Elastic MPLS

Rationale and Benefits for Service Providers

Combining Static and Dynamic MPLS

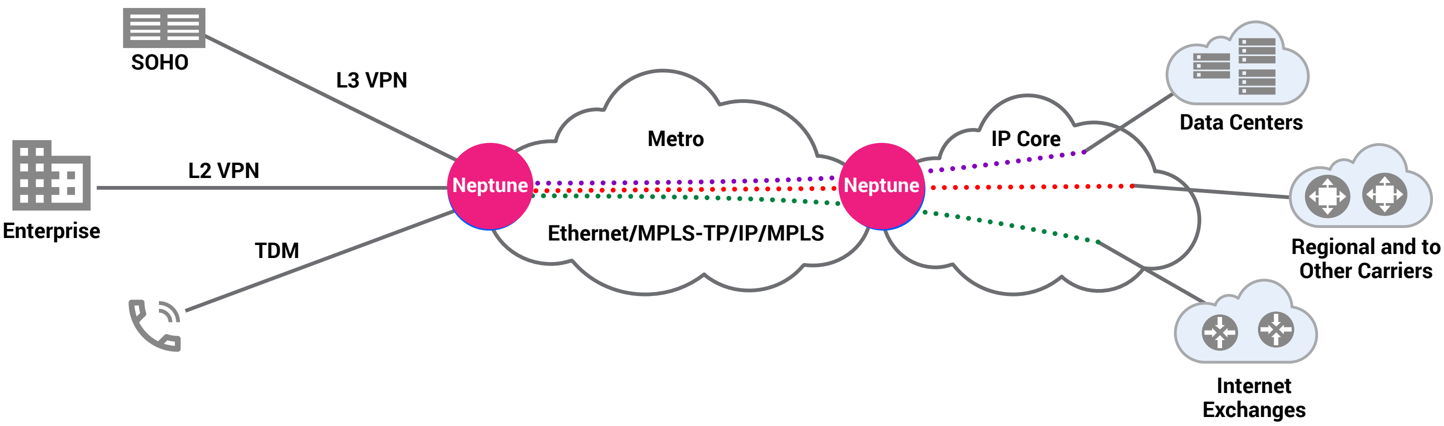
Overview

The metro networks large scale and simple-topology characteristics pose special challenges for service providers who wish to evolve to packet. We start with a description of the drivers that led to the emergence of Carrier Ethernet in general, and MPLS in particular, as viable packet transport technologies. Following this is a brief review of the differences between IP/MPLS and MPLS-TP flavors. Finally, we present the benefits and rationale of using Elastic MPLS (both IP/MPLS and MPLS-TP) in the Metro, to address its unique characteristics.

Streamline L2 and L3 VPN service provisioning, QoS, and OAM across MPLS domains

Facilitate Service Visibility and control over large-scale metro

Optimize Service for different performance and cost profiles



From Native Ethernet to Carrier Ethernet

Early-generation Ethernet switches supported high-bandwidth Ethernet access at a low cost. However, they suffered from a number of weaknesses, rooted in the fact that native Ethernet's scheme of learning bridges was not intended for use in carrier networks and that the connectionless nature of the technology does not permit deterministic behavior.

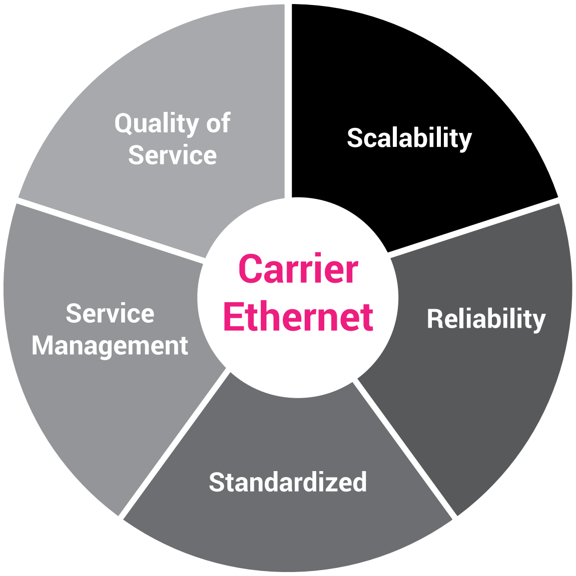
One of the biggest drawbacks of a connectionless technology such as native Ethernet is that it provides no means of reserving bandwidth or making devices along a path deliver a certain level of service at a specific bit rate. This means that the aggregation of many services results in unpredictable QoS. In native Ethernet, traffic is only differentiated by using per-hop behavior based on the values of IEEE 802.1p bits. While 802.1p offers up to eight levels of priority, it does not provide any guarantees for end-to-end service performance.

