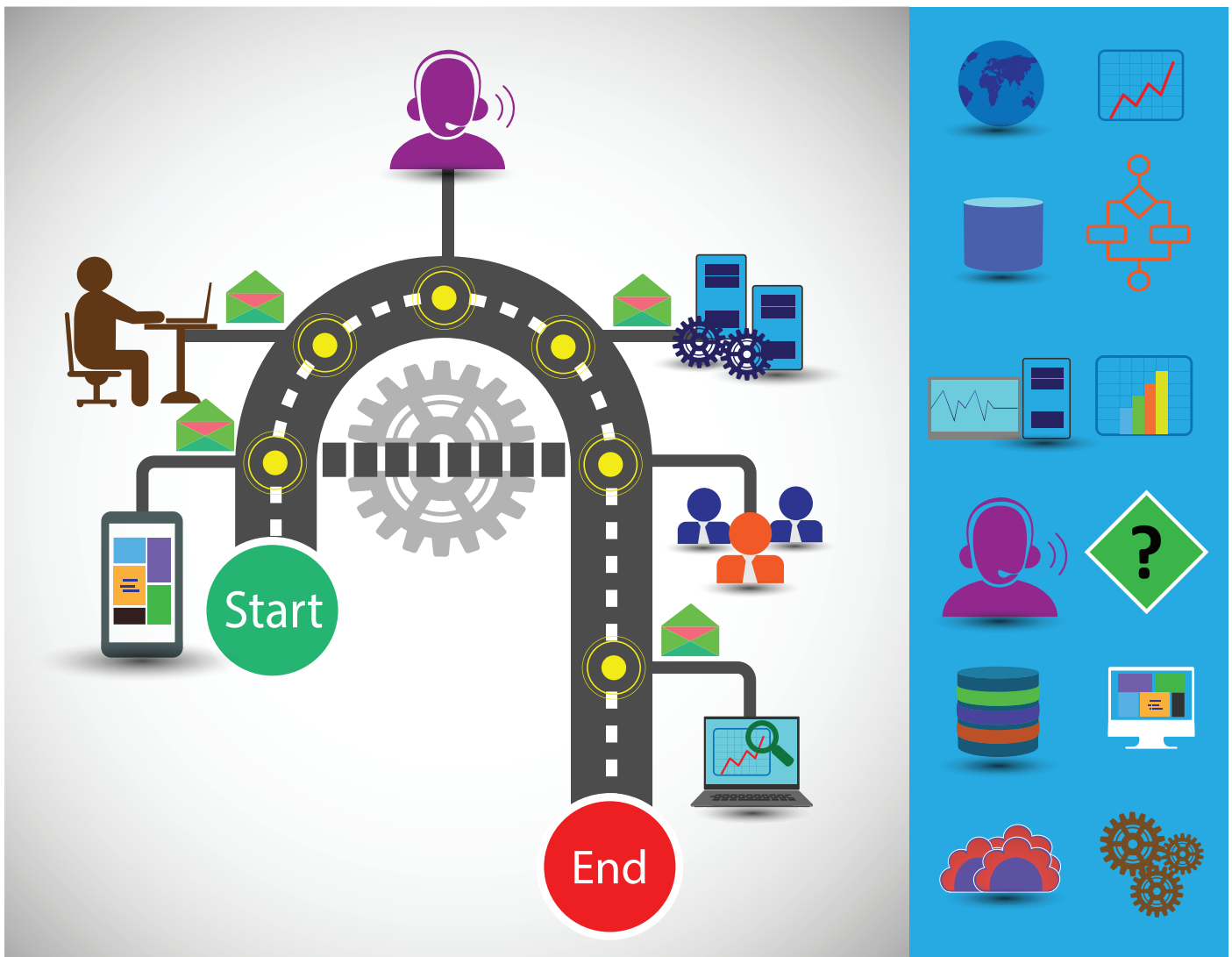


Decoding MPLS-TP and the deployment possibilities



Abstract

Over the past few years, leading communications service providers and a number of NE (network element) suppliers have supported the development of an MPLS Transport profile (MPLS-TP) that will enable the technology to be operated in a similar manner to existing transport technologies and give it the capability to support packet transport services with a degree of predictability that is found in existing

transport networks.

