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No.: RDSO-TELE0LKO(TECH)/8/2020-Telecom Directorate/RDSO **Date:** 29.03.2023

1.	**All PCSTE of Zonal Railways**.
2.	**PCSTE, Metro Railway**, 23-A, Jawaharlal Nehru Road, Kolkata – 700071.
3.	**PCSTE, CORE**, Nawab Yusuf Ali Road, Civil Lines, Prayagraj – 211001.
4.	**Director General, IRISET**, Tarnaka Road, Lallaguda (P.O.), Secunderabad – 500017.
5.	**MD, RailTel Corporation of India Ltd.**, 10th Floor, Bank of Baroda Building, Parliament Street, New Delhi – 110001.
6.	**ED/TD,** Railway Board, New Delhi-110001.
7.	**All Field unit/QA/S&T/RDSO.**

Sub.: Revision of Technical Advisory Note (TAN) for "Implementation of IP-MPLS Technology for Unified Communication Backbone on Indian Railway".

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 2.0, is issued with the approval of competent authority w.e.f. 29.03.2023.

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

Digitally Signed by Dinesh Verma
Date: 29-03-2023 16:40:24
Reason: Approved

(Dinesh Verma)
Executive Director/Telecom-I
For Director General/S&T/RDSO

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संकेत एवं दूरसंचार निदेशालय

अनुसंधान, अभिकल्प एवं मानक संगठन, लखनऊ-२२६०११

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 2.0

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 Railway Board 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 .

I. **DOCUMENT CONTROL SHEET**

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

(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 IRISET and other Zonal Training centers. IRISET 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.

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 alongwith PoC guidelines issued w.e.f. 29.03.2023.

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 Centers. 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 Divisional and Zonal NOC for NMS of the unified telecom network and make it operational.

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. 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).

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) **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.

