# MPLS-TP OAM Toolset: Interworking and Interoperability Issues

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***Abstract*—The present article is aiming at presenting different Operations, Administration and Maintenance (OAM) procedures that are used for Multiprotocol Label Switching (MPLS) Transport Profile (MPLS-TP). We start by giving a quick review of what is MPLS-TP, and what makes it the solution for the Next Generation Network (NGN). This paper exposes the problem of having two standards on the MPLS-TP OAM Toolset. We highlight the difference between the two approaches and why they are not interoperable. We propose, as future work, to use a layered model solution in order to by-pass this issue.**

***Keywords-mpls-tp; OAM; Y.1731; 802.ag; 802.ah; G.8113.1; G.8113.2***

## I. INTRODUCTION

While Time Division Multiplexing (TDM)-based technologies [1] ex. Synchronous Optical Network (SONET), and Synchronous Digital Hierarchy (SDH) has been for a long time a major player for transport, it shows weakness in the case of traffic burst such as packetized voice and video. This happens because of the fast growth of the demand for service sophistication and expansion (Triple Play, 3G / Long Term Evolution LTE, Cloud Virtualization). Carriers need to migrate from Time-Division Multiplexing (TDM) to packet in order to meet Packet Transport Network (PTN) requirements and to make efforts to minimize the cost for providing these services.

A Joint Working Team created by ITU-T and IETF is actually developing a new packet transport technology (MPLS-TP) taking benefits from existing MPLS networking infrastructure [2].

MPLS-TP is intended to provide all the advantages of the packet-based transport approach, while delivering at the same time, the reliability, availability, OAM capabilities and manageability features associated with traditional TDM transport networks. It is a subset of IP/MPLS protocol suite with new extensions which allow addressing transport network requirements. These extensions consists of adapting current MPLS to make it more “Transport like” by inheriting OAM , reliability and operational simplicity from SONET/SDH networks.

There are two approaches for MPLS-TP OAM at the standardization organizations and no industry agreement on that. The solutions are based on IETF and ITU-T recommendations. Both of OAM proposed solutions are in-band. The IETF solution is based on the existing MPLS OAM tool [3], while the ITU-T solution is based on Ethernet OAM (Y.1731) [4].

In order to best understand the impact of having two distinct standards for MPLS-TP OAM, we need to know if both of them are meeting requirements and how Carriers should take in consideration during implementation.

This paper starts by presenting fundamentals of MPLS-TP. Then we will give the actual picture of the MPLS-TP OAM toolset status and how it can be an issue. Finally, we propose a solution to overcome the problem.

## II. WHAT IS MPLS-TP ?

MPLS-TP is aimed to be based on the same architectural concepts of layered network that are already used in legacy SONET/SDH [5]. IP/MPLS [6] and MPLS-TP [7] are willing to be the main packet technologies deployed in Ethernet Backhaul Access’s and Aggregation’s Network for the next five years. Figure 1 illustrates how MPLS-TP takes the best of two worlds: OAM performance and maturity of TDM (SONET/SDH), and Control/Data Plane efficiency of IP/MPLS.

MPLS-TP has the following key characteristics:

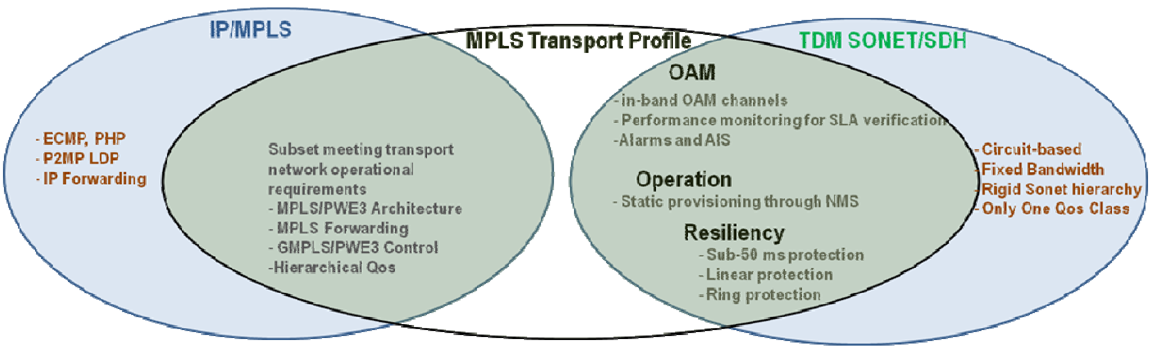


Figure 1. MPLS-TP subset of MPLS[7]