The fundamental idea is to extend MPLS wherever necessary with Operations, Administration and Maintenance (OAM) tools that are widely applied in existing transport network technologies such as SONET/SDH or OTN.

This paper provides a brief history of the MPLS-TP standardization activities and addresses the MPLS-TP

OAM functions. These functions are targeted at making MPLS comparable to SONET/SDH and OTN in terms of reliability and monitoring capabilities, i.e., MPLS-TP will become a true carrier grade packet transport technology.

Introduction

An MPLS-TP network can be operated in an SDH-like fashion and a network management system (NMS) can be used to



configure connections. Connection management and restoration functions, however, can alternatively be provided utilising the Generalised MPLS (GMPLS) control plane protocols which are also applicable to the MPLS-TP data plane. In addition to the simplification of the network operation leading to reduced operational expenditures (OPEX), the GMPLS control plane provides network restoration capabilities, in addition to the network protection features that the MPLS-TP data plane already provides. This results in a further improved network resiliency.

The MPLS-TP technology is also multi-service capable leveraging the pseudo-wire technology that has been developed at the IETF and which is still evolving. Some applications require synchronization, e.g. mobile services and interconnection of telephony switches. Ethernet is an asynchronous network protocol and hence protocol extensions are necessary. This paper discusses the different emerging standards. One of the key requirements is that the new MPLS-TP network layer must be capable to utilize the existing physical infrastructure and the paper lists the various adaptation or encapsulation techniques that allow MPLS-TP packets to be carried over a variety of different physical technologies ranging from SONET/SDH and OTN to Gigabit Ethernet.

Overview of MPLS-TP

The goal of MPLS-TP is to provide connection-oriented transport for packet and TDM services over optical networks leveraging the widely deployed MPLS technology. Key to this effort is the definition and implementation of OAM and resiliency features to ensure the capabilities needed for carrier-grade transport networks – scalable

operations, high availability, performance monitoring and multi-domain support.

Key characteristics of MPLS-TP are:

- Is strictly connection oriented
- Is client-agnostic (can carry L3, L2, L1 services)
- Is physical layer agnostic (can run over IEEE Ethernet PHYs, SONET/SDH [G.783] and OTN [G.709], [G.872] using GFP [G.7041], WDM, etc.)
- Provides strong operations, administration and maintenance (OAM) functions, similar to those available in traditional optical transport networks (e.g., SONET/SDH, OTN); these OAM functions are an integral part of the MPLS-TP data plane and are independent from the control plane.
- Provides several protection schemes at the data plane, similar to those available in traditional optical transport networks
- Allows network provisioning via a centralized NMS and/or a distributed control plane
- The GMPLS control plane is also applicable to the MPLS-TP client or server layers and allows to use a common approach for management and control of multi-layer transport networks.

Moreover, MPLS-TP provides dynamic provisioning of MPLS-TP transport paths via a control plane. The control plane is mainly used to provide restoration functions for improved network survivability in the presence of failures and it facilitates end-to-end path provisioning across network or operator domains. The operator has the choice to enable the control plane or to operate the network in a traditional way, without control plane by means of an NMS. It shall be noted that the control plane does not make the NMS obsolete – the NMS needs to configure the control plane and

also needs to interact with the control plane for connection management purposes.

MPLS-TP Drivers

Carriers are experiencing an unprecedented combination of demand for service sophistication and expansion (e.g. Triple Play, LTE in mobile radio communications) coupled with economic pressure to minimise the cost for providing these services. MPLS-TP is being defined to meet these divergent requirements by introducing SDH-like OAM features to packet transport networks.

