Understanding MPLS-TP and Its Benefits

Abstract

This paper provides an overview of Multiprotocol Label Switching – Transport Profile (MPLS-TP), with information on its standardization, how IP/MPLS and MPLS-TP are complementary, and the commitment of Cisco to its support. In addition, this paper outlines the benefits of a combined MPLS-TP and IP/MPLS-based solution, and how Pseudowire-based MPLS can be adopted for transport network services.

Why MPLS-TP?

Tomorrow's network will mostly carry packets. As a result, an evolution of existing time-division multiplexing (TDM)-based transport networks is taking place, and new architectures optimized to carry packets are being defined. The function of a transport network is to carry information between service edge devices. These devices could be Digital Subscriber Line Access Multiplexers (DSLAMs), gateways, T1/E1 aggregators, broadband remote access servers (BRAS), etc. Traditional transport systems based on SDH/SONET platforms provide low-speed bandwidth granularity network services as well as high-speed long-haul transmission services. Circuit-switched transport network services with fixed bandwidth granularity (64 Kbps, 1.5 Mbps, 2 Mbps, 50 Mbps, 150 Mbps, 600 Mbps, etc.) were emulated using connection-oriented, packet-switched (CO-PS) technologies and similar managed-bandwidth services. However, in the access/aggregation and metro domains, there is a desire by carriers to simplify packet transport networking in order to reduce capital expenditures (CapEx) and operational expenses (OpEx) in their next-generation networks.

MPLS is considered a leading connection-oriented packet transport networking technology. Recently many carriers have shown their desire to converge their next-generation core networks onto MPLS, and subsequently have deployed their core networks using MPLS. Given the deployment of MPLS networks and the desire to align packet networking with more traditional transport operations methods, Cisco is leading a large effort to standardize a simplified version of MPLS for transport networks. This standardized approach is known as MPLS Transport Profile (MPLS-TP) in the IETF (groups – MPLS, PWE3, and CCAMP) and the ITU-T SG15.

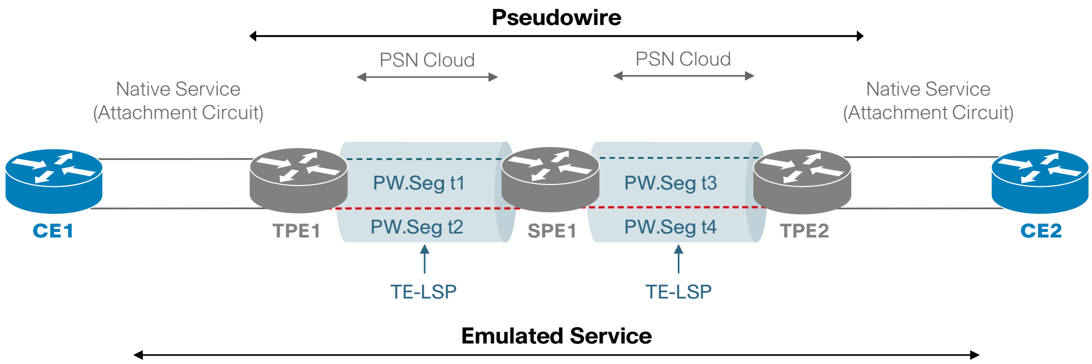
In addition to offering traditional transport operational models for packet networking, there is a requirement to interconnect the MPLS-based client customer network to the server operator network using MPLS in order to provide simple managed-bandwidth services. In this case, the customer network and the operator network are managed as independent entities (that is customer and operator), so that they can be decoupled functionally and operationally to maintain the client-server relationship.

The MPLS-TP proposal contains a set of compatible technology enhancements to existing MPLS standards to extend the definition of MPLS to include support for traditional transport operational models. This proposal adopts all of the supporting quality of service (QoS) and other mechanisms already defined within the standards, but also brings the benefits of path-based, in-band Operations, Administration, and Maintenance (OAM) protection mechanisms found in traditional transport technologies.

What is MPLS-TP?

MPLS-TP is a set of MPLS protocols that are being defined in IETF. It is a simplified version of MPLS for transport networks with some of the MPLS functions turned off, such as Penultimate Hop Popping (PHP), Label-Switched Paths (LSPs) merge, and Equal Cost Multi Path (ECMP). MPLS-TP does not require MPLS control plane capabilities and enables the management plane to set up LSPs manually. Its OAM may operate without any IP layer functionalities.

