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LDP Extensions for Proactive Operations, Administration and Maintenance  
Configuration of Dynamic MPLS Transport Profile PseudoWire  
[draft-ietf-pals-mpls-tp-oam-config-02](#)

## Abstract

This document defines extensions to LDP to configure proactive OAM functions for both SS-PW and MS-PW when the PW control plane is used.

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## **[1.](#) Introduction**

There are two documents that define MultiProtocol Label Switching (MPLS) Pseudowire (PW). [[RFC3985](#)] defines Singel Segment PW (SS-PW) and [[RFC5659](#)] defines Multi-Segment PW (MS-PW). The two documents expain how to provide emulated services over an MPLS Packet Switched Network (PSN). The MPLS Transport Profile (MPLS-TP) is described in [[RFC5291](#)], which describes a profile of MPLS that introduces the operational models that were typically used in transport networks, while providing additional Operations, Administration and Maintenance (OAM), survivability and other maintenance functions that were not previously supported by IP/MPLS network. The MPLS-TP requirements are defined in [[RFC5860](#)].

The MPLS-TP OAM mechanisms are described in [[RFC6371](#)], which can be categorized into proactive and on-demand OAM. Proactive OAM refers to OAM operations that are either configured to be carried out



periodically and continuously or preconfigured to act on certain events (e.g., alarm signals). In contrast, on-demand OAM is initiated manually and for a limited amount of time, usually for operations such as diagnostics to investigate into a defect condition.

When a control plane is not used the OAM functions are typically configured from the Network Management System (NMS). When a control plane is used, requirement 51 in [\[RFC5654\]](#) requires that it MUST be able to support configuration of the OAM functions. The control plane is also required to be able to configure, maintain and modify, as well as activation/deactivation of maintenance points.

For MPLS-TP OAM configuration, two companion documents exists. One of them is [\[RFC7260\]](#) that specifies extensions to Resource Reservation Protocol - Traffic Engineering (RSVP-TE) to support the establishment and configuration of OAM entities along with Label Switched Path (LSP) signaling. The other is [\[I-D.ietf-mpls-lsp-ping-mpls-tp-oam-conf\]](#) that defines how LSP Ping is extended to support the configuration of proactive MPLS-TP OAM functions.

This document defines extensions to the Label Distribution Protocol (LDP) to configure MPLS-TP PW OAM functions for both Point to Point SS-PW and MS-PW, which are aligned with those companion documents. Extensions to Point to Multi-Point (P2MP) PW are for future study and outside the scope of this document.

## **2. Conventions used in this document**

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 [\[RFC2119\]](#).

### **2.1. Acronyms**

AIS: Alarm indication signal

BFD: Bidirectional Forwarding Detection

CC: Continuity Check

CV: Connectivity Verification

DM: Delay Measurement

FEC: Forwarding Equivalence Class



FMS: Fault Management Signal

G-ACh: Generic Associated Channel

LDI: Link Down Indication

LDP: Label Distribution Protocol

LM: Loss Measurement

LSP: Label Switched Path

MEP: Maintenance Entity Group End Point

MIP: Maintenance Entity Group Intermediate Point

MPLS-TP: MPLS Transport Profile

MS-PW: Multi-Segment PseudoWire

NMS: Network Management System

OAM: Operations, Administration and Maintenance

P2MP: Point to Multi-Point

PE: Provider Edge

PHB: Per-Hop Behavior

PM: Performance Monitoring

PSN: Packet Switched Network

PW: Pseudowire

S-PE: Switching Provider Edge

SS-PW: Single-Segment Pseudo Wire

T-PE: Terminating Provider Edge

TLV: Type Length Value



### 3. MPLS-TP PW OAM Configuration

This document defines two new TLVs, the PW OAM Administration TLV and the PW OAM Functions TLV.

The PW OAM Administrations TLV is used setup/remove MIP and MEP Functions and to control whether alarms are suppressed or not.

The PW Functions TLV is used to configure, enable and disable OAM Functions (e.g. CC, CV and PM). More details about the new TLVs are found in [Section 4](#).