- Connection oriented: Equal cost Multi-Path ECMP and Multi-point to Point (MP2P) are excluded to ensure that, Penultimate Hop Popping PHP is disabled by default;

- L2/L3's client agnosticism;

- Control Plane: static or dynamic Generalized MPLS (GMPLS);

- Physical layer agnostic: allowing MPLS packets to be delivered over a variety of physical infra-structures including Ethernet, SONET/SDH and Optical Transport Network (OTN) using Generic Framing Procedure (GFP), Wavelength-Division Multiplexing (WDM), etc;

- Strong OAM functions similar to those available in legacy optical transport networks (e.g., SONET/SDH, OTN);
- Path protection mechanisms and control plane-based mechanism;
- Use of Generic Associated Channel (G-ACh) to support Fault, Configuration, Accounting, Performance and Security (FCAPS) functions;
- Network provisioning via a centralized Network management system (NMS) and/or a distributed control plane.

Based on the relative standards and recommendations, MPLS-TP is a solution based on existing Pseudo-wire (PW) and Label Switched Path (LSP). MPLS-TP supports two native service adaptation mechanisms via:

- A PW to emulate certain services, for example, Ethernet, Frame Relay, or Point-to-Point Protocol (PPP) / High-Level Data Link Control (HDLC). These adaptation functions are the payload encapsulation; see Figure 2.

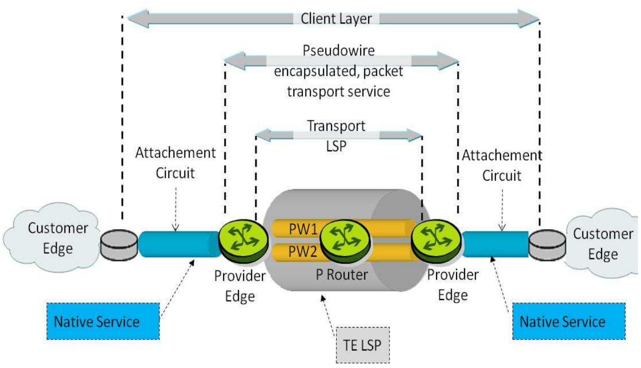


Figure 3. MPLS-TP Architecture (PW as native service)

- An LSP, to provide adaptation for any native service traffic type like IP packets and MPLS-labeled packets (i.e., PW over LSP, or IP over LSP). The adaptation function uses the MPLS encapsulation format; see Figure 3.

The major attributes of MPLS-TP protocol's suite are:

- Data Plane: remains exactly the same as MPLS to facilitate interoperability with MPLS;
- Control Plane: optional, dynamic via IP based protocols or static via management platform NMS;
- OAM: transport-like OAM;
- Protection and Resiliency: SDH-like;

In this paper, we focus on the OAM attribute in order to demystify their role and which will be the impact of having two standards options.

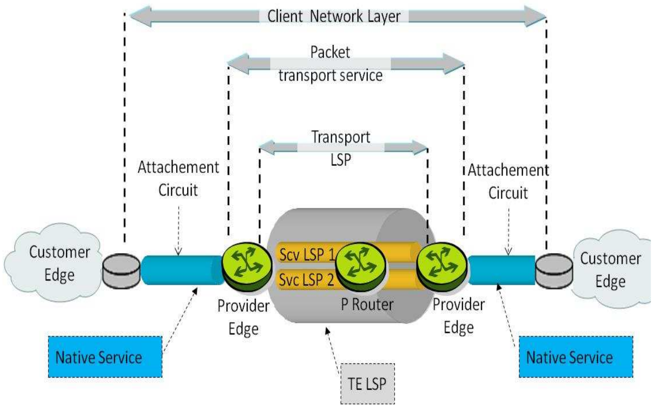


Figure 2. MPLS-TP Architecture (PW as native service)

## III. OAM TOOLSET

MPLS-TP has a robust and a transport-like operations and management (OAM) capabilities. Carriers use OAM to provide reliable services with guaranteed service level agreements (SLA), while minimizing troubleshooting time and reducing operational expenses.

