

Network Working Group  
Internet Draft  
Intended status: Standards Track  
Expires: September 2009

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March 9, 2009

Performance Monitoring of MPLS Transport Profile LSP  
draft-boutros-mpls-tp-performance-01.txt

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Abstract

This document specifies an extension to MPLS Operation, Administration, and Maintenance (OAM) for monitoring the performance of an MPLS Transport Profile(MPLS-TP) Label Switched Path (LSP) with respect to packet loss and unidirectional delay/jitter.

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## [1.](#) Introduction

In traditional transport networks, circuits such as T1 lines are provisioned on multiple switches, and service providers should be able to monitor the performance of such circuits for management purpose. For example, when performance of a primary circuit degrades backup circuit may be activated. An MPLS-TP bidirectional LSPs emulate the traditional transport circuits and hence should provide the same performance measurement capability. In this document, an MPLS-TP LSP means either an MPLS transport LSP or an MPLS Pseudowire (PW).

This document specifies an MPLS-TP LSP performance monitoring scheme that is based on two new types of MPLS-OAM packets called "MPLS-OAM Performance Control(PC)" and "MPLS-OAM Performance Flow(PF)". These packets are sent at a rate that is acceptable to both sender and receiver. The MPLS-OAM PC packets are used to setup an MPLS-TP LSP for performance monitoring, and the MPLS-OAM PF packets are used as the probes for collecting performance data.

Performance can be monitored using one of the two following modes:

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On-Demand: An MPLS-TP LSP's performance is monitored only based on operator request, i.e., performance is not monitored automatically as soon as the LSP becomes operational.

Continuous: In this mode, it is assumed that an MPLS-TP LSP is configured for continuous performance monitoring. Also, the relevant configuration can be applied to and removed from an MPLS-TP LSP at any time during the life of the LSP. When configured for continuous performance monitoring, an MPLS-TP LSP's performance is continuously monitored as soon as it becomes operational.

The following features are common to both the on-demand and the continuous modes:

1. The LSP can be optionally locked for data traffic.
2. MPLS-OAM PC and PF packets can be consumed by either a Maintenance Intermediate Point (MIP) or a Maintenance End Point (MEP).
3. MPLS-OAM PC and PF packets are intercepted at any MIP based on MPLS TTL expiry, and are intercepted at MEP simply because it is the egress LSR of the LSP (i.e., regardless of the TTL value).
4. More than one MPLS-OAM performance flows can be maintained simultaneously from a MEP to any MIP or the other MEP.
5. The transmission rate of MPLS-OAM PF packets MUST be acceptable to both the sender and the receiver, otherwise transmission of such packets MUST NOT begin. The rate is negotiated via MPLS-OAM PC packets.
6. An MPLS OAM PF packets contains sequence number and time-stamp to measure packet loss and unidirectional delay/jitter.

In the continuous mode, the MEP at which performance is monitored is configured to send MPLS-OAM PF packets continuously to different MIPs and/or the other MEP. The configuration specifies:

- . Rate at which the MPLS-OAM PF packets are sent.
- . Addresses of MIPs/MEP to which the MPLS-OAM PF packets are

destined.

- . Whether or not performance is monitored in both directions of the MPLS-TP LSP.

- . Rate at which the number of lost MPLS-OAM PF packets should be reported to the sender MEP.

The proposed mechanism is based on a set of new TLVs which can be transported using one of the following methods:

1. Using in-band MPLS OAM messages which are forwarded as MPLS packets (non-IP based).
2. Using in-band LSP-Ping extensions defined in [3] where IP/UDP packets are used (IP-based). The LSP-Ping messages are sent using the codepoint defined in [2].

Method (1) and (2) are referred to as "Non-IP option" and "LSP-Ping option" respectively in the rest of the document.

Conventions used in this document

In examples, "C:" and "S:" indicate lines sent by the client and server respectively.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC-2119](#) [1].

## [2](#). Terminology

ACH: Associated Channel Header

LSR: Label Switching Router

MEP: Maintenance End Point

MIP: Maintenance Intermediate Point

MPLS-OAM: MPLS Operations, Administration and Maintenance

MPLS-TP: MPLS Transport Profile

MPLS-TP LSP: Bidirectional Label Switch Path representing a circuit

NMS: Network Management System

PC: Performance Control

PF: Performance Flow

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PM: Performance Monitoring

TLV: Type Length Value

TTL: Time To Live

### [3.](#) MPLS-TP Performance Monitor Mechanism

For the Non-IP option, the proposed mechanism uses two new code points in the Associated Channel Header (ACH) described in [\[6\]](#). The LSP-Ping option is in compliance to the specifications [\[2\]](#), [\[3\]](#), and [\[7\]](#).