Figure 1. Pseudowires and LSPs



The essential features of MPLS-TP defined by IETF and ITU-T are:

- MPLS forwarding plane with restrictions
- PWE3 Pseudowire architecture
- Control Plane: static or dynamic Generalized MPLS (G-MPLS)
- Enhanced OAM functionality
- OAM monitors and drives protection switching
- Use of Generic Associated Channel (G-ACh) to support fault, configuration, accounting, performance, and security (FCAPS) functions
- Multicasting is under further study

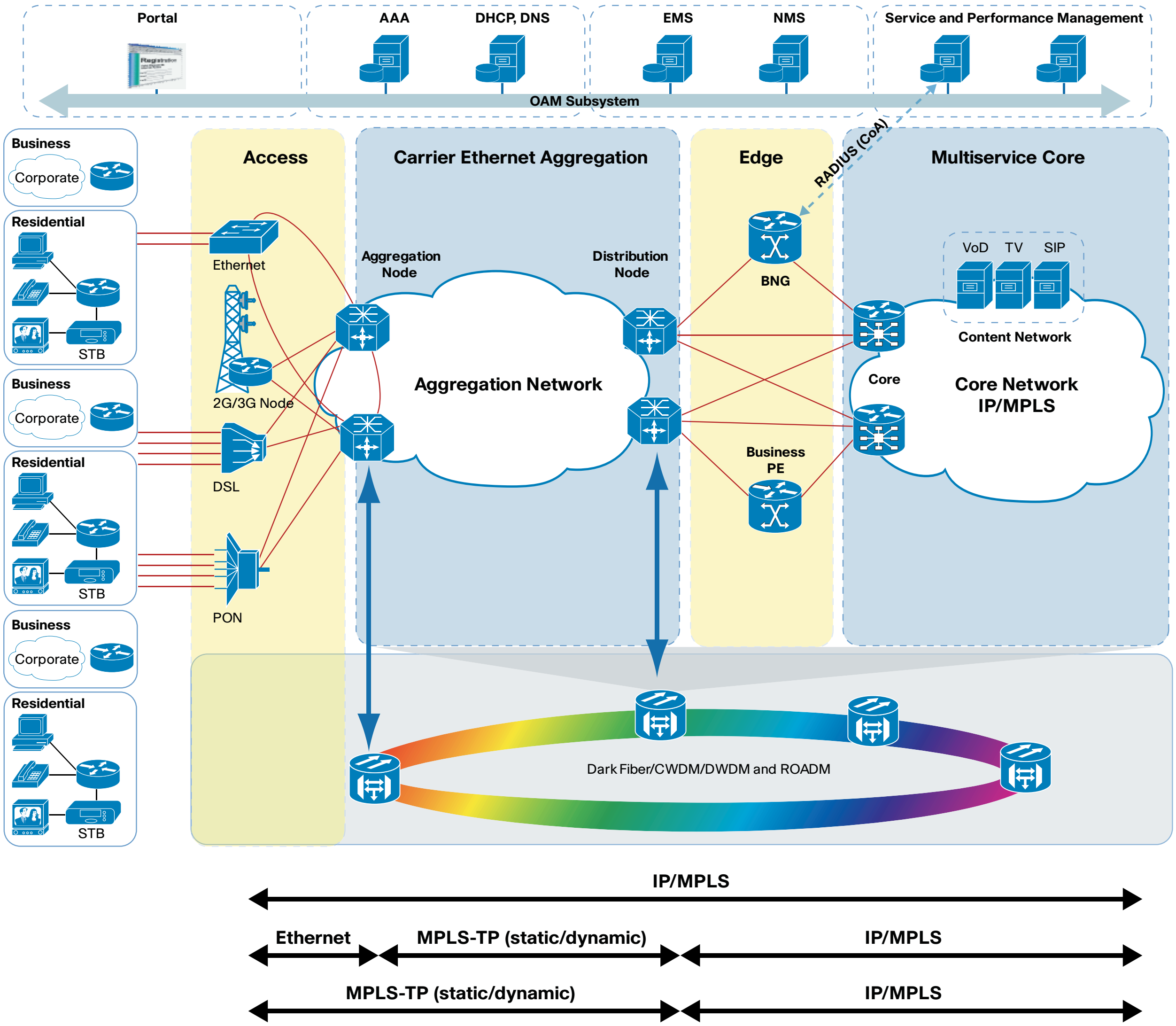
Integration of IP/MPLS and MPLS-TP

Carriers need to converge their networks to a single infrastructure to reduce OpEx and support new IP-based networking services as well as traditional layer 2 transport services. In the core network, most providers have already migrated toward an IP/MPLS-based infrastructure. IP/MPLS is highly scalable and can be deployed end-to-end to accommodate the needs of any network size.