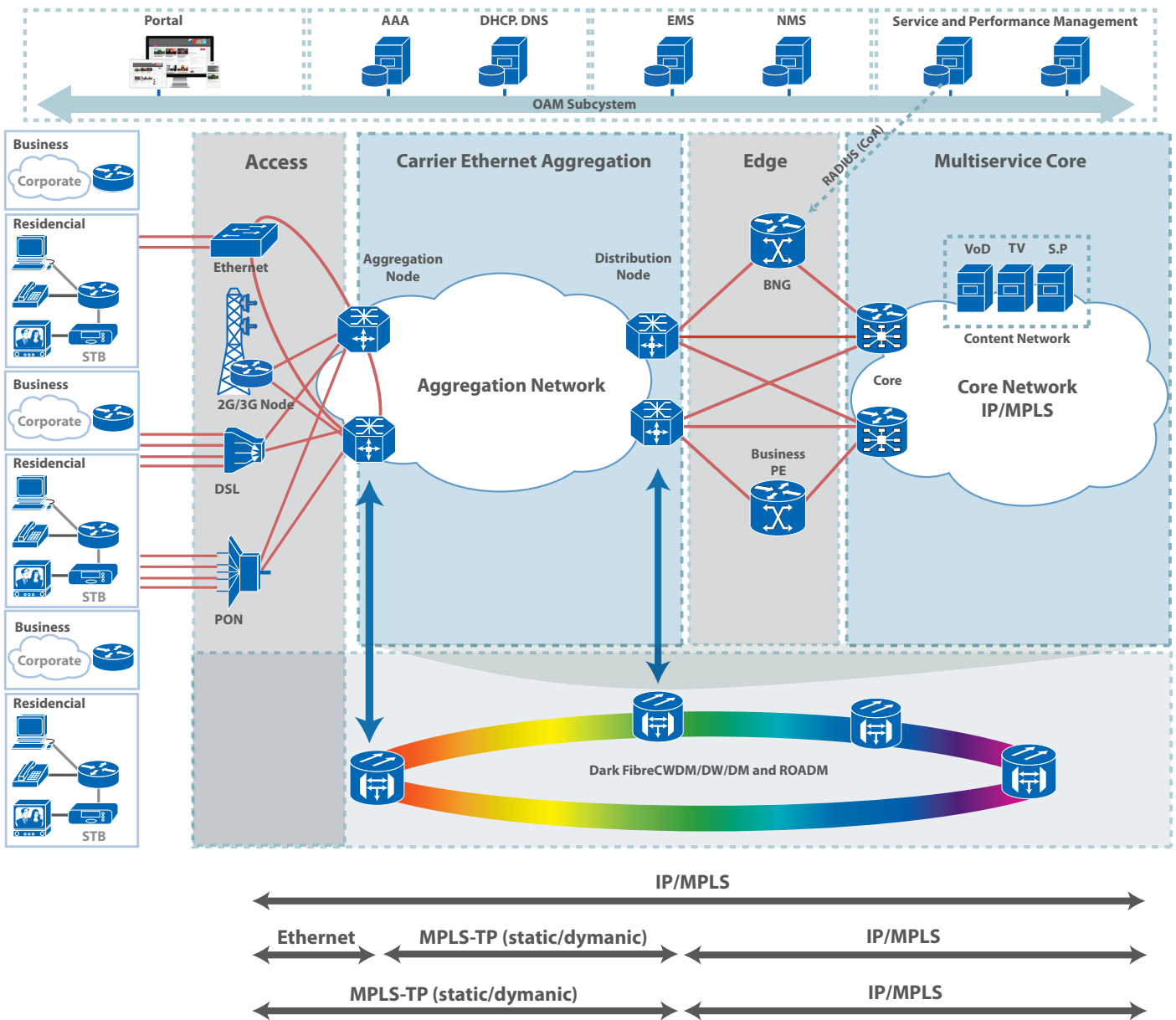
Service providers have expressed interest in MPLS-TP primarily because they are looking to control the costs of transporting packets that are increasingly dominating their traffic mix and – in many cases – are currently being carried inefficiently over legacy SDH networks that run at constant bit rates even when there is no traffic.

