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MPLS-TP OAM Analysis

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Abstract

This document analyzes the set of requirements for Operations, Administration, and Maintenance (OAM) for the Transport Profile of MPLS(MPLS-TP) as defined in [\[MPLS-TP OAM Reqs\] \(Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.\)](#), to evaluate whether existing OAM tools (either from the current MPLS toolset or from the ITU-T documents) can be applied to these requirements. Eventually, the purpose of the document is to map the set of functions to a set of tools based on the existing OAM toolset.

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1. Introduction

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1.1. Scope

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OAM (Operations, Administration, and Maintenance) plays a significant role in carrier networks, providing methods for fault management and performance monitoring in both the transport and the service layers in order to improve their ability to support services with guaranteed and strict Service Level Agreements (SLAs) while reducing their operational costs.

[\[MPLS-TP Reqs\]](#) (Niven-Jenkins, B., Nadeau, T., and C. Pignataro, "Requirements for the Transport Profile of MPLS," April 2009.) in general, and [\[MPLS-TP OAM Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) in particular define a set of requirements for OAM functionality in MPLS-Transport Profile (MPLS-TP) for MPLS-TP Segments, Label Switched Paths (LSPs) (network infrastructure) and Pseudowires (PWs) (services). One of the mandates of the joint (IETF and ITU-T) MPLS-TP work-item is the objective of developing a Transport Profile is to base the toolset on existing MPLS technologies. In addition, [\[MPLS-TP Reqs\]](#) (Niven-Jenkins, B., Nadeau, T., and C. Pignataro, "Requirements for the Transport Profile of MPLS," April 2009.) indicates the need for the OAM toolset for MPLS-TP to be fully interoperable with existing MPLS OAM tools. The purpose of this document is to outline the recommendations of the MPLS-TP design team and confirmed by the working group for the toolset that should be defined to fulfill the OAM functionality requirements as documented in [\[MPLS-TP OAM Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) and [\[MPLS-TP OAM Frwk\]](#) (Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.). Based on the principles cited above, it was determined to base the MPLS-TP OAM toolset on the following existing MPLS tools:

*LSP-Ping as defined in [\[LSP Ping\] \(Kompella, K. and G. Swallow, "Detecting Multi-Protocol Label Switched \(MPLS\) Data Plane Failures," February 2006.\)](#).

*Bidirectional Forwarding Detection (BFD) as defined in [\[BASE BFD\] \(Katz, D. and D. Ward, "Bidirectional Forwarding Detection," February 2009.\)](#) and refined in [\[MPLS BFD\] \(Aggarwal, R., Kompella, K., Nadeau, T., and G. Swallow, "BFD For MPLS LSPs," June 2008.\)](#).

*ITU-T OAM for Ethernet toolset as defined in [\[Y.1731\] \(International Telecommunications Union - Standardization, "OAM functions and mechanisms for Ethernet based networks," May 2006.\)](#) this will be used for functionality guidelines for the performance measurement tools that are not currently supported in MPLS.

It should be noted that certain extensions and adjustments may be made to the existing MPLS tools, in order to conform to the transport environment and the requirements of MPLS-TP.

1.2. Organization of the document

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Section 2 of the document provides references to the basic OAM tools that are provided for MPLS-TP OAM.

Section 3 outlines the different tools that are required for MPLS-TP OAM and references the documents that will define the appropriate tools based on the principles outlined above.

1.3. Contributing Authors

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1.4. Acronyms

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This draft uses the following acronyms:

ACH	Associated Channel Header
BFD	Bidirectional Forwarding Detection

CC-V	Continuity Check and Connectivity Verification
G-ACH	Generic Associated Channel Header
LSP	Label Switched Path
MPLS-TP	Transport Profile for MPLS
OAM	Operations, Administration, and Maintenance
PW	Pseudowire
RDI	Remote Defect Indication
SLA	Service Level Agreement
TLV	Type, Length, Value
VCCV	Virtual Circuit Connectivity Verification

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**Basic
OAM**

**infrastructure
functionality**

[\[MPLS-TP OAM](#)

[Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) defines a set of requirements on OAM architecture and general principles of operations which are evaluated below:

- *[\[MPLS-TP OAM Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) requires that OAM mechanisms in MPLS-TP are independent of the transmission media and of the client service being emulated by the PW.
- *[\[MPLS-TP OAM Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) requires that the MPLS-TP OAM must be able to support both an IP based and non-IP based environment. If the network is IP based, i.e. IP routing and forwarding are available, then the MPLS-TP OAM toolset should rely on the IP routing and forwarding capabilities. On the other hand, in environments where IP functionality is not available, the OAM tools must still be able to operate without dependence on IP forwarding and routing.
- *[\[MPLS-TP OAM Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) requires that all OAM protocols support identification information, at least in the form of IP addressing structure and be extensible to support additional identification schemes.
- *It is also required that OAM packets and the user traffic are congruent (i.e. OAM packets are transmitted in-band) and there is a need to differentiate OAM packets from user-plane ones. Inherent in this requirement is the principle that MPLS-TP OAM be independent of any existing control-plane, although it should not preclude use of the control-plane functionality.
- *[\[MPLS-TP OAM Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.)

requires a single OAM technology and consistent OAM capabilities for LSPs, PWs, and Sections.

- *[\[MPLS-TP OAM Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) requires allowing OAM packets to be directed to an intermediate point of a LSP/PW.

The following comprise the document-set that addresses the basic requirements listed above:

- *The [\[MPLS-TP OAM Frwk\]](#) (Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.) document describes the architectural framework for conformance to the basic requirements listed above. It also defines the basic relationships between the MPLS structures, e.g. LSP, PW, and the structures necessary for OAM functionality, i.e. the Managed Entity Group, its End-points, and Intermediate Points.
- *The [\[MPLS G-ACH\]](#) (Bocci, M., Bryant, S., and M. Vigoureux, "MPLS Generic Associated Channel," June 2009.) document specifies the use of the MPLS-TP in- band control channel. This is modeled after the VCCV channel described in [\[PW ACH\]](#) (Bryant, S., Swallow, G., Martini, L., and D. McPherson, "Pseudowire Emulation Edge-to-Edge (PWE3) Control Word for Use over an MPLS PSN," February 2006.) and allows transporting the OAM messages congruently with the data traffic while allowing the required identification of the packets. It is expected that all of the OAM protocols will be used in conjunction with this Generic Associated Channel.
- *The [\[MPLS-TP ACH TLV\]](#) (Boutros, S., Bryant, S., Sivabalan, S., Swallow, G., and D. Ward, "Definition of ACH TLV Structure," June 2009.) document specifies a basic set of TLV fields that could be used by different OAM messages, in conjunction with the Generic Associated Channel, to supply the additional parameter values necessary for the proper functionality.
- *The [\[MPLS TP Idents\]](#) (Bocci, M. and G. Swallow, "MPLS-TP Identifiers," March 2010.) document addresses the need of MPLS-TP to support different addressing spaces. This document describes different formats for addresses that could be used to identify the transport entities in the network and referenced by the different OAM protocols.

3. MPLS-TP OAM Functions

The following sections discuss the required OAM functions that were identified in [\[MPLS-TP OAM Regs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) and expanded upon in [\[MPLS-TP OAM Frwk\]](#) (Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.).

3.1. Continuity Check and Connectivity Verification

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Continuity Check and Connectivity Verification (CC-V) are OAM operations generally used in tandem, and compliment each other. These functions are generally run proactively, but may also be used on-demand, either due to bandwidth considerations or for diagnoses of a specific condition. Proactively [\[MPLS-TP OAM Regs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.) states that the function should allow the MEPS to monitor the liveness and connectivity of a transport path. In on-demand mode, this function should support monitoring between the MEPS and, in addition, between a MEP and MIP.

The [\[MPLS-TP OAM Frwk\]](#) (Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.) highlights the need for the CC-V messages to include unique identification of the MEG that is being monitored and the MEP that originated the message. The function, both proactively and in on-demand mode, need to be transmitted at regular rates pre-configured by the operator.