#### 3.1. OAM Configuration for SS-PW

##### 3.1.1. Establishment of OAM Entities and Functions

OAM entities and functions can be setup, configured and activated either when the PW first is signalled or on an already established PW. This section describes how the OAM entities and functions are setup and configured with the signalling of a PW.

For the case where OAM entities and functions are setup and configured after PW establishment of a PW, the procedures are identical to the "adjustment of OAM parameters" procedures, more detail can be found in [Section 3.1.2](#).

Given that a SS-PW needs to be setup between PE1 and PE2 (see Figure 1) . OAM functions MUST be setup and enabled in the appropriate order so that spurious alarms can be avoided.



Figure 1 SS-PW OAM Configuration Scheme

Figure 1: SS-PW OAM Configuration Scheme

First, the ingress PE (e.g., PE1) must setup the OAM sink function and prepare to receive OAM messages. Until the PW is fully established, any OAM alarm SHOULD be suppressed.

To achieve this, a Label Mapping message with the "OAM Alarms Enabled" flag cleared is sent. In the message, the "OAM MEP Entities Desired" flag is set. Since there is no MIPs for a SS-PW, the "OAM





MIP Entities desired" flag MUST be cleared. In addition, to configure and enable particular OAM functions, the PW OAM Functions TLV and relevant sub-TLVs MUST be included.

When the Label Mapping message is received by PE2, PE2 needs to check whether it supports the requested OAM configuration. If it does not support the requested OAM configuration, a Label Release message MUST be returned to PE1, with a Status Code set to "MPLS-TP PW OAM Parameters Rejected". The PW signalling is complete and the PW will not be established. If the requested OAM parameters and configuration are supported, PE2 will establish and configure the requested OAM entities.

If PE2 fails to establish and configure the OAM entities, a Label Release message will be returned to PE1, with a Status Code set to "MPLS-TP PW MEP Configuration Failed". The PW signalling is complete and the PW will not be established.

If the OAM entities are setup and configured successfully, the OAM sink and source functions is setup and the OAM sink function will be configured to receive OAM messages.

Since the OAM alarm is disabled, no alarms will be generated. The OAM source function can start to send OAM messages. PE2 will then reply a Label Mapping message to PE1, the PW OAM Administration TLV and PW OAM Configuration TLV from the received Label Mapping message MUST be copied and carried in the Label Mapping message.

When PE1 receives this Label Mapping message, PE1 completes any pending OAM configuration and enables the OAM source function to send OAM messages.

For PE1, the OAM entities and functions are now setup and configured, and OAM messages may be exchanged. The OAM alarms can be safely enabled. The initiator PE (PE1) will send another Label Mapping message with "OAM Alarms Enabled" flag set to PE2, this will allow PE2 to enable the OAM alarm function.

When the Label Mapping message is received by PE2, the OAM alarm will be enabled. PE2 then sends a Notification message with the Status Code set to "MPLS-TP PW OAM Alarms enabled" to PE1.

When the Notification message is received by PE1, PE1 enables the OAM alarm function. At this point, data-plane OAM is fully functional.



### **3.1.2. Adjustment of OAM Parameters**

Existing OAM parameters may be changed during the life time of a PW. To achieve this, PE1 sends a Label Mapping message with the updated OAM parameters to PE2.

To avoid spurious alarms, it is important that OAM sink and source functions on both PEs are updated in a synchronized way. First, the alarms of the OAM sink function should be suppressed. After that, new OAM parameters can be adjusted. Subsequently, the parameters of the OAM source function can be updated. Finally, the alarms can be enabled again.

Consequently, the ingress PE needs to keep its OAM sink and source functions running without any changes until the OAM parameters are updated. However, in order to suppress spurious alarms, it also need to disable the alarm functions before the Label Mapping message, with the "OAM Alarms Enabled" flag cleared and the updated PW OAM Function TLV, is sent. The OAM alarm function needs to be disabled until the corresponding response message is received.