In some cases, however, a service provider may not want to deploy a dynamic control plane based on IP protocols in some areas of the network. For example, the multiplication of Pseudowires (PWs) for some applications such as mobile backhaul requires IP addresses for the PWs that cannot be summarized. Thousands of such addresses carried by an Interior Gateway Protocol (IGP) could be problematic. A static configuration of PWs alleviates this problem. In addition, protection based on MPLS-Traffic Engineering (TE) may not be manageable in a situation where the complexity associated with a TE/Fast Reroute (FRR) setup to protect thousands of nodes/paths could be a challenge.

Cisco will offer an MPLS-TP solution that will allow static provisioning in the MPLS-TP domain. This approach will ease the transition from legacy transport technologies to an MPLS infrastructure. Cisco is committed to delivering the necessary integration between MPLS-TP and IP/MPLS so that LSPs and PWs may be provisioned and managed smoothly, end-to-end.

Figure 2. Examples of IP/MPLS and MPLS-TP Deployments



MPLS-TP OAM and Survivability

The functions of OAM and survivability for MPLS-TP networks are intended to reduce network operational complexity associated with network performance monitoring and management, fault management, and protection switching. These are required in order to operate without any IP layer functions.

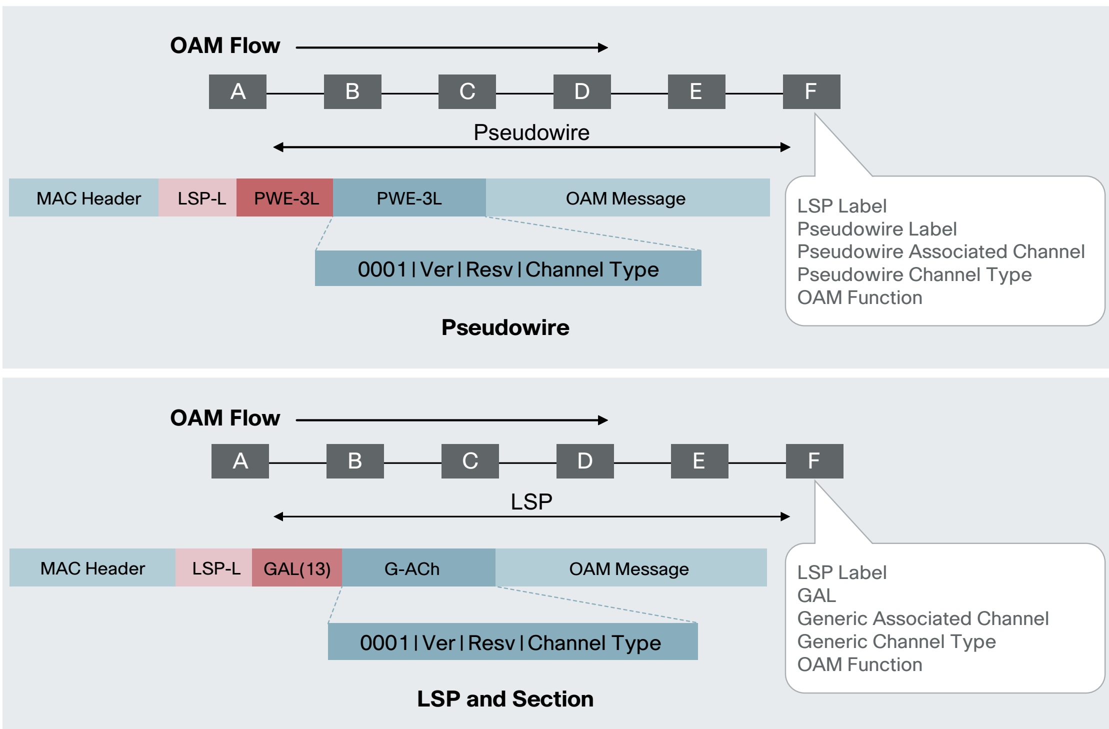
One of the goals of MPLS-TP OAM is to provide the tools needed to monitor and manage the network with the same attributes offered by legacy transport technologies. For example, the OAM is designed to travel on the exact same path that the data would take. In other words, MPLS-TP OAM monitors PWs or LSPs.

Two important components of the OAM mechanisms are the G-ACh and the Generic Alert Label (GAL). As their names indicate, they allow an operator to send any type of control traffic into a PW or an LSP. The G-ACh is used in both PWs and MPLS-TP LSPs. The GAL is used today in MPLS-TP LSPs to flag the G-ACh.