3.1.1. Documents for CC-V tools

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[\[Pro CC-V\]](#) (Allan, D. and G. Swallow, "Proactive Connection Verification, Continuity Check and Remote Defect indication for MPLS Transport Profile," June 2010.) defines the BFD extensions that will be used for proactive CC-V applications. While [\[Demand CV\]](#) (Bahadur, N., Aggarwal, R., Boutros, S., and E. Gray, "MPLS on-demand Connectivity Verification, Route Tracing and Adjacency Verification," June 2010.) provides the LSP-Ping extensions that will be used to implement on-demand Connectivity Verification. Both of these tools will be used together with the basic tools mentioned above in section 2

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3.2. Remote Defect Indication

Remote Defect Indication (RDI) is used by a path end-point to report to its peer end-point that a defect is detected on a bi-directional connection between them. [\[MPLS-TP OAM Reqs\] \(Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.\)](#) points out that this function may be applied to a unidirectional LSP only if there a return path exists. [\[MPLS-TP OAM Frwk\] \(Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.\)](#) points out that this function is associated with the proactive CC-V function

3.2.1. Documents for RDI

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The [\[Pro CC-V\] \(Allan, D. and G. Swallow, "Proactive Connection Verification, Continuity Check and Remote Defect indication for MPLS Transport Profile," June 2010.\)](#) document includes an extension for BFD that would include the RDI indication in the BFD format, and a specification of how this indication is to be used.

3.3. Route Tracing

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[\[MPLS-TP OAM Reqs\] \(Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.\)](#) defines that there is a need for functionality that would allow a path end-point to identify the intermediate and end-points of the path. This function would be used in on-demand mode. Normally, this path will be used for bidirectional PW, LSP, and sections, however, unidirectional paths may be supported only if a return path exists.

3.3.1. Documents for Route Tracing

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The [\[Demand CV\] \(Bahadur, N., Aggarwal, R., Boutros, S., and E. Gray, "MPLS on-demand Connectivity Verification, Route Tracing and Adjacency Verification," June 2010.\)](#) document that specifies the LSP-Ping enhancements for MPLS-TP on-demand Connectivity Verification includes information on the use of LSP-Ping for route tracing of a MPLS-TP transport path.

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3.4. Alarm Reporting

Alarm Reporting is a function used by an intermediate point of a path, that becomes aware of a fault on the path, to report to the end-points of the path. [\[MPLS-TP OAM Frwk\] \(Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.\)](#) states that this may occur as a result of a defect condition discovered at a server sub-layer. This generates an Alarm Indication Signal (AIS) that continues until the fault is cleared. The consequent action of this function is detailed in [\[MPLS-TP OAM Frwk\] \(Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.\)](#).

3.4.1. Documents for Alarm Reporting

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MPLS-TP defines a new protocol to address this functionality that is documented in [\[Fault Mng\] \(Swallow, G., Fulignoli, A., and M. Vigoureux, "MPLS Fault Management OAM," March 2010.\)](#). This protocol uses all of the basic mechanisms detailed in Section 2.

3.5. Lock Reporting

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Lock reporting, defined in [\[MPLS-TP OAM Reqs\] \(Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.\)](#), is similar to the Alarm Reporting function described above. It is used by an intermediate point to notify the end points of a transport path that an administrative lock condition exists for this transport path.

3.5.1. Documents for Lock Reporting

[TOC](#)

MPLS-TP defines a new protocol to address this functionality that is documented in [\[Fault Mng\] \(Swallow, G., Fulignoli, A., and M. Vigoureux, "MPLS Fault Management OAM," March 2010.\)](#). This protocol uses all of the basic mechanisms detailed in Section 2.

3.6. Diagnostic

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The [\[MPLS-TP OAM Reqs\] \(Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.\)](#)

indicates that there is need to provide a OAM function that would enable conducting different diagnostic tests on a PW, LSP, or Section. The [\[MPLS-TP OAM Frwk\] \(Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.\)](#) provides two types of specific tests to be used through this functionality:

- *Throughput Estimation – allowing the provider to verify the bandwidth/throughput of a transport path. This is an out-of-service tool, that uses special packets of varying sizes to test the actual bandwidth and/or throughput of the path.