The proposed mechanism requires a set of new TLVs called Performance Request TLV, Performance Loss Report TLV.

In addition, the proposed mechanism uses the Address and LSPI TLVs defined in [\[5\]](#). Moreover, it can also be used in conjunction with the data-locking mechanism defined in [\[4\]](#).

The new TLVs are described below.

## [4.](#) MPLS-OAM Performance Message

### [4.1.](#) In-band Message Identification

In the in-band option, under MPLS label stack of the MPLS-TP LSP, the ACH with "MPLS-TP Performance Control" code point indicates that the message is an MPLS OAM Performance Control (PC) message. The ACH with code point "MPLS-TP Performance Flow" indicates that the message is an MPLS OAM Performance Flow (PF) message.

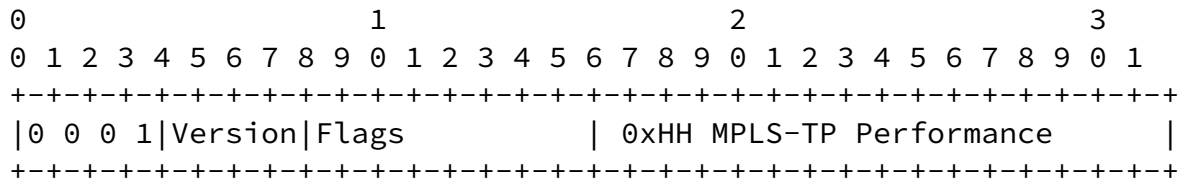


Figure 1: ACH Indication of MPLS-TP Performance Control

The first nibble (0001b) indicates the ACH. The version and the reserved values are both set to 0 as specified in [1]. MPLS-TP Performance control and performance flow code points = 0xHH and 0xhh. [HH and hh to be assigned by IANA from the PW Associated Channel Type registry.]

#### 4.2. Out-of-band Message Identification

[To be added]

#### 4.3. MPLS-OAM Performance control Message Format

The format of an MPLS-OAM Performance control Message is shown below.

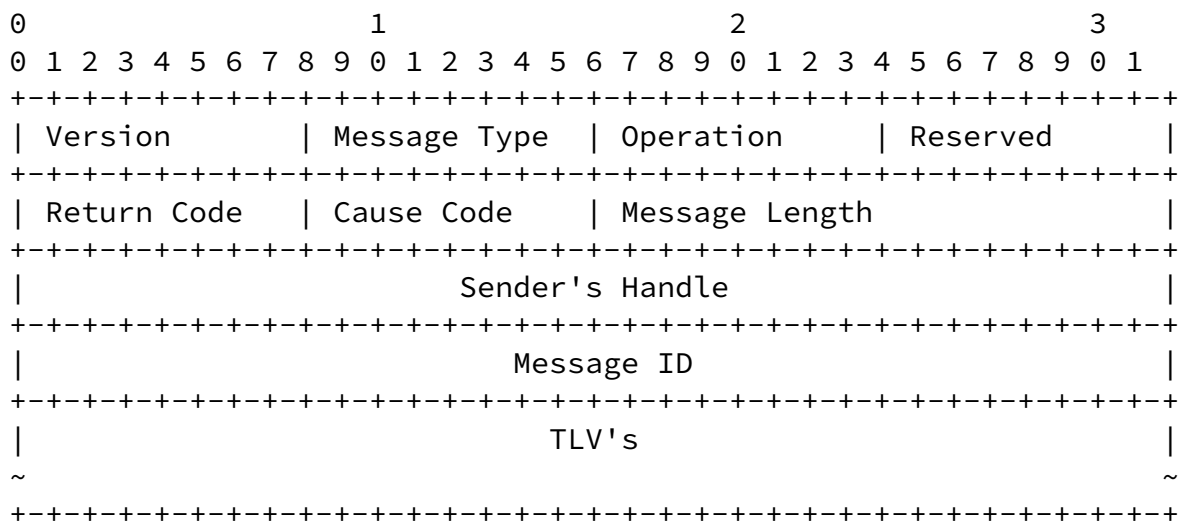


Figure 2: MPLS-TP OAM Message Format

#### Version

The Version Number is currently 1.

