iv) Chassis Size (v) No. of Slots in chassis with details for which slots are used. (vi) Details i.e. Make, Model, Version, Serial Number etc. of all type cards i.e. Power Supply, Controller, Fan and Interface cards etc. (vii) Number of spare slots (if any).

3.0 FRS_03: Functional and Technical Requirements of LER test cases			
S.No.	Test Scenario	Input Specification	Expected Output/Values
3.1	Power Supply	Router shall work on -48VDC nominal power supply (with a voltage variation –40 V to –57 V DC). Router should have 1+1 redundant, field replaceable DC power supply units. In case of failure of one power supply unit/card, other power supply unit/card will take full load without any interruption of services.	Demonstrate the Router shall work on -48VDC nominal power supply (with a voltage variation – 40 V to –57 V DC). Router should have 1+1 redundant, field replaceable DC power supply units. In case of failure of one power supply unit/card, other power supply unit/card will take full load without any interruption of services.
3.2	Port Configuration	<p>LER shall have the provision of following interfaces:</p> <ul style="list-style-type: none"> a) 4x10G (optical) interface equally distributed in minimum two cards to connect to the adjacent stations. b) 8x1GbE (optical) interface equally distributed in minimum two cards, to connect various networks at stations optically. c) 4x1GbE (copper) to connect various networks at stations This can be accommodated in 1G (Optical) Cards by addition of ports or may be provided as separate card. d) 8xE1 (G.703) for working various TDM circuits of stations utilizing PD Mux as well as directly. e) 2xSTM1 (channelized, optical) ports. 	<p>Physically verify the individual cards available and to ensure that LER can support multiple cards.</p> <ul style="list-style-type: none"> a) 4x10G (optical) interface equally distributed in minimum two cards, to connect to the adjacent stations. b) 8x1GbE (optical) interface equally distributed in minimum two cards, to connect various networks at stations optically. c) 4x1GbE (copper) to connect various networks at stations. This can be accommodated in 1G (Optical) Cards by addition of ports or may be provided as separate card. d) 8xE1 (G.703) for working various TDM circuits of stations utilizing PD Mux as well as directly. e) 2xSTM1 (channelized, optical) ports.
		Each type of Interfaces mentioned for LER and LSR shall be provided in separate modular cards.	Verify that each type of Interfaces mentioned for LER and LSR shall be provided in separate modular cards.
3.3	Alarm	The router should have suitable onboard visual indication for various functionalities/failures.	Demonstrate the provision and functionality of alarm option as onboard visual indication for

3.0	FRS_03: Functional and Technical Requirements of LER test cases		
S.No.	Test Scenario	Input Specification	Expected Output/Values
			various functionalities/failures available in the Router.
3.4	Hot Swappable	Fan Tray, Controller cards, interface card should be hot - swappable and field replaceable unit (FRU)	Demonstrate the hot - swappable and field replaceable unit (FRU) feature for Fan Tray, Controller cards, interface card.
3.5	Redundancy	Control plane should be redundant and should be able to take full load even with failure of one controller card.	Demonstrate the redundant feature of control plane. It shall able to take full load even with failure of one controller card.
3.6	Out of band Management port	The Router shall have provision for remote out-of-band management capability through Ethernet management port.	Demonstrate the availability and functionality of out of band Management port through Ethernet management port.
3.7	Console Port	The Router shall have console management access, with the provision for console port.	Demonstrate the availability and functionality of Console port.

Note: All the cards i.e. Power supply card, controller card, interface cards shall fit directly into the individual slots in the chassis to ensure redundancy and avoid single point of failure.

4.0 FRS_04: Functional and Technical Requirements of LSR test cases			
S.No.	Test Scenario	Input Specification	Expected Output/Values
4.1	Power Supply	Router shall work on -48VDC nominal power supply (with a voltage variation –40 V to –57 V DC). Router should have 1+1 redundant, field replaceable DC power supply units. In case of failure of one power supply unit/card, other power supply unit/card will take full load without any interruption of services.	Demonstrate the Router shall work on -48VDC nominal power supply (with a voltage variation –40 V to –57 V DC). Router should have 1+1 redundant, field replaceable DC power supply units. In case of failure of one power supply unit/card, other power supply unit/card will take full load without any interruption of services.
4.2	Port Configuration	The LSR should be equipped with 8x10G (optical) ports, equally distributed in minimum two cards. Upgrade the router to 16 X 10 G (Optical) by way of adding/replacing the card.	Physically verify the individual cards available and to ensure that LSR can support multiple cards. 1. The Router shall be equipped with 8 x 10G optical ports. 2. The ports equally distributed in minimum two cards. 3. Upgrade the router to 16 X 10 G (Optical) by way of adding/replacing the card.
4.3	Alarm	The router should have suitable onboard visual indication for various functionalities/failures.	Demonstrate the provision and functionality of alarm option as onboard visual indication for various functionalities/failures available in the Router.
4.4	Hot - swappable	Fan Tray, Controller cards, interface card should be hot - swappable and field replaceable unit FRU	Demonstrate the hot - swappable and field replaceable unit (FRU) feature for Fan Tray, controller cards, interface card.
4.5	Control plane redundancy	Control plane should be redundant and should be able to take full load even with failure of one controller card	Demonstrate the redundant feature of control plane. It shall able to take full load even with failure of one controller card.
4.6	Out of band Management port	The Router shall have provision for remote out-of-band management capability through Ethernet management port.	Demonstrate the out of band Management port with its functionality through Ethernet management port.
4.7	Console port	The Router shall have console management access, with the provision for console port.	Demonstrate availability and functionality of Console Port.