Without the ability to control how the traffic flows throughout the network, native Ethernet cannot isolate guaranteed services for various performance parameters, such as frame delay (latency), frame delay variation (jitter), frame loss, and resiliency.

Enterprise-centric native Ethernet switches also suffer from other known issues involving: slow restoration, poor reliability, limited scalability and lack of service management.

MEF (Metro Ethernet Forum) defined a new class of Ethernet, Carrier Ethernet, to comply with the following five attributes:

Standardized Services
enables coordination of subscribers, service providers, and operators, to achieve Carrier Ethernet-based data connectivity between multiple subscriber sites across multiple operator networks. This has become a necessity for organizations all over the globe. Standardized services gives service providers guaranteed interoperability between any network elements that are MEF certified.



Scalability
enables data connectivity of any number of multiple end-user sites over any distance. It also supports a wide range of interface speeds for varied traffic demands, allowing ample network growth.

Reliability
enables end-users to employ Carrier Ethernet to run their business and mission critical applications. These services run on transport layers that provide the most stringent resiliency and recovery constraints.

Service Management
enables service providers to roll out, maintain, and troubleshoot Carrier Ethernet based data-connectivity services in a cost-effective and timely manner.

Quality of Service
enables a single network to run multiple services to multiple end-users running a wide variety of applications with different bandwidth and latency requirements - using Carrier Ethernet. It also provides the required tools to ensure that services maintain the performance requirements, according to Service Level Specifications (SLS).

The Emergence of MPLS (IP/MPLS)

Standardized by the IETF, MPLS (Multi Protocol Label Switching) is a scalable, protocol-agnostic mechanism designed to carry circuit and packet traffic over virtual circuits known as Label Switched Paths (LSPs). Operating at an OSI layer, situated between the traditional definitions of Layer 2 and Layer 3, MPLS makes packet-forwarding decisions based on the contents of the label without examining the packet itself.

MPLS was developed originally to facilitate packet forwarding by using label switching. But it has additional attributes, like connection establishment, improved network resiliency, and OAM functions, which help overcome native Ethernet transport gaps and achieve Carrier Ethernet grade.

MPLS enhances Ethernet's capabilities across the entire collection of MEF Carrier Ethernet defined attributes, as follows:

Standardized Services

MPLS enables a full range of high-performance MEF-defined point-to-point (E-LINE), point-to-multipoint (E-TREE), and multipoint-to-multipoint (E-LAN) connectivity services. In addition, circuit emulation services can be delivered using TDM pseudowires in an MPLS network, ensuring support for legacy services. The abundance of MPLS throughout the Service Provider edge and metro-core networks ensures MPLS-based Ethernet services to extend between metro markets and even across continents. The addition of multicast capabilities in MPLS also initiated the possibility of efficient IPTV service delivery over a carrier-grade infrastructure.

Quality of Service

MPLS can transport all types of traffic with guaranteed QoS per application, regardless of the protocol of the encapsulated data. LSPs provide a way to engineer network traffic patterns independent of routing tables, steer traffic flows from congested links to alternate links, and control the paths of specific traffic flows to guarantee fast resiliency or other QoS parameters, such as frame delay, jitter, or packet loss. MPLS enables bandwidth to be reserved for selected traffic and admission control.