#### Message Type

Four message types are defined as shown below.

Message Type	Description
-----	-----
0x1	Performance Request
0x2	Performance Report
0x3	Performance Removal
0x4	Performance Response

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Two operations are defined as shown below. In the unidirectional mode, the receiver MIP or MEP does not have to maintain a PM flow towards the sender MEP. But, in the bidirectional mode, the receiver MIP or MEP MUST maintain a PM flow towards the sender MEP.

Operation	Description
-----	-----
0x0	Unidirectional
0x1	Bidirectional

#### Sender's Handle

The Sender's Handle is filled in by the sender. There are no semantics associated with this handle.

#### Message Length

The total length of any included TLVs.

#### Message ID

The Message ID is set by the sender and is incremented everytime the sender sends a new message. The receiver MUST include the Message ID in the response. This way, the sender can correlate a reply with the corresponding request.

#### Return code

Value	Meaning
0	Informational
1	Success
2	Failure

#### Cause code

Value	Meaning
1	Fail to match MPLS-TP LSP ID.
2	Malformed performance message received
3	One or more of the TLVs is/are unknown
4	Authentication failed
5	Specified PF Packet Rate cannot be supported
6	Specified Packet Loss Report Rate cannot be supported

Note that the MPLS-TP LSP whose performance is to be monitored is identified by the LSP ID TLV as defined in [5] in the MPLS-OAM performance message.

MPLS-TP performance control message may include authentication TLV defined in [4].

#### 4.4. Performance Request TLV

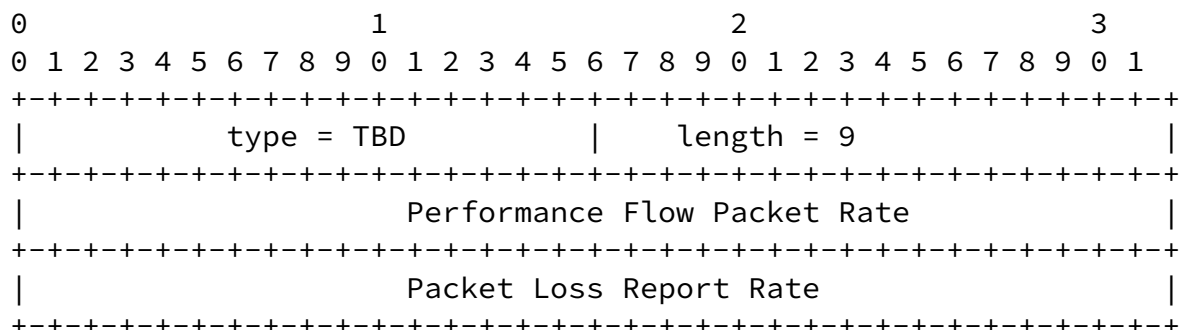


Figure 2: Performance Request TLV



When a MEP wants to monitor performance on an MPLS-TP, it sends an MPLS-OAM PC packet with Performance Request TLV. The Performance Request message can be intercepted by either a MIP (due to TTL expiry) or a MEP (simply because it is the egress LSR).

Performance Flow Packet Rate (in packets per second) specifies the maximum rate at which MPLS-OAM PF packets can be sent.

Packet loss Report Rate specifies the maximum rate at which the loss of MPLS-OAM PF packets can be reported to the sender MEP.

The receiver MIP or MEP MUST send either an ACK or NAK response to the sender MEP using an MPLS OAM performance response message. An ACK response is sent if the receiver can support the specified rates. Otherwise, a NAK response is sent. Until an ACK response is received, the sender MEP MUST NOT assume that the MPLS-TP LSP is ready for performance monitoring.

If multiple Performance Request TLVs are present, only the first TLV is taken into consideration.