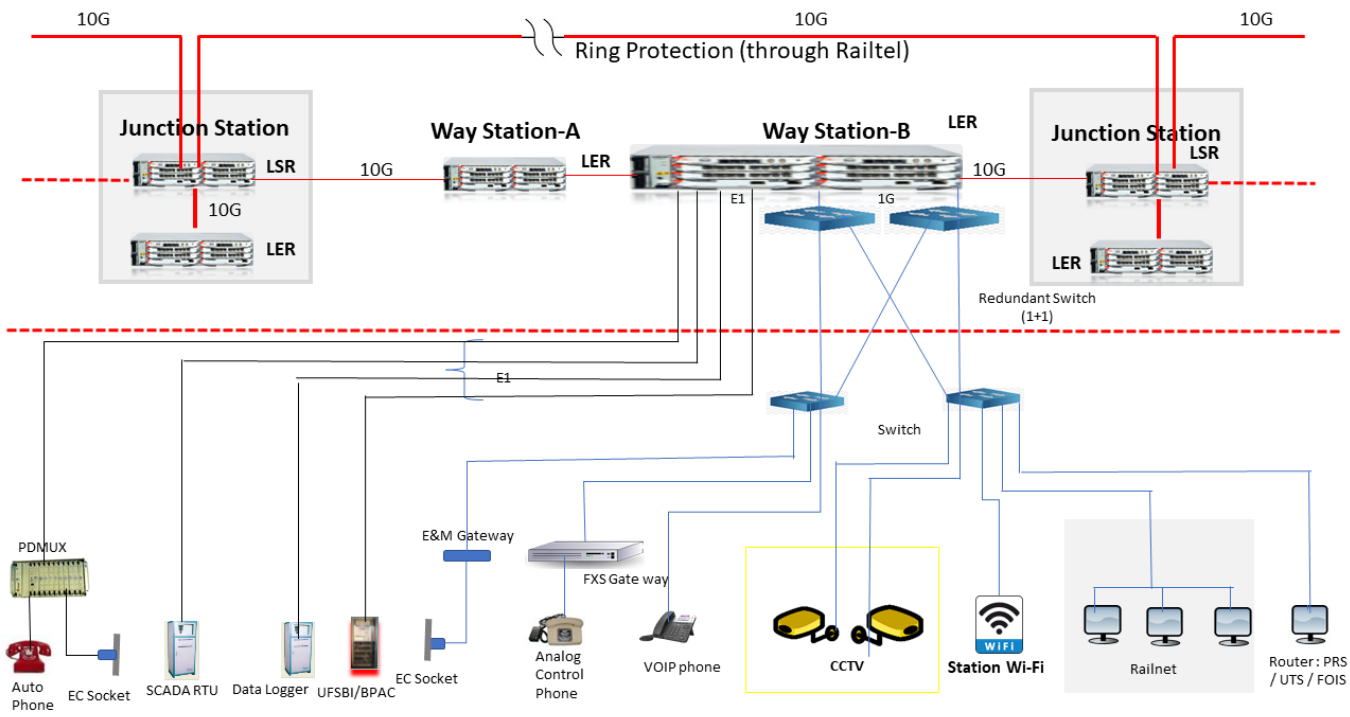

Fig. 1 Typical schematic diagram for implementation of IP-MPLS network

Note: E1 interface shown in the LER is optional.

7) 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.

8) 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.

9) At station where Railnet/Internet is being extended through Modem, the same can be migrated to Ethernet.

10) The IP-MPLS migration must be done control section wise. Section control of unimportant branch lines should be migrated first to train telecom personnel of division on IP-MPLS and LAN working. Their experience can be used to successfully migrate other section controls.

11) STM-1 transport must be used to connect the adjacent section that has SDH equipment.

12) Divisional MPLS network shall be connected with RCIL's MPLS network using 1G / 10G interface at 3-4 locations in the division.

13) The divisional MPLS network should normally not be used for transit traffic. RCIL's MPLS network shall be used for this purpose.

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) Since the total migration will take considerable time, the existing IP addressing planning under the control of Rly Bd will require to be modified on case to case basis as to integrate various services or applications and also to operate multiple VPNs so that, during the migration exercise there are no situations like IP clash etc. This exercise shall be done by the S&T Dept. of individual Rly units in coordination with Telecom Dte of Rly Bd.

16) An all India IP plan for the loopback IPs and interface IPs will have to be planned and followed for the migration. This IP plan must be in consonance with RCIL's MPLS network so that in future if IP level connectivity is required to be done with RCIL, it becomes smooth.

17) At the junction stations one LSR to be provided in addition to LER.

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 provide the following minimum interfaces or as per purchaser requirement:
   a) 4x10G (optical) distributed in minimum two cards, minimum 2X10G in each card, to connect to the adjacent stations.

b) 4x1GbE (copper) to connect various networks at stations (**Optional**).
c) 8x1GbE (optical) distributed in minimum two cards, minimum 4X1GbE in each card, to connect various networks at stations optically.
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) The LSR should be equipped with minimum 8x10G (optical) ports distributed in minimum two cards, minimum 4X10G in each card, or as per purchaser requirements. It should be possible to upgrade the router to 16 X 10 G (Optical) by way of adding/replacing the card.

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	Chassis shall fit into a standard sized 19 inch rack mounting.
1.2	Router shall work on -48VDC nominal power supply. 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.
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-upto system capacity.
1.5	LER shall provide the following minimum interfaces or as per purchaser requirement: (i) 4x10G (optical) ports distributed in minimum two cards, minimum 2X10G in each card, to connect to the adjacent stations. (ii) 4x1GbE (copper) ports to connect various networks at stations (**optional**). (iii) 8x1GbE (optical) ports distributed in minimum two cards,