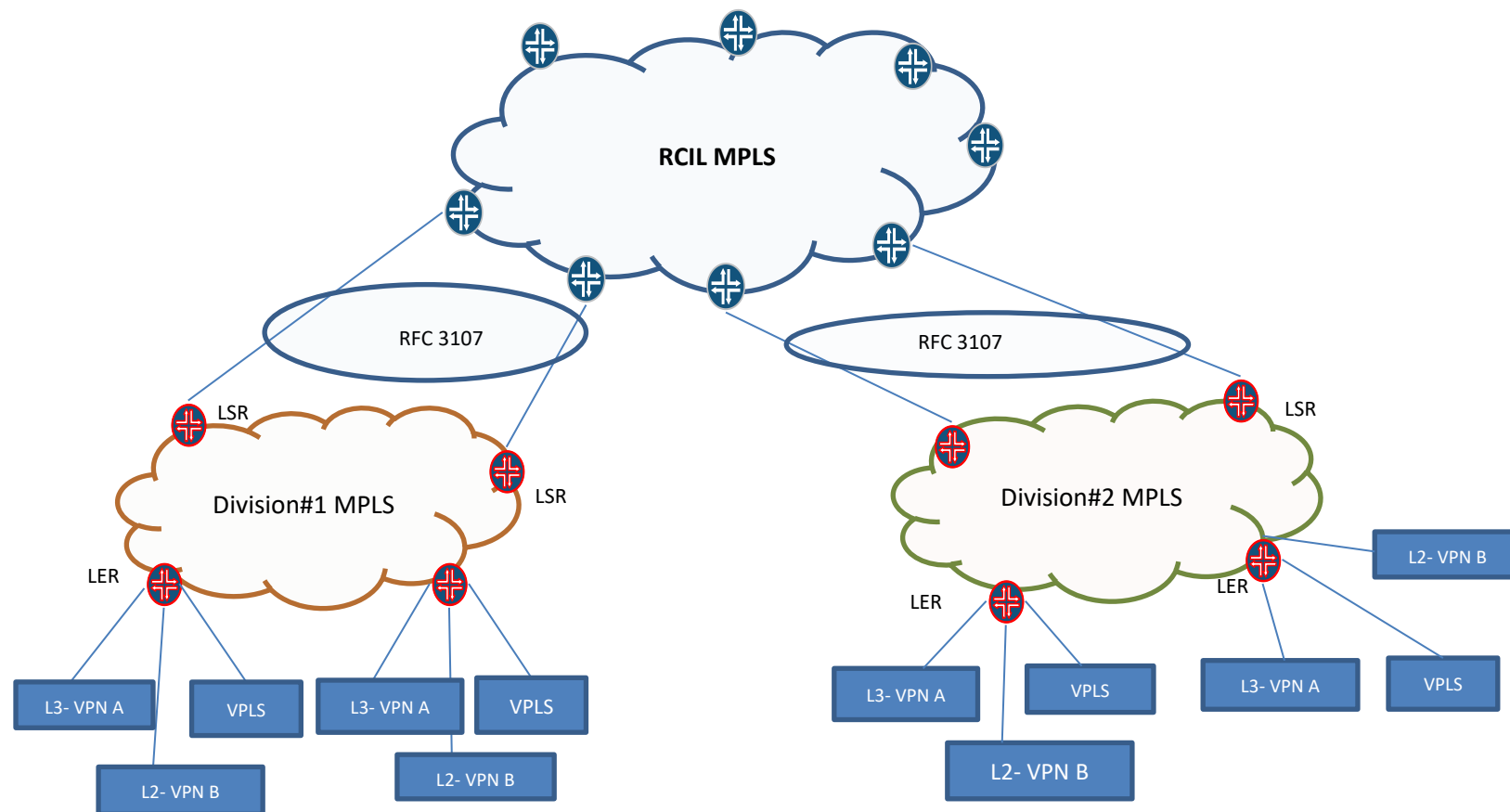
Note: All the cards i.e. Power supply card, controller card, interface cards shall fit directly into the individual slots in the chassis to ensure redundancy and avoid single point of failure.