#### [4.5.](#) Packet Loss Reporting TLV

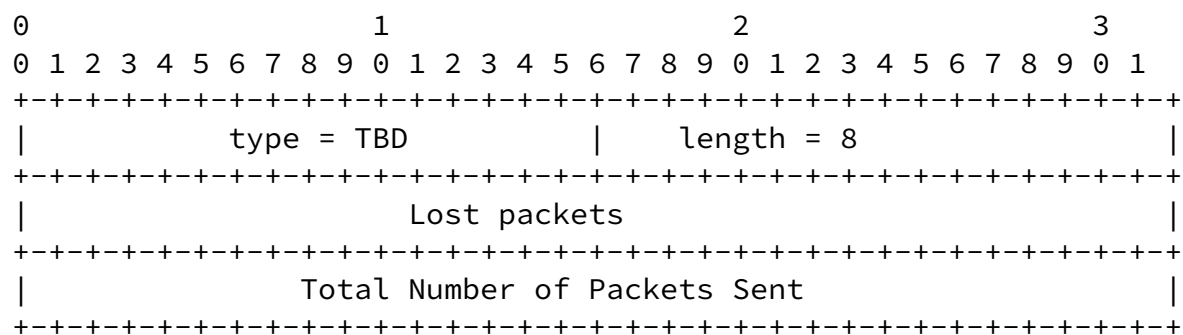


Figure 4: Packet Loss Report TLV

Performance monitor report MPLS-OAM Messages will be sent at the rate that does not exceed the maximum packet loss reporting rate specified in the MPLS-OAM Performance Request TLV.

This TLV includes the number of lost MPLS-OAM PF packets as well as the total number of MPLS-OAM PF flow packets that it must have received from the sender. The receiver figures out the latter using the sequence number in the MPLS-OAM PF packets (described below).

#### 4.6. Performance Removal

When performance monitor mode operation of an MPLS-TP LSP is no longer required, the MEP that previously sent the MPLS OAM Performance request message sends another MPLS OAM performance removal message.

The receiver MEP or MIP MUST send either an ACK or NAK response to the sender MEP using an MPLS OAM performance response message. An ACK response is sent if the MPLS-TP LSP is already monitoring performance. Otherwise, a NAK response is sent.

#### 4.7. MPLS-OAM PF Packet

When the performance of MPLS-TP LSP is monitored, MPLS-OAM PF packets are sent from the sender MEP to the MEP/MIP end of the flow. A PF packet contains a sequence number and a time-stamp using which the receiver can calculate packet loss and one-way delay/jitter.

```

0                               1                               2                               3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                               MPLS Label stack                               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                               Label with EOS bit set                               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|0 0 0 1|Version|Reserved      |0xHH (MPLS-TP Performance Flow)|
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                               Sequence Number                               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+
|                               TimeStamp                               |
+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+---+

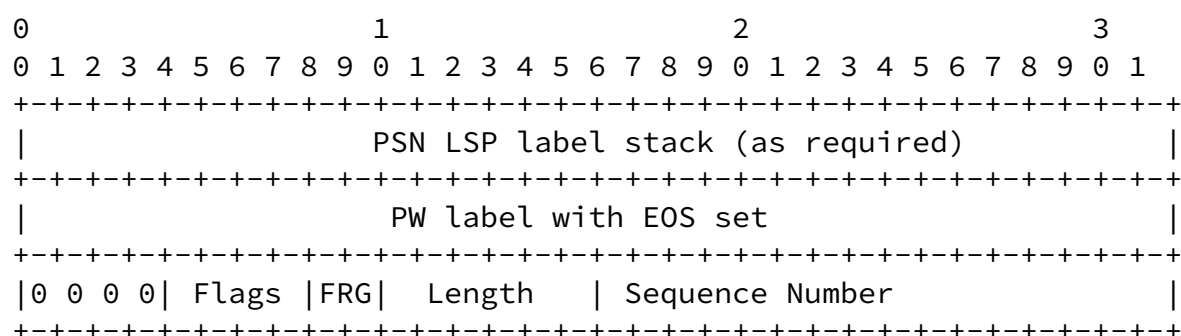
```

Figure 5: MPLS-OAM PF Packet

#### 4.8. Monitoring regular PW packets

When the performance of PW is monitored, in continuous mode, regular PW data packets can be used to monitor performance. PW packets in the presence of CW contain a sequence number that can be used to measure packets loss.

Data traffic is sent over an MPLS-TP PW using the format shown below:-



#### 4.9. Network Management System

An operator should be able to provision any given LSR to:

1. Lock/Unlock any MPLS-TP LSP.
2. Send MPLS OAM packets from a MEP and notify NMS when MPLS OAM response arrives.

When NMS is used to provision any of the above the functionality, the corresponding MPLS OAM message is not used.