On receipt of the Label Mapping message, PE2 needs to check whether the updated parameters can be supported. If they can be supported, PE2 needs first disable the OAM alarms firstly and then update the OAM parameters. When the update is done, a Notification message needs to be sent to PE1, with the Status Code set to "MPLS-TP PW MEP Configuration Succeed", to acknowledge the update. If PE2 can not support the update, a Notification message with Status Code set to "MPLS-TP PW OAM Parameters Rejected" will be sent to PE1.

When PE1 receives the Notification message with the Status Code set to "MPLS-TP PW MEP Configuration Succeed", PE1 will update using the new OAM parameters. After the OAM parameters are updated and the OAM is running with the new parameter settings, OAM alarms are still disabled. A subsequent Label Mapping message with "OAM Alarms Enabled" flag set will be sent to re-enable OAM alarms. If the Status Code of the received Notification message is "MPLS-TP PW OAM Parameters Rejected", it will not update the OAM parameters. The OAM alarms are just enabled again and the OAM will keep running with the old parameters. PE1 can also re-try changing the OAM parameters using a different set of parameters.

When PE2 received the Label Mapping message with "OAM Alarms Enabled" flag set, it will enable the OAM alarms and reply a Notification message with Status Code set to "MPLS-TP PW OAM Alarms Enabled". When received the Notification message, PE1 will enable the OAM alarms again.



### 3.1.3. Deleting OAM Entities

In some cases it may be useful to remove all OAM entities and functions from a PW without actually tearing down the connection. The deleting procedures are defined as below:

First, the ingress PE (e.g., PE1) disables its own the OAM alarms and then sends a Label Mapping message to the remote PE (e.g., PE2) with the "OAM Alarms Enabled" flag set but with all other OAM configurations unchanged.

When received the Label Mapping message, PE2 disables the OAM alarm and then send a Notification message with Status Code set to "MPLS-TP PW OAM Alarms Disabled" to PE1.

When received the confirmation from PE2, it's safe to delete the OAM entities. PE1 will delete the OAM entities related to the PW and send another Label Mapping message with the "OAM MEP Entities desired" flag cleared to PE2.

When PE2 received the Label Mapping message, it will delete all OAM entities related to the PW and then reply a Notification message with the Status Code set to "MPLS-TP PW MEP Entities Disabled" to PE1.

## 3.2. OAM Configuration for MS-PW

### 3.2.1. Establishment of OAM Entities and Functions

Given that a MS-PW needs to be setup between T-PE1 and T-PE2, across S-PE1 and S-PE2 (see Figure 2) . OAM functions MUST be setup and enabled in the appropriate order so that spurious alarms can be avoided.

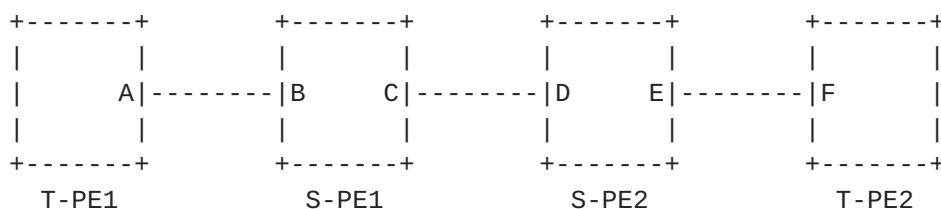


Figure 2 MS-PW Scenario

Figure 2: MS-PW OAM Configuration Scheme

Fist, T-PE1 must setup the OAM sink function and prepare to receive OAM messages. Until the PW is fully established, any OAM alarm SHOULD be suppressed.



To achieve this, a Label Mapping message with the "OAM Alarms Enabled" flag cleared is sent. If the S-PEs are expected to setup and configure the MIP entities, the "OAM MIP Entities desired" flag MUST be set. In the message, the "OAM MEP Entities Desired" flag is set. In addition, to configure and enable particular OAM functions, the PW OAM Functions TLV and relevant sub-TLVs MUST be included.