Reliability

MPLS has a variety of local and path-protection mechanisms that help minimize packet loss in an LSP and ensure high-service reliability. MPLS Fast Reroute (FRR), for instance, enables service restoration with SONET/SDH-like protection (<50 ms). Also, MPLS can reduce congestion and improve network predictability by enabling a high degree of load balancing – the equal distribution of traffic across LSPs.

Scalability

By layering multiple services onto each MPLS LSP, MPLS can support a high number of service instances in each network. Each service can be provisioned with the bandwidth tailored to the particular needs of the customer at each site.
MPLS-enabled services can scale geographically because they can be provisioned over multiple MPLS-based carrier networks. New options, such as pseudowire switching, help scale Ethernet services over several networks.

Service Management

A number of MPLS OAM tools have emerged in recent years that enable operators to better monitor network performance, diagnose and isolate faults, and centrally manage networks via standard-based vendor implementations in line with the MEF's vision. New tools also help speed up service provisioning and facilitate automation and self-healing. The MPLS OAM tools complement the Ethernet link OAM (IEEE 802.3ah) and service management OAM (EEE 802.1ag and ITU-T Y.1731) tools that have been developed over the last years. Together, these create a multilayer OAM solution to better support the service provider requirements for network and application assurance.

Extending MPLS to the Metro

Consumer demands for mobile, cloud, and video services require a lot more bandwidth, forcing telecommunication service providers worldwide to upgrade existing networking infrastructure with the appropriate technology and equipment. Metro-only traffic (traffic that traverses only the metro and bypasses long-haul traffic links) already exceeds long-haul traffic and therefore, the metro infrastructure is crucial for supporting Next Generation telecommunication services. While IP is the leading technology for communication services, the transport infrastructure comprises both L2 and L3 VPNs to fit various end-user requirements and preferences.

A key element for cost-efficient metro infrastructure, resides in the MPLS control plane which provides carrier-grade attributes to the services (QoS, OAM, resiliency). The natural inclination is to extend IP/MPLS from the core, where it is the de-facto standard, into the metro. However, there are quite a few differences between the metro and the core, which may affect the optimal choice.

What makes the metro a special case?

Two key attributes make the metro a special case - scale and topology:

Large Scale

The core comprises a relatively small number of network elements. In contrast, the metro consists of a large number of network elements. This number increases as we get closer to the customer premises. As a result, the NEs used in the metro should be optimized for cost, size, and power consumption and are, therefore, limited in their processing capability. The large number of NEs also makes simple operation an absolute necessity for cost-effective service delivery.

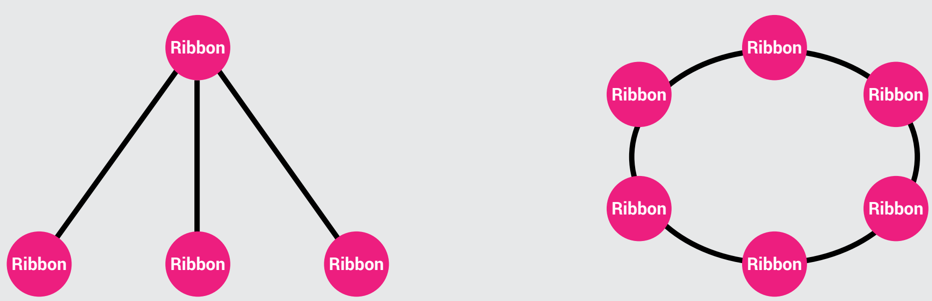
Number of Metro Network Elements

x10000	x1000	x100
METRO ACCESS	METRO AGGREGATION	METRO CORE

Simple Topologies

The core uses mesh topology, which provides comprehensive connectivity options. However, the metro is based on simple topologies like hub and spoke, or ring. As a result, fast restoration schemes that are not based on complex protocols (and therefore don't require heavy processing power) are a key concern in metro networks.