5.0	Per_05: Performance LER/LSR test cases		
S. No.	Test Scenario	Input Specification	Expected Output/Values
5.1	Non-blocking throughput	Router shall support non-blocking throughput of 60 Gbps full duplex for LER and or higher & 200Gbps switching speed Full duplex for LSR or as specified by the user	1. Support of non-blocking throughput of 60 Gbps full duplex for LER shall be demonstrated. 2. Support of non-blocking throughput of 200 Gbps switching speed Full duplex for LSR shall be demonstrated.
5.2	No. of Routes	Router shall support 10K IPv4 & 5K Pv6 routes (LER) & Shall support 64K IPV4 & 16K IPV6 Routes (LSR)	1. LER support for 10K IPv4 & 5K Pv6 routes to be demonstrated. 2. LSR support for 64K IPV4 & 16K IPV6 Routes to be demonstrated.
5.3	Multicast groups	Router shall support 100 multicast groups	LER & LSR support 100 multicast group shall be demonstrated.
5.4	Layer 3 VPN	Minimum 100 MPLS layer-3 VPN's (LER) & 500 MPLS layer - 3 VPN's (LSR)	1. Minimum 100 MPLS layer-3 VPN's configuration for LER shall be demonstrated. 2. Minimum 500 MPLS layer - 3 VPN's for LSR shall be demonstrated.
5.5	VPLS	Minimum 64 MPLS VPLS (LER) & 500 MPLS VPLS (LSR)	1. LER is configurable Minimum 64 MPLS VPLS shall be demonstrated. 2. LSR is configurable minimum 500 MPLS VPLS shall be demonstrated.
5.6	PW's	Minimum 500 MPLS Layer-2 PWs	1. LER is configurable Minimum 500 Layer-2 PWs shall be demonstrated. 2. LSR is configurable minimum 500 Layer-2 PWs shall be demonstrated.
5.7	BFD Session's	Router shall support min 64 BFD sessions.	Router support for min 64 BFD sessions shall be demonstrated.

Note: The above performance parameters shall be demonstrated during the PoC and Test report and Certificates shall also be submitted from the Govt. Lab/ NABL accredited Lab.

INT_06: INTEGRATION OF DIVISIONAL IPMPLS NETWORK WITH RAILTEL NETWORK

6.1: Typical Schematic Overall Integration Scheme



6.2 Integration Design

1. The integration of the IP/MPLS network of the division will be done using MPLS VPN CSC¹.
2. Each Division will have its own MPLS domain with unique BGP AS numbers.
3. The IP/MPLS network of the division will be interconnected with RCIL IPMPLS PoP at two or more locations.
BGP-LU session will be required at junction location (LSR) between Division and RCIL for exchanging labelled infrastructure routes among divisions.
4. The division will be able to create, extend and delete services on their own without any intervention from RCIL with this integration scheme.

6.3 Key Functionality to be tested for Integration

1. The CSC configuration should be completed between RCIL-LER and DIV-LSR router. It should be ensured that proper route exchange happens using BGP.
2. L3VPN, L2VPN, CES services feature testing within Division. These services shall be configured between two divisional setup and services to be configured and should work without any additional configuration from RailTel.
3. End-to-end QoS starting from Div-1 to RCIL and finally to Div-2 to be implemented and tested for ensuring proper marking, classification, and scheduling of respective service type(s).
4. LAG, Load-balancing, redundancy between Div(s) and RCIL at NNI to be checked as the MPLS network of divisions will be connected to MPLS network of RailTel at two or more locations.
5. Latency measurement to be tested end-to-end (Div-1 to Div-2 over RCIL backbone) using Y.1731 and RFC 2544.
6. Verify Division 2 LER and LSR infra loopback labelled IP Prefixes are learnt via RCIL IPMPLS network over BGP and can be resolved in Division 1 LER routers via BGP over LDP.
7. Check if the BFD of fast failure detection works on BGP link established between the network of RCIL and Division.

¹ Carrier Support Carrier

6.4 INT_06: Integration with Railtel Network Test cases			
S.No.	Details	Observation	OK / Not OK
6.4.1	<ul style="list-style-type: none"> BGP over LDP, BGP in each Railway Division, Labeled E-BGP Session between LSR and RCIL PE. 		
6.4.2	<ul style="list-style-type: none"> Layer2 VPN, Layer3 VPN, Circuit-Emulation Service between Division-1 and Division-2 		
6.4.3	<ul style="list-style-type: none"> Link Aggregation Group (LAG) & Load Balancing 		
6.4.4	<ul style="list-style-type: none"> BFD for BGP session between LSR and RCIL PE 		
6.4.5	<ul style="list-style-type: none"> Performance Monitoring for Layer-2 and layer-3 services 		
6.4.6	<ul style="list-style-type: none"> End to end Quality of Service between Division-1, RCIL, and Division-2. 		