On receipt of the Label Mapping message, S-PE(e.g., S-PE1) needs to check whether it supports MIP function. If S-PE1 does not support MIP function, a Notification message will be sent to T-PE1, with the Status Code set to "MPLS-TP PW MIP Configuration Failed". If S-PE1 supports MIP function, it will establish and configure the MIP entities according to the "OAM MIP Entities desired" flag in the PW OAM Administration TLV. No matter whether S-PE1 supports MIP function, it will relay the Label Mapping message downstream to the next S-PE. All the subsequent S-PEs along the PW will perform the same operations as S-PE1 does until the Label Mapping message reaches the remote T-PE (T-PE2).

When the Label Mapping message is received by the remote T-PE (T-PE2), T-PE2 needs to check whether it support the requested OAM configuration. If it does not support the requested OAM configuration, a Label Release message MUST be returned to its upstream PE, with a Status Code set to "MPLS-TP PW MEP Configuration Failed". The signalling is complete and the PW will not be established. If the requested OAM parameters and configuration are supported, T-PE2 will establish and configure requested OAM entities.

If T-PE2 fails to establish and configure the OAM entities, a Label Release message MUST be replied to its upstream PE, with a Status Code set to "MPLS-TP PW MEP Configuration Failed". The signalling is complete and the PW will not be established.

If the OAM entities established and configured successfully, the OAM sink and source functions are setup and the OAM sink function will be configured to receive OAM messages. Since the OAM alarm is disabled, no alarms will be generated. The OAM source function can start to send OAM messages. T-PE2 will then reply a Label Mapping message, the PW OAM Administration TLV and PW OAM Function TLV from the received Label Mapping message MUST be copied and carried in the returned Label Mapping message.

S-PEs will relay the Label Mapping message upstream until it reaches T-PE1. When the Label Mapping message is received by T-PE1, T-PE1 will complete any pending OAM configuration and enables the OAM source function to send OAM messages.





For T-PE1, the OAM entities and functions are now setup and configured, and OAM messages may be exchanged. The OAM alarms can be safely enabled. T-PE1 will send another Label Mapping message with "OAM Alarms Enabled" flag set to enable the OAM alarm function.

When the Label Mapping message is received by S-PEs, S-PEs will enable the OAM alarm and relay the Label Mapping message downstream until it reaches T-PE2.

When the Label Mapping message is received by T-PE2, the OAM alarm will be enabled. T-PE2 then sends a Notification message to T-PE1, with the Status Code set to "MPLS-TP PW OAM Alarms Enabled". Once the Notification message is received by T-PE1, T-PE1 enables the OAM alarm function. At this point, data-plane OAM is fully functional.

### **3.2.2. Adjustment of OAM Parameters**

Existing OAM parameters may be changed during the life time of a PW. To achieve this, the T-PE1 needs to send a Label Mapping message with the updated OAM parameters to adjust and update OAM parameters.

To avoid spurious alarms, it is important that OAM sink and source functions on both sides are updated in a synchronized way. First, the alarms of the OAM sink function should be suppressed. After that, new OAM parameters can be adjusted. Subsequently, the parameters of the OAM source function can be updated. Finally, the alarms can be enabled again.

Consequently, T-PE1 needs to keep its OAM sink and source functions running without any changes until the OAM parameters are updated. However, in order to suppress spurious alarms, it also needs to disable the alarm functions before the Label Mapping message, with the "OAM Alarms Enabled" flag cleared and the updated PW OAM Function TLV, is sent. The OAM alarm function needs to be disabled until the corresponding response message is received.

When the Label Mapping message is received by S-PEs, each S-PE just disables the OAM alarm and relay the Label Mapping message downstream until the Label Mapping message reaches the remote T-PE (T-PE2).

On receipt of the Label Mapping message, T-PE2 needs to check whether the updated parameters can be supported. If they can be supported, T-PE2 needs first to disable the OAM alarms and then update the OAM parameters. When the update is done, a Notification message needs to be sent to T-PE1, with the Status Code set to "MPLS-TP PW MEP Configuration Succeed", to acknowledge the update. If T-PE2 cannot support the update, a Notification message with Status Code set to "MPLS-TP PW OAM Parameters Rejected" will be sent to T-PE1.