Simple Topologies (hub-and-spoke, ring)



The Rise of MPLS-TP

Similar to the way MPLS enables the use of Ethernet for transport, MPLS Transport Profile (MPLS-TP) enables MPLS to be used for transport, and specifically, for metro transport. It is a simplified version of IP/MPLS, optimized for transport networks. MPLS-TP is both a subset and an extension of IP/MPLS. Some of the complex IP/MPLS functionality, which is not relevant for transport networks, is disabled while other transport features are added.

MPLS-TP objectives are to streamline operational models, simplify converged networks, and gain better control of Ethernet networks in order to enable packet-based services with a similar degree of predictability as in existing transport networks. To meet these objectives, MPLS-TP is strictly connection-oriented and does not rely on IP forwarding or routing.

Key benefits offered by MPLS-TP include:

Deterministic Transport

While MPLS-TP and IP/MPLS use the same data-plane mechanism, MPLS-TP uses Bidirectional PseudoWire (PW) and Label Switching Path (LSP), while IP/MPLS uses Unidirectional PW and LSP. Having bidirectional traffic following exactly the same path ensures intuitive, predictable, and deterministic transport and bears special importance for providing accurate, reliable packet synchronization.

Full Control

Centralized NMS and static configuration provide a broader view of the network and enable the use of intelligent planning and prediction tools. These ensure continuous traffic flow, even in the event of failure in the control plane.

Transport Class OAM

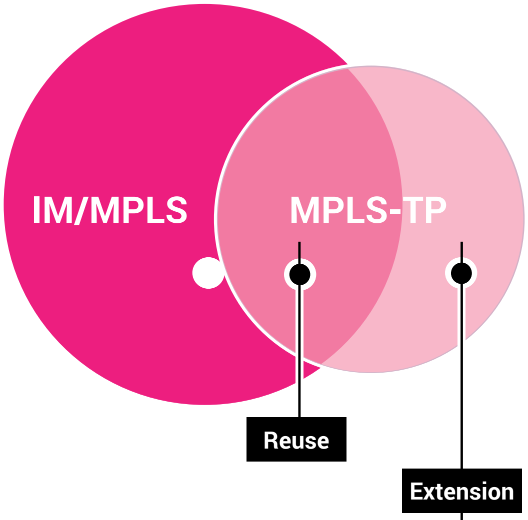
MPLS-TP supports extensive Operation, Administration, and Maintenance (OAM) functions similar to those available in traditional optical transport networks (like SONET/SDH and OTN). These include enhanced fault management, performance monitoring, and in-band PW/LSP/Section OAM levels. The OAM functions are an integral part of the MPLS-TP data plane and are independent of the control plane.

Improved Resiliency

Predetermined alternative paths ensure sub-50 msec switch to protection.

Lower TCO

Metro networks are usually large-scale networks. Thus, the Total Cost of Ownership (TCO) is a significant factor. IP/MPLS usually requires the use of full-blown L3 routers, resulting in higher NE cost (CAPEX) as well as higher operational expenditures and complexity (OPEX). In contrast, MPLS-TP can be implemented over simpler devices that do not require distributed control planes and are easier to operate.