The general MPLS-TP OAM requirements are:

- Proactive (continuous) monitoring features, including continuity supervision, connectivity supervision, signal quality supervision (packet loss, frame delay, frame delay variation), alarm suppression, remote quality and continuity indication
- Proactive monitoring applications, including Fault management, Performance/SLA monitoring, Protection switching
- Re-active/on-demand monitoring, including fault localization, signal quality measurement (throughput, ordering and error measurement, transfer delay, delay variation and jitter measurement)
- Communication channels, including protection switching head/tail-end coordination, network management, remote node management, service management [8]:

There is three kind of OAM: Hop-by-hop (e.g., control plane based), Out-of-band OAM (e.g., User Datagram Protocol UDP return path) and In-band OAM (e.g., PW Associated Channel ACh). Within the MPLS, the ACh is known as technique for in-band Virtual Circuit Connectivity Verification (VCCV) applicable only for PW, while LSPs have no mechanism to differentiate user packets from OAM packets [9]. MPLS-TP extended the ACh to the Generic Associated Channel (G-ACh) and introduced a new label G - ACh Alert Label (GAL) to identify packets on the G-Ach. It is an in-band management channel on a PW or LSP that does not rely on routing, user traffic, or dynamic control plane functions. The OAM packets can then share the same path of user traffic, operate on a per-domain basis and/or across multiple domains, and are able to be configured in the

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absence of a control plane. This constitutes an important toolbox which allows carriers to run OAM at each network level: LSP, PW and Section [10].

The network model of MPLS-TP OAM consists of:

- Different OAM Level (administrative domains). Each Level can be independently monitored by its own Ethernet Connectivity Fault Management (CFM) frames. The scope of OAM frames is limited to the domain in which the carried information is significant.
- Two plans; see Figure 4:
    - o A "vertical plan" (red) that represents the OAM entities across different administrative domains,
    - o An "horizontal plan" (blue) that represents the OAM entities within a single administrative domain.

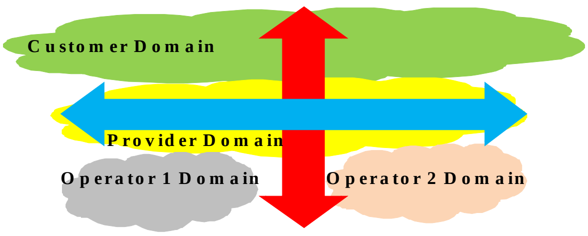


Figure 4. OAM Network Model

The Maintenance Entity Group (MEG) is the portion of the transport path that is being monitored or maintained. MEG endpoints are referred as management end points (MEPs) and intermediated nodes are referred as management intermediate points (MIPs). OAM message can be exchanged between MEPs, or from one MEP to other MIP. MEP handle OAM packet when it arrives at Label Edge Router (LER) because the label is popped and then the GAL is exposed which allow MEP to start processing by the corresponding OAM function. MIP can handle OAM packet using Time To Leave (TTL) mechanism. The TTL expiration causes the packet to be processed, and the existence of the GAL under the label for which the TTL expired causes the packet to be processed. MIPs cannot initiate OAM message, but may send an answer.

There are two proposed standards for MPLS-TP OAM and no industry agreement on that. They are based on IETF (G.8113.2) and ITU-T (G.8113.1) recommendations [11].

### A. ITU-T OAM Tools G.8113.1

ITU-T suggests reuse the same OAM Protocol Data Units (PDUs) and procedures defined in Ethernet OAM ITU-T Y.1731 [12]. The presence of Y.1731 OAM PDU is identified by a single ACH channel Type (0xXXXX). Within the OAM PDU, the OpCode field allows identifying the type of OAM frame.