The ability to support multiple services and applications over a common MPLS enable infrastructure provides flexibility to more rapidly add new offerings and to cost-effectively scale with demand over time. While IP/MPLS is widely deployed in carrier networks and has rich multiservice and scalability features, it generally offers more than what is needed for transport application. Major operators have encouraged development of a transport-oriented version of MPLS with a rich set of OAM features to complement IP/MPLS deployed in their networks.

MPLS-TP OAM

The MPLS-TP OAM tool set is currently under definition at the IETF and comprises the OAM features listed in Figure below. The





fundamental idea is that dedicated OAM packets are interspersed into the associated user traffic flows. These OAM packets are created and processed by maintenance end point. Maintenance intermediate points can also process these OAM packets and may collect data or raise alarms. The tools can be categorised in proactive OAM functions that are running all the time and on-demand monitoring 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.

MPLS-TP Control Plane

The IETF further defined Generalized MPLS (GMPLS) as a generalization of the MPLS control plane to develop a dynamic control plane that can be applied



Pro-active monitoring features

- Continuity supervision (Integrity)
- Connectivity supervision
- Signal quality supervision (packet loss)
- Alarm Suppression (Silencing)
- Single-ended maintenance

Pro-active monitoring features

- Fault management
- Performance monitoring
- Protection switching

Re-active/On-demand monitoring

- Fault Localization
- Signal quality measurement
 - Throughput
 - Packet Loss
 - Transfer delay and jitter

Communication channels

- Protection switching head/tail-end coordination
- Control Plane
- Network management
- Remote node management
- Service management

to packet switched and optical networks. The GMPLS architecture is described in [RFC3945]. The GMPLS control plane, or its ITU-T counterpart, Automatically Switched Optical Network (ASON) [G.8080], supports connection management functions as well as protection and restoration techniques and thus providing network survivability across networks comprising routers, MPLS-TP LSRs, optical ADMs, cross connects, and WDM devices.

MPLS-TP may utilize the distributed control plane to enable fast, dynamic and reliable service provisioning in multi-vendor and multi-domain environments using standardized protocols that ensure interoperability.

The MPLS-TP control plane is based on a combination of the MPLS control plane for pseudowires and the GMPLS control plane for MPLS-TP LSPs, respectively. This is illustrated in Figure above. The distributed MPLS-TP control plane provides the following basic functions:

- Signalling

- Routing
- Traffic engineering and constraint-based path computation

Moreover, the MPLS-TP control plane is capable of performing fast restoration in the event of network failures.

The MPLS-TP control plane provides features to ensure its own survivability and to enable it to recover gracefully from failures and degradations. These include graceful restart and hot redundant configurations. The MPLS-TP control plane is as much as possible decoupled from the MPLS-TP data plane such that failures in the control plane do not impact the data plane and vice versa.

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.