	minimum 4X1GbE in each card, to connect various networks at stations optically. (iv) 8xE1 (G.703) for working various TDM circuits of stations utilising PD Mux as well as directly (**optional**). (v) 2xSTM1 (channelized, optical) ports (**optional**). All the optical interfaces shall be equipped with suitable optics to work on two single mode fibres upto 40km
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, IGMP, MLD, and PIM-SM & SSM, 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) v1, 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.
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 SNMPv1/v2/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 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	Chassis shall fit into a standard sized 19 inch rack mounting.
1.2	Router shall work on -48VDC nominal power supply. 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.
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	The Router should be equipped with minimum 8x10G (optical) ports, distributed in minimum two cards, minimum 4X10G in each card or as per purchaser requirements. It should be possible to upgrade the router to 16 X 10 G (Optical) by way of adding/replacing the card. All the optical interfaces shall be equipped with suitable optics to work on two single mode fibres upto 40km.
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 a 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.
2	**Protocols supported**
2.1	Router should support unicast IPv4/IPv6 routing protocols (BGP, OSPF, IS-IS, OSPF v3, Segment Routing or similar protocol).
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, IGMP, MLD, and PIM-SM & SSM, 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) v1, 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 troubleshooting mechanism..
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.
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 SNMPv1/v2/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. 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 requires 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 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

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

b) NOC

Divisional and Zonal HQ NOC to be manned round the clock on 24X7 basis.

1. **Zone HQ NOC capabilities:**
   - **a.** Single point of contact for the interdivisional and interzonal 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. **DIV HQ NOC capabilities:**
   - **a.** Troubleshooting and updating.
   - **b.** Field support.
   - **c.** Node installations, troubleshooting and updating.
   - **d.** Service provisioning.
   - **e.** Performance reporting and improvement recommendations.
   - **f.** Patch management and whitelisting.
   - **g.** Backup management.

G. Functional and Technical requirements of eMS/Network monitoring and provisioning system at division and zonal HQ :

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 V1, 2 and 3 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.
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. Each NMS should have minimum 2 X 10 Core CPU and 256GB DRAM and 4x1TB Hard disk or higher.
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-proprietry 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.
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

H. PC Workstation

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

S. No.	Parameter	:	Specification
i.	Processor	:	Latest generation x86 Intel Processor/ AMD Processor
ii.	No. of Cores	:	4 Core or higher
iii	Frequency	:	1.6 GHz or higher
iv.	Memory	:	32 GB or higher
v.	Operating System	:	Windows Operating System or Linux, latest
vi.	LAN/ Ethernet	:	10/100/1000 base T, Onboard/ on slot Gigabit Ethernet (RJ45), IPv6 compliant.
vii.	Hard Disk Drive	:	2 x 500GB SATA III 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

I. 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, GoI (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
8.	Immunity to Surges	EMI EMC Standard EN/IEC:61000-4-5.Annex-B

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 MTCTE certification for the product as per relevant TEC ER.

J. 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.

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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
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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.	FRS_ 02	Functional and Technical requirements of Label Edge Router (LER)	Functionality of LER along with the integrated components for all the services used by Railways.
3.	FRS_ 03	Functional and Technical requirements of Label Switching Router (LSR)	Functionality of LSR along with the integrated components for all the services used by Railways.
4.	Per_04	Performance of LER/LSR	Performance of LER/LSR as per TAN.
5.	INT_05	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.