- *Data-plane loopback – this out-of-service tool that causes all traffic that reaches the target node, either a MEP or MIP, to be looped back to the originating MEP. For targeting MIPs, a corouted bi-directional path is required.

3.6.1. Documents for Diagnostic Testing

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These diagnostic functions are being defined in a merge of existing separate individual drafts. The merged document will define a new G-ACH based protocol message that addresses the Throughput Estimation tool, and also provide various flavors of loopback functionality.

3.7. Lock Instruct

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The Lock Instruct function is an administrative control tool that allows a path end-point to instruct its peer end-point to lock the path. The tool is necessary to support single-side provisioning for administartive locking, according to . This function is used on-demand.

3.7.1. Documents for Lock Instruct

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Work is being done on a document that will specify the new ACH based protocol format for this tool.

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3.8. Client Failure Indication

Client Failure Indication (CFI) is defined in [\[MPLS-TP OAM Reqs\]](#) ([Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.](#)) to allow the propagation information from one edge of the network to the other. The information concerns a defect to a client, in the case that the client does not support alarm notification.

3.8.1. Documents for CFI

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Work is being done on a document that will specify the new ACH based protocol format for this tool.

3.9. Packet Loss Measurement

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Packet Loss Measurement is required, by [\[MPLS-TP OAM Reqs\]](#) ([Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.](#)) to provide a quantification of the packet loss ratio on a transport path. This is the ratio of the number of user packets lost to the total number of user packets during a defined time interval. To employ this function, [\[MPLS-TP OAM Frwk\]](#) ([Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.](#)) defines that the two end-points of the transport path should exchange counters of messages transmitted and received within a time period bounded by loss-measurement messages. The framework warns that there may be small errors in the computation that result from various issues.

3.9.1. Documents for Packet Loss Measurement

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The [\[Loss-Delay\]](#) ([Frost, D. and S. Bryant, "Packet Loss and Delay Measurement for the MPLS Transport Profile," April 2010.](#)) describes the protocol formats and procedures for using the tool. The tool logic is based on the behavior of the parallel function described in [\[Y.1731\]](#) ([International Telecommunications Union - Standardization, "OAM functions and mechanisms for Ethernet based networks," May 2006.](#)).

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3.10. Packet Delay Measurement

Packet Delay Measurement is a function that is used to measure one-way or two-way delay of a packet transmission between a pair of the end-points of a path (PW, LSP, or Section), as described in [\[MPLS-TP OAM Reqs\]](#) (Vigoureux, M., Betts, M., and D. Ward, "Requirements for OAM in MPLS Transport Networks," April 2009.). Where:

*One-way packet delay is the time elapsed from the start of transmission of the first bit of the packet by a source node until the reception of the last bit of that packet by the destination node.

*Two-way packet delay is the time elapsed from the start of transmission of the first bit of the packet by a source node until the reception of the last bit of the loop-backed packet by the same source node, when the loopback is performed at the packet's destination node.

[\[MPLS-TP OAM Frwk\]](#) (Busi, I., Niven-Jenkins, B., and D. Allan, "MPLS-TP OAM Framework and Overview," July 2010.) describes how the tool could be performed (both in proactive and on-demand modes) for either one-way or two-way measurement. However, it warns that the one-way delay option requires precise time synchronization between the end-points.

3.10.1. Documents for Delay Measurement

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The [\[Loss-Delay\]](#) (Frost, D. and S. Bryant, "Packet Loss and Delay Measurement for the MPLS Transport Profile," April 2010.) describes the protocol formats and procedures for using the tool. The tool logic is based on the behavior of the parallel function described in [\[Y.1731\]](#) (International Telecommunications Union - Standardization, "OAM functions and mechanisms for Ethernet based networks," May 2006.).

4. IANA Considerations

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This document makes no request of IANA.

Note to RFC Editor: this section may be removed on publication as an RFC.

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5. Security Considerations

This document does not by itself raise any particular security considerations.

6. Acknowledgements

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The editors wish to thank the MPLS-TP Design Team members, from both the IETF and ITU-T leadership teams, in formulating the recommendations documented here. In particular, we would like to thank Loa Andersson, Huub van Helvoort, and the Area Directors for their suggestions and enhancements to the text.

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