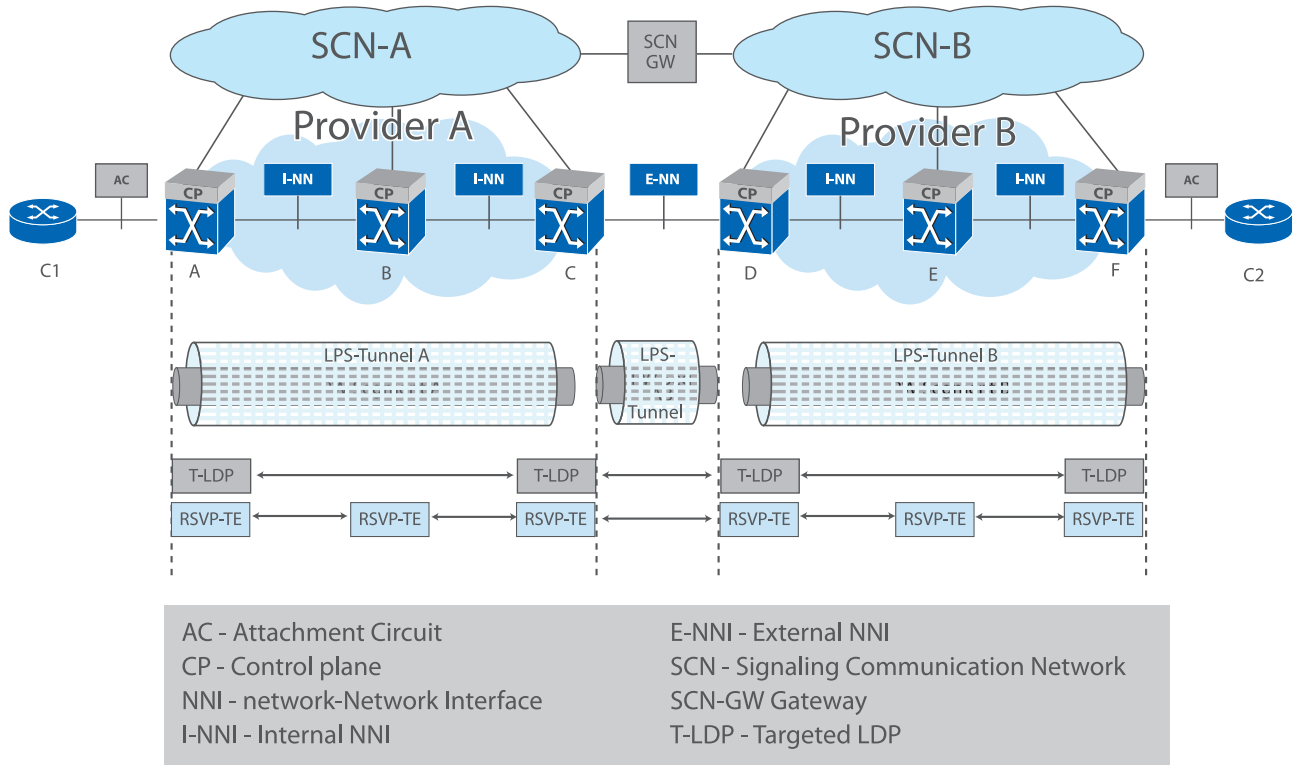
Physical Layers supporting MPLS-TP

It is mandatory for MPLS-TP that it can be carried over the existing and still evolving physical transport technologies such as SONET/SDH, OTN/WDM, and Gigabit Ethernet. The encapsulation techniques for these technologies are briefly described below.

MPLS-TP over SONET/SDH, PDH and OTN

ITU-T Recommendation G.7041 [G.7041] defines a generic framing





procedure (GFP) to encapsulate variable length payload of various client signals for subsequent transport over SONET/SDH, PDH, and OTN networks. The GFP header contains a User Payload Identifier (UPI) field for which values are defined that indicate that the carried protocol data unit is an MPLS packet. MPLS-TP uses that same UPI code point as MPLS. The OTN [G.709] includes a WDM network layer for the transport of a variety of OTN client signals. In the SONET/SDH case, virtual concatenation can be applied to form transmission pipes with larger capacities ($n \times 150$ Mbit/s).

MPLS-TP over Gigabit Ethernet

Similar to GFP, MPLS-TP can be

carried across Ethernet links. A two-octet Ether Type field has been defined by the Ethernet II framing networking standard to indicate which protocol is encapsulated in the payload area of the frame.

Conclusion

The increasing demand for highly reliable and large-capacity packet transport technology has facilitated the development of MPLS-TP technology. The key features of MPLS-TP in comparison to IP/MPLS include separation of the data plane and control plane, OAM, centralized operation by NMS, and high-speed recovery of signals by a protection mechanism. MPLS-TP standardization has progressed to the point of completion of some

common documents and two kinds of solutions including G.8113.1 and G.8113.2 for OAM and G.8121.1 and G.8121.2 for equipment functional blocks. The differences in these two solutions can be characterised by their simplicity and the behavioural inclination to Ethernet/OTN/SDH or IP/MPLS and a scenario for deployment of future new technology such as SDN. Thus, G.81xx.1 based MPLS-TP will become a key technology for multi-layer converged transport networks driven by SDN as a promising solution for future cost-effective networks.

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