When T-PE1 receives the Notification message with the Status Code set to "MPLS-TP PW MEP Configuration Succeed", T-PE1 will update using the new OAM parameters. After the OAM parameters are updated and the OAM is running with the new parameter settings, OAM alarms are still disabled. A subsequent Label Mapping message with "OAM Alarms Enabled" flag set will be sent to re-enable OAM alarms. If the Status Code of the received Notification message is "MPLS-TP PW OAM Parameters Rejected", it will not update the OAM parameters. The OAM alarms are just enabled again and the OAM will keep running with the old parameters. T-PE1 can also re-try changing the OAM parameters using a different set of parameters.

When S-PEs receives the Label Mapping message, they will enable the OAM alarms and relay the Label Mapping message downstream.

When T-PE2 receives the Label Mapping message with the "OAM Alarms Enabled" flag set, it will enable the OAM alarms and reply a Notification message with Status Code set to "MPLS-TP PW OAM Alarms Enabled". When received the Notification message, T-PE1 will enable the OAM alarms again.

### **3.2.3. Deleting OAM Entities**

In some cases it may be useful to remove all OAM entities and functions from a PW without actually tearing down the connection. The deleting procedures are defined as below:

First, T-PE1 disables its own the OAM alarms and then sends a Label Mapping message to the remote PE (e.g., T-PE2) with the "OAM Alarms Enabled" flag cleared but with all other OAM configurations unchanged.

When received the Label Mapping message, S-PEs will disable the OAM alarm and relay the Mapping message downstream until the Label Mapping message reaches the remote T-PE (T-PE2).

When received the Label Mapping message, T-PE2 will disable the OAM alarm and then reply a Notification message with Status Code set to "MPLS-TP PW OAM Alarms Disabled" to T-PE1.

When received the confirmation from T-PE2, it's safe to delete the OAM entities. T-PE1 will delete the all OAM entities associated with the PW and send another Label Mapping message with both the "OAM MEP Entities desired" and "OAM MIP Entities desired" flags cleared to the remote T-PE.

When received the Label Mapping message, S-PE (e.g., S-PE1) will delete all the OAM entities associated with the PW and relay the



The "OAM MIP Entities Desired" flag is used to direct the S-PE(s) along a PW to establish (when set) or delete (when cleared ) the OAM MIP entities. This flag only applies to MS-PW scenario. For SS-PW









OAM Function Flags bit#	Description
-----	-----
0	Continuity Check (CC)
1	Connectivity Verification (CV)
2	Fault Management Signals (FMS)
3	Performance Monitoring (PM) Loss
4	Performance Monitoring (PM) Delay
5	Performance Monitoring (PM) Throughput
6-31	Reserved

The sub-TLVs corresponding to the different OAM function flags are as follows.

- o BFD Configuration sub-TLV MUST be included if the CC and/or the CV OAM Function flag is set. Furthermore, if the CV flag is set, the CC flag MUST be set as well.
- o Performance Monitoring sub-TLV MUST be included if the PM Loss/Delay OAM Function flag is set.
- o MPLS-TP PW FMS sub-TLV MAY be included if the FMS OAM Function flag is set. If the MPLS-TP PW FMS sub-TLV is not included, the default configuration values are used.

PW OAM Functions TLV is designed to share the sub-TLVs with MPLS OAM Functions TLV that is defined in [\[I-D.ietf-mpls-lsp-ping-mpls-tp-oam-conf\]](#). No assignments of sub-TLVs are made directly for PW OAM Functions TLV, the sub-TLV space and assignments for PW OAM Functions TLV will be the same as that for MPLS OAM Functions TLV. Sub-types for MPLS OAM Functions TLV and PW OAM Functions TLV MUST be kept the same. Any new sub-type added to MPLS OAM Functions TLV MUST apply to the PW OAM Functions TLV as well. More detail about the sub-TLVs definitions, please refer to Section 2.2 of [\[I-D.ietf-mpls-lsp-ping-mpls-tp-oam-conf\]](#).