#### 5. Operation

Consider an MPLS-TP LSP LSR-1 <--> LSR-2 <--> LSR-3 <--> LSR-4 <--> LSR-5. LSR-1 and LSR-5 are ingress and egress LSR for the respective direction, and LSR-1 and LSR-5 act as MEPs and LSR-2, LSR-3 and LSR-5 acts as a MIPs.

Assume that the objective is to evaluate the performance of the segment between LSR-1 and LSR-2 at LSR-1. Thus, LSR-2 is the destination for the MPLS-OAM PM packets.

- 1- LSR-1 sends an optional Lock Request MPLS-OAM message to LSR-5 (egress LSR) to take the MPLS-TP LSP out of service
- 2- LSR-5 takes the MPLS-TP LSP out of service from data-plane and sends an ACK MPLS-OAM message back to LSR-1
- 3- LSR-1 sends a PM Request MPLS-OAM message to LSR-2 containing its source address the MPLS-TP LSP ID, and destination address of LSR-2, maximum rate at which PF packets are to be sent, maximum packet loss report rate (back to LSR-1), and an indication as to whether or not LSR-2 also needs to send MPLS-OAM PM packets.
- 4- LSR-2 verifies the LSP ID, and the destination address and sends a performance response MPLS-OAM message with return code 1(success) back to LSR-1 if it can handle the specified PM packet transmission and loss reporting rate, otherwise LSR-2 sends the performance response MPLS-OAM message with return code 2(failure) back to LSR-1 with the following cause codes:
  1. if destination address or LSP-ID cannot be matched, it sends a response with cause code 1.
  2. if the message is malformed, it sends a response with the cause code 2.
  3. if any of the TLV is not known, it sends a response with cause code 3. It may also include the unknown TLVs.
  4. if message authentication fails, it sends a response with the cause code 4.
  5. if the specified PF packet rate cannot be handled, it sends a response with cause code 5.

6. if the specified packet loss report rate cannot be supported, it sends a response with cause code 6.

Note that MPLS TTL value is set to 255 in the response message.

After receiving the ACK from LSR-2 for the MPLS-OAM PM request, MPLS-OAM PF packets are transmitted on the MPLS-TP LSP.

Both LSR-1 and LSR-2 keep a count of the lost MPLS-OAM PF packets.

The receiver LSR computes the number of lost MPLS-OAM PF flow packets using the sequence number. Note that the sequence number equals the total number of packets that must have received in the absence of any packet loss.

The receiver periodically send the number of lost MPLS-OAM PF packets as well as the total number of MPLS-OAM PF packets that it must have received to the sender.

Removal of PM mode (only for on-demand mode)

- 1- LSR-1 sends an MPLS-OAM message to LSR-2 in order to stop operating the MPLS-TP LSP in Performance Management mode.
- 2- LSR-2 sends its latest Packet Loss Report to LSR-1 via an MPLS-OAM message.
- 3- LSR-1 sends an Unlock Request MPLS-OAM message to LSR-5
- 4- LSR-5 puts the MPLS-TP LSP back in service and sends an ACK MPLS-OAM message back to LSR-1.

## 6. Security Considerations

The security considerations for the authentication TLV need further study.

## 7. IANA Considerations

To be added.

## 8. References

### 8.1. Normative References

- [1] Bradner. S, "Key words for use in RFCs to Indicate Requirement Levels", [RFC 2119](#), March, 1997.

- [2] T. Nadeau, et. al, "Pseudowire Virtual Circuit Connectivity Verification (VCCV): A Control Channel for Pseudowires ", [RFC 5085](#), December 2007.
- [3] K. Kompella, G. Swallow, "Detecting Multi-Protocol Label Switched (MPLS) Data Plane Failures", [RFC 4379](#), February 2006.
- [4] S. Boutros, et. al., "Operating MPLS Transport Profile LSP in Loopback Mode", [draft-boutros-mpls-tp-loopback-01.txt](#), Work in Progress, December 2008.

## 8.2. Informative References

- [5] S. Boutros, et. al., "Definition of ACH TLV Structure", [draft-bryant-mpls-tp-ach-tlv-00.txt](#), Work in Progress, January 2009.
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- [7] Nabil Bitar, et. al, "Requirements for Multi-Segment Pseudowire Emulation Edge-to-Edge (PWE3) ", [RFC5254](#), October 2008.

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#### Acknowledgment

Funding for the RFC Editor function is currently provided by the Internet Society.

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