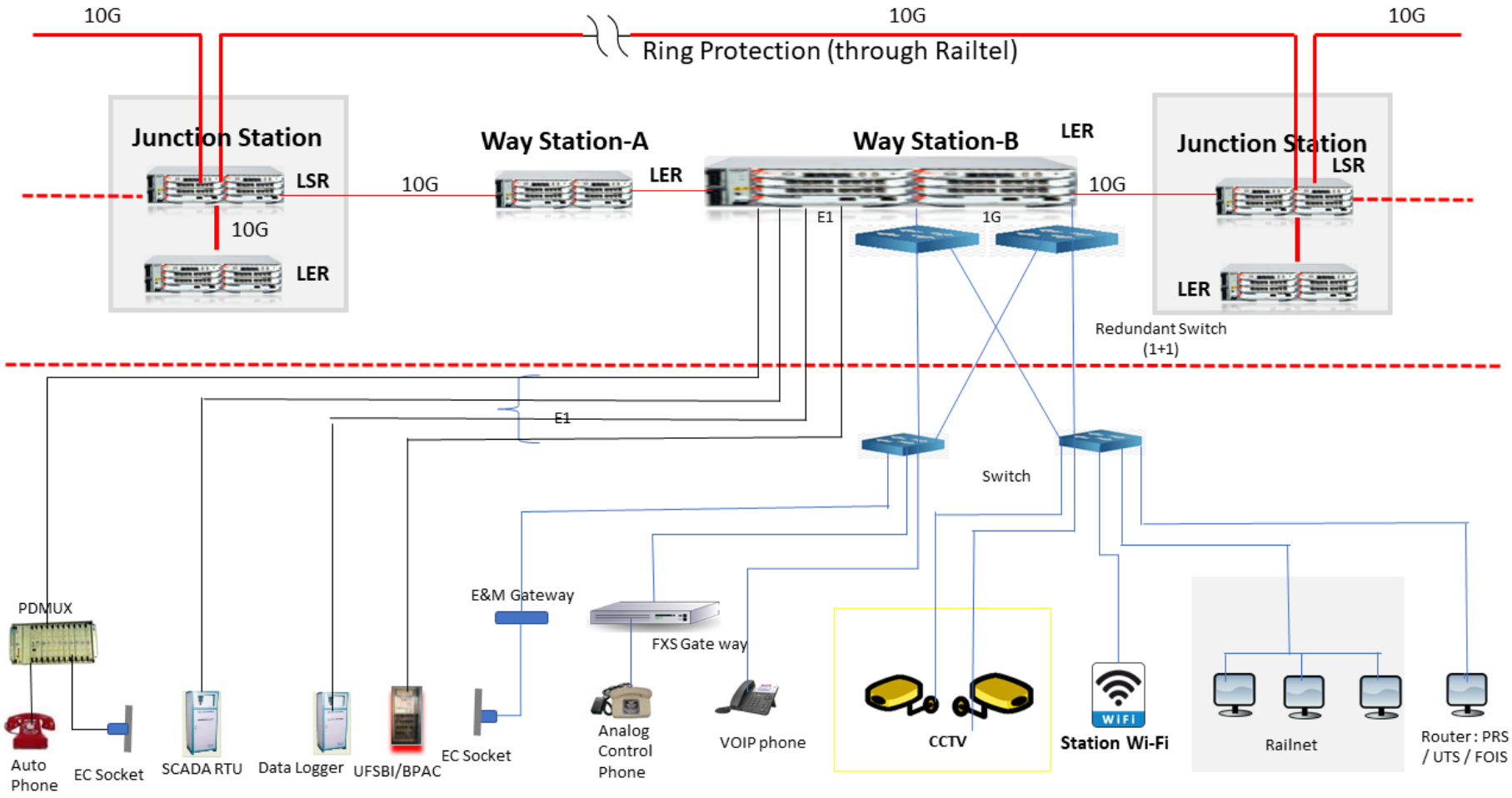


Fig. 1: Typical schematic diagram for implementation of IP-MPLS network

Note: E1 interface shown in the LER is optional.

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.	Electronic Interlocking		Demonstrate the availability of EI connectivity.
14.	Any Other Services	As per purchaser requirements.	

2.0	**FRS_02: Functional and Technical Requirements of LER test cases**		
S.No.	**Test Scenario**	**Input Specification**	**Expected Output/Values**
2.1	Power Supply	Router shall work on -48VDC nominal power supply. 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.	Demonstrate the Router shall work on -48VDC nominal power supply. 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.
2.2	Port Configuration	LER shall provide the following minimum interfaces or as per purchaser requirement: a) 4x10G (optical) distributed in minimum two cards, minimum 2X10G in each card to connect to the adjacent stations. b) 4x1GbE (copper) to connect various networks at stations (Optional). c) 8x1GbE (optical) distributed in minimum two cards, minimum 4X1GbE in each card to connect various networks at stations optically. d) 8xE1 (G.703) for working various TDM circuits of stations utilizing PD Mux as well as directly (optional). e) 2xSTM1 (channelized, optical) ports (optional).	Physically verify the individual cards available and to ensure that LER can support multiple cards. a) 4x10G (optical) distributed in minimum two cards, minimum 2X10G in each card to connect to the adjacent stations. b) 4x1GbE (copper) to connect various networks at stations (**Optiona**l). c) 8x1GbE (optical) distributed in minimum two cards, minimum 4X1GbE in each card to connect various networks at stations optically. d) 8xE1 (G.703) for working various TDM circuits of stations utilizing PD Mux as well as directly (**optional**). e) 2xSTM1 (channelized, optical) ports (**optional**).
2.3	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.
2.4	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.
2.5	Redundancy	Control plane should be redundant and should be able to take full load even with failure of one	Demonstrate the redundant feature of control plane.