The ITU-T OAMs provide a set of mechanisms that meets the MPLS-TP OAM requirements. The methods and procedure supported are listed in Table. 1:

TABLE I. G.8113.1 OAM FUNCTIONS [13]

| Application | OAM Function (IETF draft-bhh-mpls-tp-oam-y1731) | |
|---|---|---|
| Fault Management (FM) | Pro-active | Continuity check and Connectivity Verification (CC/CV) |
| | | Remote Defect Indication (RDI) |
| | | Alarm Indication signal (AIS) |
| | | Client signal Fail (CSF) |
| | On-demand | Connectivity Verification (CV) |
| | | Diagnostic test (DT) |
| | | Locked Signal (LCK) |
| Performance Management (PM) | Pro-active | Loss Measurement (LM) |
| | | Delay Measurement (DM) |
| | On-Demand | Loss Measurement (LM) |
| | | Delay Measurement (DM) |
| Other Applications | Automatic Protection Switching (APS) | |
| | Management communication channel/ Signaling communication channel (MCC/SCC) | |
| | Vendor-specific (VS) | |
| | Experimental (EXP) | |

This OAM toolset claims to be mature and widely deployed. It is still under consensus of standardization. However G.8113.1 requires a G-Ach codepoint to be assigned by IANA (IETF).

### B. IETF OAM Tools G.8113.2

The IETF solution is based on the existing MPLS OAM toolset and provides the following functions: CC for proactive monitoring, CV for End-point verification, PM, FM and Diagnostics. This solution needs specifics extensions of Bidirectional Forwarding Detection (BFD) and LSP Ping and needs also to introduce new mechanisms for the function that are not available in MPLS such as loss and delay measurement. BFD and LSP should be able to run without IP (IP less). The methods and procedure supported are listed in Table. 2:

TABLE II. IETF MPLS-TP OAM FUNCTIONS/RFCS

| | OAM Functions | RFC/draft |
|---|---|---|
| Pro-active FM OAM | MPLS-TP Identifiers | RFC6370 09/2011 |
| | RDI – use BFD extension | RFC6428 11/2011 |
| | AIS | RFC6427 11/2011 |
| | Link Down Indication (LDI) | |
| | Lock Report (LKR) | |
| | Config MPLS-TP OAM using LSP Ping | draft-absw-mpls-lsp-ping-mpls-tp-oam-conf-04 April 13, 2012 |
| On-Demand FM OAM | CV – use LSP Ping and BFD Extensions | RFC6426 11/2011 |
| | Loopback Message/Replay (LBM/LBR) | RFC6435 11/2011 |
| | Lock Instruct (LI) | |
| Proactive PM OAM Functions | Packet Loss Measurement (LM) | RFC6374 09/2011 |
| | Packet Delay Measurement (DM) | RFC6375 09/2011 |

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| | OAM Functions | RFC/draft |
|---|---|---|
| and On demand PM OAM | Throughput measurement (use LM) | |
| | Delay variation measurement (use DM) | |

IETF has overcome to luck of MPLS OAM by extending BFD and LSP Ping, and also by creating new tools in order to satisfy Transport-like OAM expectations.

Since both of solutions are meeting MPLS-TP OAM requirements, the selection criteria depend on each scenario:

- Different operators have different network scenarios
- Different vendors have different implementations.

G.8113.1 is supported by Alcatel-Lucent and Huawei Technologies Co. Ltd. and by carriers China Mobile Communications Corp. and Telecom Italia SpA. The G.8113.2 camp, meanwhile, counts Cisco Systems Inc. and Ericsson AB among its supporters.

## IV. Interoperability or Interworking : issues

ITU-T continues to standardize its Y.1731 based OAM solution, and is currently using an "experimental" MPLS OAM. IETF, on their side, published about many RFCs last year in order to complete their MPLS based OAM solution. Both of proposed standards claim to satisfy MPLS-TP OAM requirements. The biggest difference is the PDU format and how to identify an OAM function which makes interoperability impossible. When both solutions are present in the same network, or when interconnecting two different networks using different OAM solution, delivering end-to-end OAM become an issue.

The first option to resolve this issue is by implementing Interworking Function (IWF) at edge router to secure the mapping of different OAM message. This is also the most expensive option, since vendors have to develop IWF on their equipments.