In addition, [\[I-D.ietf-mpls-lsp-ping-mpls-tp-oam-conf\]](#) uses the LSP Ping return codes to carry the OAM parameters process related error codes. When the sub-TLVs of MPLS OAM Functions TLV are used for MPLS-TP PW OAM configuration, those related error codes apply. Since this document is based on LDP protocol, the LDP Status Codes are used to carry those error codes. More detail about the error codes please refer to Section 2.2 of [\[I-D.ietf-mpls-lsp-ping-mpls-tp-oam-conf\]](#) and [Section 5.2](#) of this document.



## **5. IANA Considerations**

### **5.1. TLVs**

IANA is requested to assign two new TLV types from the registry "TLV Type Name Space" in the "Label Distribution Protocol (LDP) Parameters" registry.

Value	TLV	References
-----	-----	-----
TBD1	PW OAM Administration TLV	this document
TBD2	PW OAM Functions TLV	this document

The sub-TLV space and assignments for the PW OAM Functions TLV will be the same as that for the MPLS OAM Functions TLV. Sub-types for the MPLS OAM Functions TLV and the PW OAM Functions TLV MUST be kept the same. Any new sub-type added to the MPLS OAM Functions TLV MUST apply to the PW OAM Functions TLV as well.

### **5.2. OAM Configuration Status Code**

IANA is requested to assign the following LDP status codes from the registry "STATUS CODE NAME SPACE" in the "Label Distribution Protocol (LDP) Parameters" registry.



Range/Value	E	Description	Reference
TBD3	0	"MPLS-TP PW OAM Alarms Enabled"	This document
TBD4	0	"MPLS-TP PW OAM Alarms Disabled"	This document
TBD5	0	"MPLS-TP PW MEP Configuration Failed"	This document
TBD6	0	"MPLS-TP PW MEP Configuration Succeed"	This document
TBD7	0	"MPLS-TP PW MEP Entities Disabled"	This document
TBD8	0	"MPLS-TP PW MIP Configuration Failed"	This document
TBD9	0	"MPLS-TP PW OAM Parameters Rejected"	This document
TBD10	0	"OAM Problem/Unsupported BFD Version"	LSP-OAM-CONF
TBD11	0	"OAM Problem/Unsupported BFD Encapsulation format"	LSP-OAM-CONF
TBD12	0	"OAM Problem/Unsupported BFD Authentication Type"	LSP-OAM-CONF
TBD13	0	"OAM Problem/Mismatch of BFD Authentication Key ID"	LSP-OAM-CONF
TBD14	0	"OAM Problem/Unsupported Timestamp Format"	LSP-OAM-CONF
TBD15	0	"OAM Problem/Unsupported Delay Mode"	LSP-OAM-CONF
TBD16	0	"OAM Problem/Unsupported Loss Mode"	LSP-OAM-CONF
TBD17	0	"OAM Problem/Delay variation unsupported"	LSP-OAM-CONF
TBD18	0	"OAM Problem/Dyadic mode unsupported"	LSP-OAM-CONF
TBD19	0	"OAM Problem/Loopback mode unsupported"	LSP-OAM-CONF
TBD20	0	"OAM Problem/Combined mode unsupported"	LSP-OAM-CONF
TBD21	0	"OAM Problem/Fault management signaling unsupported"	LSP-OAM-CONF
TBD22	0	"OAM Problem/Unable to create fault management association"	LSP-OAM-CONF

## 6. Security Considerations

Security considerations relating to LDP are described in [section 5 of \[RFC5036\]](#) and [section 11 of \[RFC5561\]](#). Security considerations relating to use of LDP in setting up PWs is described in [section 8 of \[RFC4447\]](#).

This document defines new TLV/sub-TLV types, and OAM configuration procedures intended for use with MPLS-TP, which do not raise any additional security issues.



## **7. Acknowledgement**

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## **8. References**

### **8.1. Normative references**

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