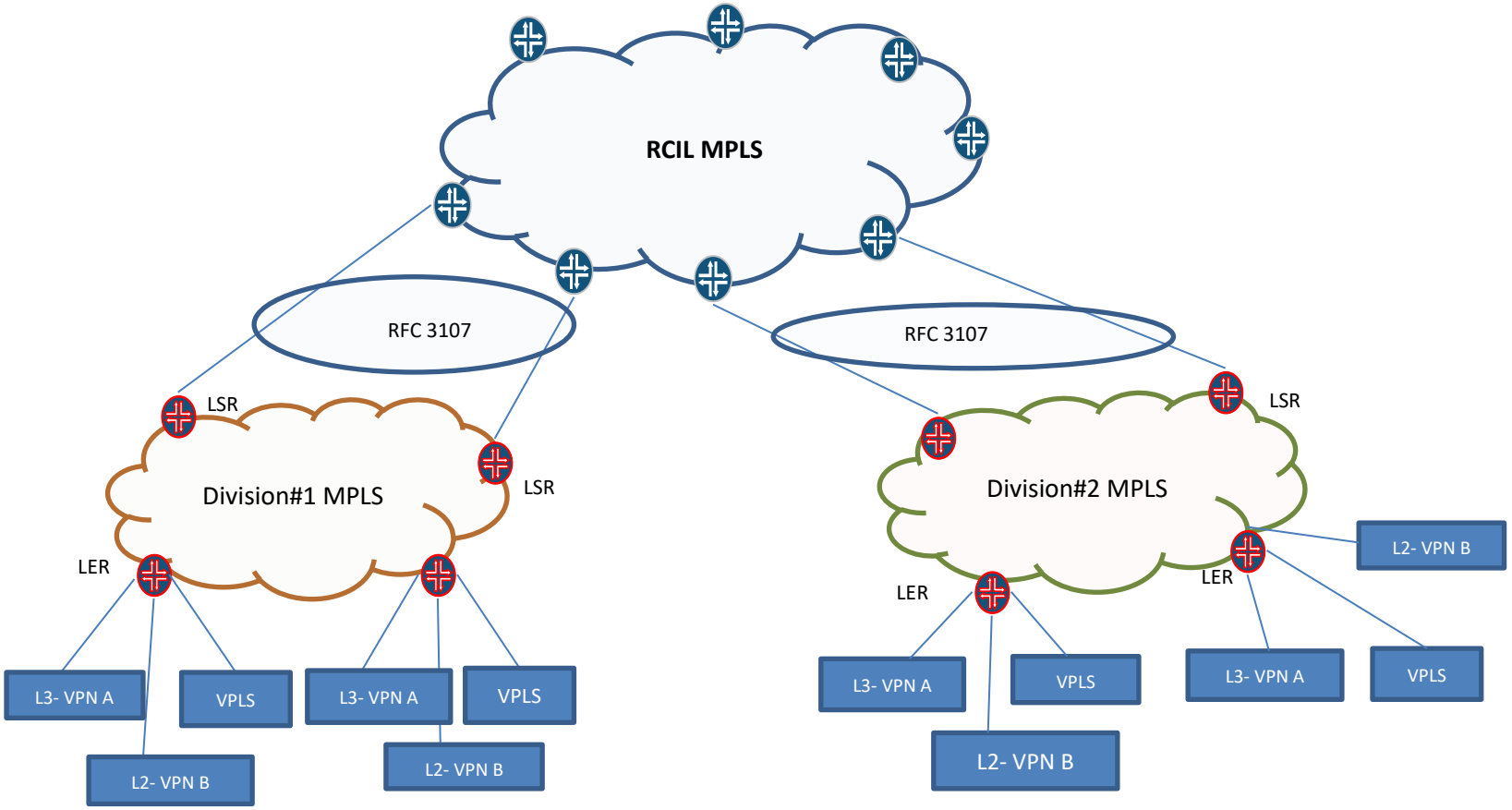
2.0	**FRS_02: Functional and Technical Requirements of LER test cases**		
S.No.	**Test Scenario**	**Input Specification**	**Expected Output/Values**
		controller card.	It shall able to take full load even with failure of one controller card.
2.6	Out of band Management port	The Router shall have provision 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.
2.7	Console Port	The Router shall have console management access, with the provision for console port.	Demonstrate the availability and functionality of Console port.

