Carrier Ethernet Technical Standard Compliance Register: MPLS-TP Tunneling Implementation in Metro Optical Networks

TECHNOLOGY OVERVIEW

MPLS-TP (Transport Profile) represents a critical evolution in the convergence of packet and optical transport technologies, specifically engineered to meet the stringent requirements of metro optical networks. This datasheet details the implementation of MPLS-TP tunneling as a carrier-grade transport mechanism, bridging the gap between traditional SONET/SDH-like operational models and the statistical multiplexing efficiency of packet-switched networks. The architecture eliminates the inherent complexity of full IP/MPLS routing at the transport layer, providing a connection-oriented, deterministic forwarding paradigm essential for Service Level Agreement (SLA) assurance in modern metro environments. By leveraging a reduced control plane and static provisioning capabilities, this implementation ensures unparalleled operational stability and interoperability across multi-vendor optical transport domains.



SFP+/QSFP INTERFACE MAPPING

The physical layer implementation of MPLS-TP tunneling relies on a robust set of high-density optical and electrical interfaces designed for flexible service demarcation and high-capacity trunking. The platform supports a comprehensive range of pluggable transceivers, ensuring seamless integration with existing fiber plant infrastructure. Key interface capabilities include:

- 10GE/25GE SFP28 Ports: Optimized for high-bandwidth metro aggregation rings, supporting both grey and DWDM/CWDM colored optics for extended reach.
- 100GE QSFP28/QSFP-DD Ports: Designed for core-facing uplinks and high-capacity inter-office transport, providing non-blocking line-rate forwarding.

- 1GE SFP Ports: Legacy and edge aggregation support for lower-speed customer premise equipment (CPE) and low-density service nodes.
- 10/100/1000Base-T RJ45 Ports: Out-of-band management and auxiliary control plane connectivity.

The forwarding engine maps these physical interfaces directly to MPLS-TP Label Switched Paths (LSPs), ensuring that the ingress classification and encapsulation occur at the line rate without introducing jitter or excessive latency.

REDUNDANT POWER SYSTEM

To achieve the carrier-grade availability expected in metro optical deployments, the hardware platform incorporates a fully redundant, load-sharing power architecture. The system supports dual hot-swappable AC or DC power supply units (PSUs), ensuring continuous operation in the event of a single power feed failure or PSU malfunction. The power subsystem is engineered with advanced monitoring capabilities, providing real-time telemetry on voltage, current, and temperature status to the network management system (NMS). This design adheres to the strictest telecom power specifications, including wide input voltage ranges and surge protection, ensuring resilience against unstable grid conditions typical of remote central office (CO) or street cabinet environments.

CAPABILITY METRICS

The performance of MPLS-TP tunneling is characterized by its deterministic forwarding behavior and comprehensive Operations, Administration, and Maintenance (OAM) toolset. Key capability metrics include:

- Deterministic Latency: Guaranteed end-to-end latency under 50 microseconds for 10Gbps line-rate traffic, essential for mobile backhaul and financial services.
- OAM Scalability: Support for 1,000+ concurrent Maintenance Entity Groups (MEGs) with hardware-accelerated Continuity Check Messages (CCM) at 3.3ms intervals.
- Protection Switching: Sub-50ms protection switching utilizing 1:1 and 1+1 linear protection schemes, as well as G.8032 Ethernet Ring Protection.
- Bandwidth Profiles: Granular traffic policing and shaping with Committed Information Rate (CIR) and Excess Information Rate (EIR) enforcement.

Parameter	**Specification**
Form Factor	2RU Modular Chassis / 1RU Fixed Configuration
Switching Capacity	1.2 Tbps (Full-Duplex) / 4.8 Tbps (Fabric Aggregated)

Power Supply	Dual Hot-Swappable Redundant AC/DC (-48V DC / 220V AC)
MPLS-TP Label Depth	Up to 3 Label Stack Entries (LSE) for hierarchical tunneling
OAM Support	ITU-T Y.1731, IEEE 802.1ag, RFC 6371 (CCM, LBM, LTM, DM, LM)
Protection Switching	1:1, 1+1 Linear Protection, G.8032v2 Ethernet Ring Protection (<50ms)
Latency	< 40 microseconds (Port-to-Port, 10Gbps Line Rate)
Management Interfaces	CLI, SNMPv3, NETCONF/YANG, gRPC Telemetry
Operating Temperature	-40°C to +65°C (Hardened Outdoor / Central Office)
MTBF	> 350,000 Hours (Telcordia SR-332 Method 1 Case 1)

COMPLIANCE AUDIT

The platform has been rigorously audited against global telecommunications standards to ensure multi-vendor interoperability and regulatory compliance.

The implementation strictly adheres to the following normative references:

- ITU-T G.8112: Interfaces for the MPLS Transport Profile (MPLS-TP) layer network.
- ITU-T G.8121: Characteristics of MPLS-TP equipment functional blocks.
- IETF RFC 5960: MPLS-TP Data Plane Architecture.
- IETF RFC 6371: Operations, Administration, and Maintenance Framework for MPLS-TP.
- IEEE 802.1Q and 802.1ad: VLAN and Provider Bridging support for service multiplexing.
- MEF 22.1: Mobile Backhaul Implementation Agreement Phase 2.

SCALING STRATEGY

Scaling the MPLS-TP metro optical network is achieved through a combination of physical interface expansion and logical tunnel aggregation. The platform supports a hierarchical scaling model:

1. Vertical Scaling: Adding high-density line cards to the modular chassis to increase port count and switching capacity up to 4.8 Tbps.
2. Horizontal Scaling: Utilizing MPLS-TP Label Switched Path (LSP) hierarchy to aggregate thousands of customer edge tunnels into a smaller number of core

transport tunnels.

3. Control Plane Scalability: Supporting both static provisioning (NMS-based) and dynamic control plane (GMPLS/OSPF-TE) for flexible tunnel setup across large multi-domain networks.

4. Service Scaling: Integrating with Multi-Segment Pseudowire (MS-PW) architectures to extend Ethernet, TDM, and ATM services over the packet transport network.