The G-ACh is very similar to the associated channel as defined by RFC4385. The G-ACh is like a container or channel that runs on the PW and carries OAM messages. For example, Virtual Circuit Connectivity Verification (VCCV)[1] may be sent over an associated channel to monitor if the PW is available. The associated channel is a generic function, such that it can also run over LSPs. This generic function is capable of carrying user traffic, OAM traffic, and management traffic over either a PW or an LSP. It can also carry Automatic Protection Switching (APS)[2] information and Data Communications Channel (DCC), Signaling Communication Channel (SCC), and Management Communication Channel (MCC)[3] management traffic, etc.

It is important to note that this generic construct defined for MPLS-TP will be reused by IP/MPLS. This will provide a very extensive set of OAM tools, and support FCAPS functions for end-to-end management.

Figure 3. Associated Channel and GAL



MPLS-TP Control Plane

Within the context of MPLS-TP, the control plane is the mechanism used to set up an LSP automatically across a packet-switched network domain. The use of a control plane protocol is optional in MPLS-TP. Some operators may prefer to configure the LSPs and PWs using a Network Management System in the same way that it would be used to provision a SONET network. In this case, no IP or routing protocol is used.

On the other hand, it is possible to use a dynamic control plane with MPLS-TP so that LSPs and PWs are set up by the network using Generalized (G)-MPLS and Targeted Label Distribution Protocol (T-LDP) respectively. G-MPLS is based on the TE extensions to MPLS (MPLS-TE). It may also be used to set up the OAM function and define recovery mechanisms. T-LDP is part of the PW architecture and is widely used today to signal PWs and their status.

[1] VCCV Pseudowire Virtual Circuit Connectivity Verification: a control channel that is associated with a PW
[2] APS Automatic Protection Switching: involves reserving a protection channel (dedicated or shared) with the same capacity as the channel or facility to be protected
[3] Data Communications Channel (DCC) is the in-band data communication channel in SONET/SDH communication. SCC Signaling communication channel, MCC Management communication channel

Summary

MPLS-TP represents a new development in the larger MPLS protocol suite. It offers an evolution architecture for TDM-based transport networks, and is optimized to carry packets. It carefully preserves the OAM and management characteristics that transport groups have been using in the past and allows a full end-to-end integration with existing and future IP/MPLS infrastructures. By using IP/MPLS and MPLS-TP, service providers will have a consistent way of provisioning, troubleshooting, and managing their networks from edge to edge.

Cisco is committed to supporting MPLS-TP components on its key platforms, with an initial emphasis on providing it for aggregation and access equipment. Service providers will now have maximum flexibility when addressing their transition to packet networks.

References

IETF References

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- ietf-mpls-tp-gach-gal
- ietf-mpls-tp-oam-requirements
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- ietf-mpls-tp-gach-dcn
- ietf-mpls-tp-oam-framework
- ietf-mpls-tp-survive-fwk
- IETF RFC 3031 “Multiprotocol label switching architecture”
- IETF RFC 3032 “MPLS label stack encoding”
- IETF RFC 3270 “Multi-Protocol Label Switching (MPLS) support of Differentiated Services”
- IETF RFC 3443 “Time To Live (TTL) processing in Multi-Protocol Label Switching (MPLS) networks”
- IETF RFC 3985 “Pseudowire Emulation Edge-to-Edge (PWE3) Architecture”
- IETF RFC 4448 “Encapsulation Methods for Transport of Ethernet over MPLS Networks”
- IETF draft-bryant-pwe3-mpls-transport-00 “Application of PWE3 to MPLS Transport Networks”

ITU-T References

- ITU-T Recommendation G.8110.1 “Architecture of MPLS-TP Layer Network”
- ITU-T Recommendation G.8112 “Interfaces for the MPLS-TP Hierarchy”
- ITU-T Recommendation G.8121 “Characteristics of MPLS-TP Network Equipment Functional Blocks”
- ITU-T Recommendation G.8131 “MPLS-TP linear Protection”
- ITU-T Recommendation G.8132 “MPLS-TP Ring Protection”
- ITU-T Recommendation G.8101 “Terms and definition for MPLS-TP”
- ITU-T Recommendation G.7712 “Architecture and Specification of Data Communication Network”
- ITU-T Recommendation G.8151 “Management aspects of the MPLS-TP network element”

Refer to the following liaison for a complete list of IETF/ITU documents:
https://datatracker.ietf.org/documents/LIAISON/file648.pdf

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