3.0	FRS_03: Functional and Technical Requirements of LSR test cases		
S.No.	**Test Scenario**	**Input Specification**	**Expected Output/Values**
3.1	Power Supply	Router shall work on -48VDC nominal power supply. 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.	Demonstrate the Router shall work on -48VDC nominal power supply. 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.
3.2	Port Configuration	The LSR should be equipped with minimum 8x10G (optical) ports distributed in minimum two cards, minimum 4X10G in each card or as per purchaser requirements. It should be possible to upgrade the router to 16 X 10 G (Optical) by way of adding/replacing the card.	1. Physically verify the individual cards available and to ensure that LSR can support multiple cards. 2. The Router shall be equipped with 8 x 10G optical ports. 3. The ports distributed in minimum two cards minimum 4X10G in each card. 4. It should be possible to upgrade the router to 16 X 10 G (Optical) by way of adding/replacing the card.
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 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	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.
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 out of band Management port with its functionality through Ethernet management port.
3.7	Console port	The Router shall have console management access, with the provision for console port.	Demonstrate availability and functionality of Console Port.

4.0	Per_04: Performance LER/LSR test cases		
S.No.	**Test Scenario**	**Input Specification**	**Expected Output/Values**
4.1	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. (Alternatively, Certificate from accredited Lab of internationally/National repute shall be acceptable). 2. Support of non-blocking throughput of 200 Gbps switching speed Full duplex for LSR shall be demonstrated. (Alternatively, Certificate from accredited Lab of internationally/National repute shall be acceptable).
4.2	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.
4.3	Multicast groups	Router shall support 100 multicast groups	LER & LSR support 100 multicast group shall be demonstrated.
4.4	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.
4.5	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.
4.6	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.
4.7	BFD Session’s	Router shall support min 64 BFD sessions.	Router support for min 64 BFD sessions shall be demonstrated.

INT_05: INTEGRATION OF DIVISIONAL IPMPLS NETWORK WITH RAILTEL NETWORK

5.1: Typical Schematic Overall Integration Scheme



5.2 Integration Design

1. The integration of the IP/MPLS network of the division will be done using MPLS VPN CSC[1].
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.

5.3 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

5.4	**INT_05: Integration with Railtel Network Test cases**		
S.No.	**Details**	**Observation**	**OK / Not OK**
5.4.1	• BGP over LDP,		
	• BGP in each Railway Division,		
	• Labeled E-BGP Session between LSR and RCIL PE.		
5.4.2	• Layer2 VPN,		
	• Layer3 VPN,		
	• Circuit-Emulation Service between Division-1 and Division-2		
5.4.3	• Link Aggregation Group (LAG) & Load Balancing		
5.4.4	• BFD for BGP session between LSR and RCIL PE		
5.4.5	• Performance Monitoring for Layer-2 and layer-3 services		
5.4.6	• End to end Quality of Service between Division-1, RCIL, and Division-2.		

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