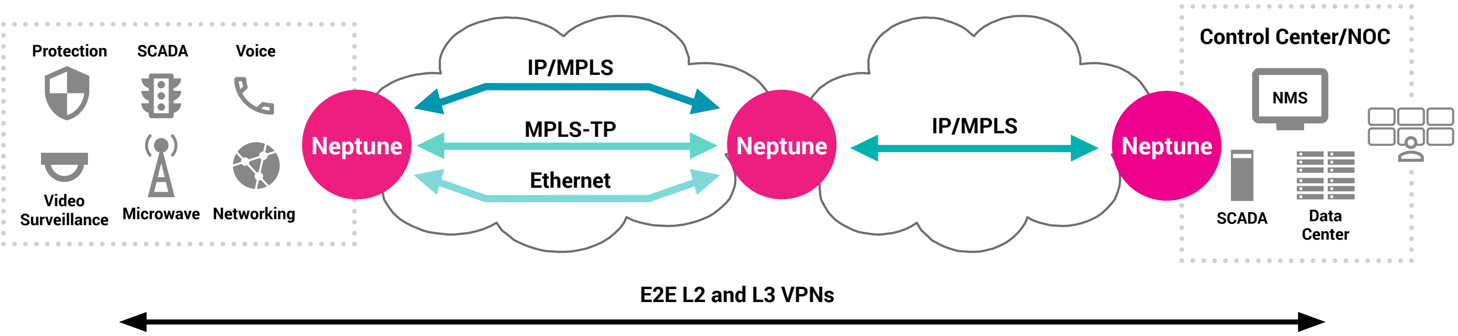


Transport-Class
- **Data plane:** bi-dir paths
- **Control plane:** separated from data plane, static (NMS)
- **OAM:** hardware based, enjanced
- **Protection:** sub 50mSec, predetermined backup paths

Extending MPLS to the Metro

As explained in the previous sections, both IP/MPLS and MPLS-TP offer advantages to the metro network domain. Ribbon sees MPLS technology as a key building block in realizing the efficiency of packet-based transport while maintaining transport-grade resiliency and manageability. Whilst IP/MPLS is the de-facto standard for metro networks a number of customers have services and applications which require the highly deterministic performance offered by MPLS-TP, especially those businesses supporting mission critical applications like energy distribution.

The Elastic (Dual Stack) MPLS enables seamless interworking between IP/MPLS and MPLS-TP domains. This eliminates the need to choose one standard over the other and makes it easier and risk-free to extend MPLS to the metro Consequently, service providers can support the dual stack across numerous platforms, from the metro access and up to the metro core. This gives them the flexibility to set the extent of the IP/MPLS reach, and switch to either static MPLS (MPLS-TP) or Ethernet.



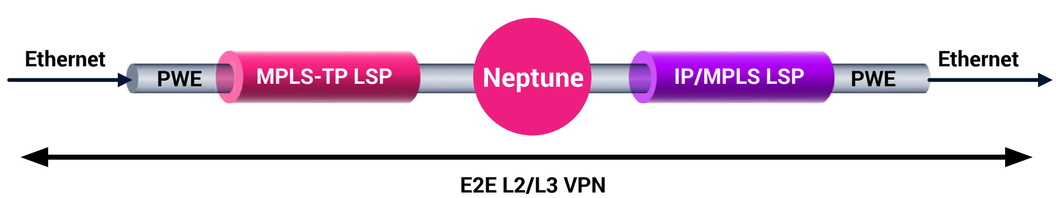
In addition to standard L3 VPNs (using E2E IP/MPLS) and L2 VPNs (either using static MPLS-TP or dynamic IP/MPLS), Elastic MPLS offer additional advantages, including:

Lower TCO L3 VPN

Lower TCO is achieved by using MPLS-TP network elements to transport the service in parts of the metro domains or in its entirety. In addition, it provides a proactive OAM of the working path and the protection path in the MPLS-TP domain. Even though the L3 VPN service crosses different MPLS domains, Elastic MPLS provides a unified management plane for end-to-end service and fault correlation.

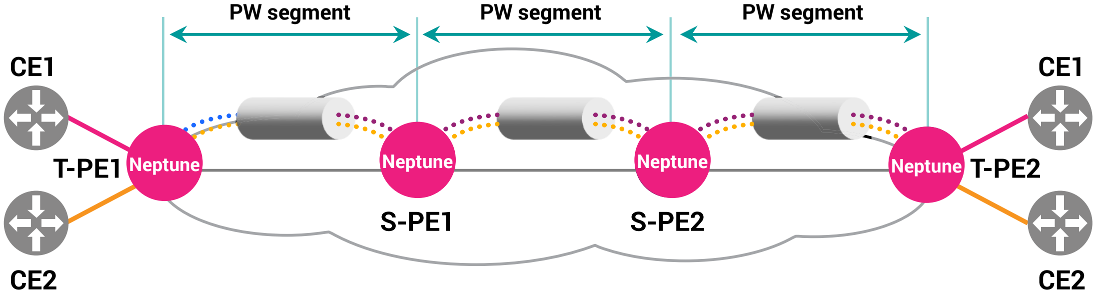
Streamlined L2 Service Interworking

Elastic MPLS enables E2E L2 VPN service with unified management plane for E2E service provisioning, visibility, and fault correlation. This includes E2E OAM across different network domains. Without elastic MPLS capabilities, service providers would be forced deliver the service via two or more separate services, per network domain.