The second one is to choose a network model in such a way to use the layered characteristics of MPLS-TP OAM: Section OAM (Link OAM), PW OAM, and LSP OAM. We suggest here, when possible, to run MPLS-TP OAM independently within each segment; see Figure 5. Maintenance Entity (ME) that exchange OAM inside the same Maintenance Domain has to use same OAM toolset. So "Operator Network 1" and "Operator Network 2" can run different OAM Toolset. Layered architecture can be based on peer or overlay model, or a mixture (hybrid).

We need to study the layered architecture to figure out how it is resolving MPLS-TP OAM interoperability issues with respect to standard requirements. An OAM discovery mechanism can be a solution where each MEP inside a maintenance domain will discover other MEPs and then exchange their capabilities.

## V. Conclusion

It is sufficient to have only one OAM solution for MPLS-TP, however there is two standard or pre-standard toolset and both of them are supported by industry. Consequently, equipment and network deployments will be more complex and interoperability issues are becoming reality. Introduction of new interworking functions can present a solution but are cost effective and software/hardware update will be more complex. We propose to use layering model which can avoid developing IWF in a lot of cases. We suggest creating new capabilities on border Node (at layer level) which allow dynamic exchange of OAM information: Type of toolset, MEs, MEPs, MIPs, etc. the associated Channel ACh would be a good starting point of this vision.

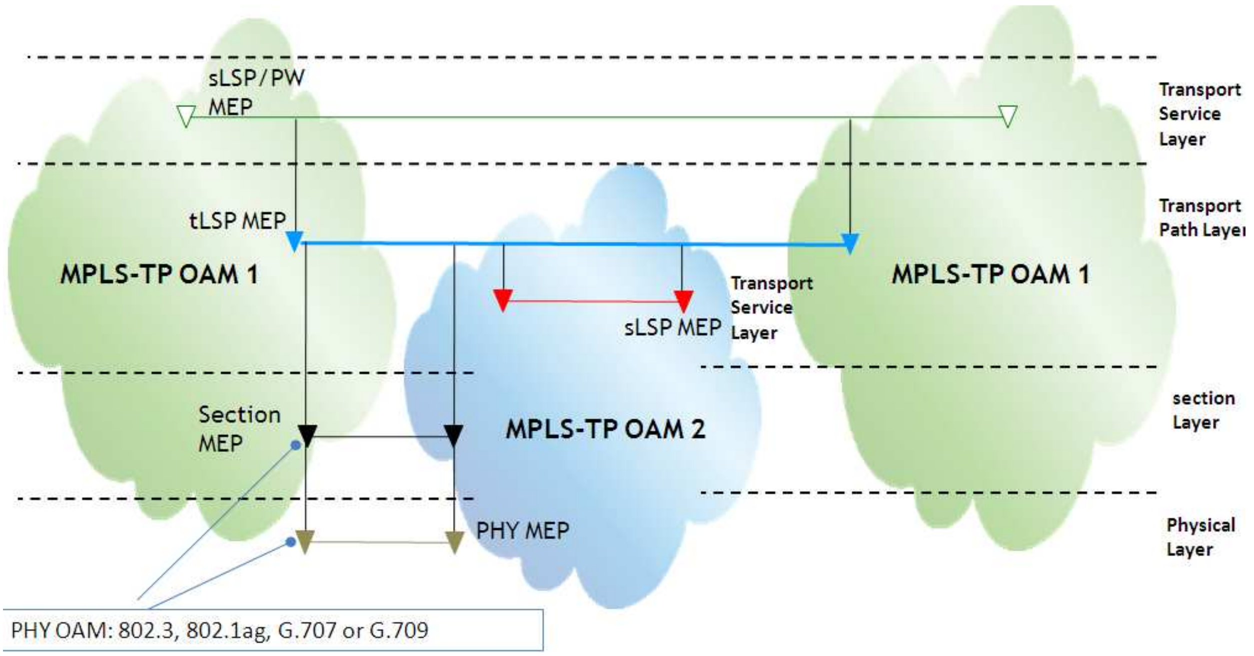


Figure 5. Layered OAM Model

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