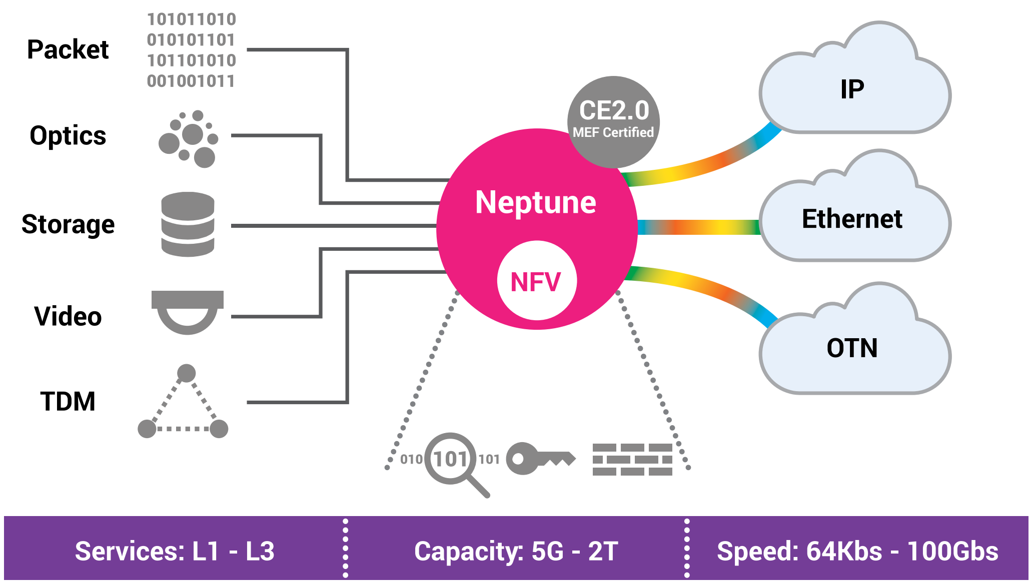
Easier Control

Elastic MPLS enables you to divide the metro into segments (multisegment pseudowire) and thereby gain large-scale control more easily, while maintaining an E2E service experience.



True Convergence

One of the key ambitions for next-generation transport is running all types of services on a unified networking layer. This convergence includes both packet-based NG services and TDM-based legacy services. Convergence should apply to a wide range of applications (mobile backhaul, VPNs, residential triple play, and so on) that prefer different control planes. An elastic MPLS implementation makes total migration to a unified packet transport network both a doable and practical goal. Moreover, a single network management system that can handle both IP/MPLS and MPLS-TP with full operational convergence is a valuable asset.



Summary

The rationale for designing and deploying elastic MPLS includes a wide range of commercial, technical, and economic benefits. With elastic MPLS implementations, service providers enjoy reduced risks from introduction of new technologies, simpler migration and interoperability, and the lowest possible TCO. Ultimately, this fulfills the network vision of unified Packet Transport Networks (PTN).

About Ribbon

Ribbon Communications (Nasdaq: RBBN) delivers communications software, IP and optical networking solutions to service providers, enterprises and critical infrastructure sectors globally. We engage deeply with our customers, helping them modernize their networks for improved competitive positioning and business outcomes in today's smart, always-on and data-hungry world. Our innovative, end-to-end solutions portfolio delivers unparalleled scale, performance, and agility, including core to edge software-centric solutions, cloud-native offers, leading-edge security and analytics tools, along with IP and optical networking solutions for 5G. We maintain a keen focus on our commitments to Environmental, Social and Governance (ESG) matters, offering an annual Sustainability Report to our stakeholders. To learn more about Ribbon visit rbbn.com.

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