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MPLS On-Demand Connectivity Verification and Route Tracing

Abstract

Label Switched Path Ping (LSP ping) is an existing and widely deployed Operations, Administration, and Maintenance (OAM) mechanism for Multi-Protocol Label Switching (MPLS) Label Switched Paths (LSPs). This document describes extensions to LSP ping so that LSP ping can be used for on-demand connectivity verification of MPLS Transport Profile (MPLS-TP) LSPs and pseudowires. This document also clarifies procedures to be used for processing the related OAM packets. Further, it describes procedures for using LSP ping to perform connectivity verification and route tracing functions in MPLS-TP networks. Finally, this document updates RFC 4379 by adding a new address type and creating an IANA registry.

Status of This Memo

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1. Introduction

Label Switched Path Ping (LSP ping) [RFC4379] is an Operations, Administration, and Maintenance (OAM) mechanism for Multi-Protocol Label Switching (MPLS) Label Switched Paths (LSPs). This document describes extensions to LSP ping so that LSP ping can be used for on-demand monitoring of MPLS Transport Profile (MPLS-TP) LSPs and pseudowires. It also clarifies the procedures to be used for processing the related OAM packets. This document describes how LSP ping can be used for on-demand connectivity verification (Section 3) and route tracing (Section 4) functions required in [RFC5860] and specified in [RFC6371].

1.1. Conventions Used in This Document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "NOT RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in [RFC2119].

There is considerable opportunity for confusion in use of the terms "on-demand connectivity verification" (CV), "on-demand route tracing" and "LSP ping." In this document, we try to use the terms consistently as follows:

- o LSP ping: refers to the mechanism - particularly as defined and used in referenced material;

- On-demand CV: refers to on-demand connectivity verification and -- where both apply equally -- on-demand route tracing, as implemented using the LSP ping mechanism extended for support of MPLS-TP;

- On-demand route tracing: used in those cases where the LSP ping mechanism (as extended) is used exclusively for route tracing.

From the perspective of on-demand CV and route tracing, we use the concepts of "Requester" and "Responder" as follows:

- Requester: Originator of an OAM Request message,

- Responder: Entity responding to an OAM Request message.

Since, in this document, all messages are assumed to be carried in an LSP, all Request messages would be injected at the ingress to an LSP. A Responder might or might not be at the egress of this same LSP, given that it could receive Request messages as a result of time-to-live (TTL) expiry. If a Reply is to be delivered via a reverse-path LSP, the message would again be inserted at the ingress of that LSP.

1.2. On-Demand CV for MPLS-TP LSPs Using IP Encapsulation

LSP ping requires IP addressing on responding Label Switching Routers (LSRs) for performing OAM on MPLS-signaled LSPs and pseudowires. In particular, in these cases, LSP ping packets generated by a Requester are encapsulated in an IP/UDP header with the destination address from the 127/8 range and then encapsulated in the MPLS label stack ([RFC4379] , [RFC5884]). A Responder uses the presence of the 127/8 destination address to identify OAM packets and relies further on the UDP port number to determine whether the packet is an LSP ping packet. It is to be noted that this determination does not require IP forwarding capabilities. It requires the presence of an IP host stack, which enables responding LSRs to process packets with a destination address from the 127/8 range. [RFC1122] allocates the 127/8 range as "Internal host loopback address" and [RFC1812] states that "a router SHOULD NOT forward, except over a loopback interface, any packet that has a destination address on network 127".

1.3. On-Demand CV for MPLS-TP LSPs Using Non-IP Encapsulation

In certain MPLS-TP deployment scenarios, IP addressing might not be available or use some form of non-IP encapsulation might be preferred for on-demand CV, route tracing, and BFD packets. In such scenarios, on-demand CV and/or route tracing SHOULD be run without IP addressing, using the Associated Channel (ACH) channel type specified in Section 3.

Section 3.3 and Section 4.2 describe the theory of operation for performing on-demand CV over MPLS-TP LSPs with any non-IP encapsulation.

2. LSP Ping Extensions

2.1. New Address Type for Downstream Mapping TLV

[RFC4379] defines the Downstream Mapping (DSMAP) TLV. [RFC6424] further defines the Downstream Detailed Mapping (DDMAP) TLV. This document defines the following new address type, which MAY be used in any DSMAP or DDMAP TLV included in an on-demand CV message:

Type #	Address Type	K Octets
5	Non IP	12

Figure 1: New Downstream Mapping Address Type

The new address type indicates that no address is present in the DSMAP or DDMAP TLV. However, IF_Num information (see definition of "IF_Num" in [RFC6370]) for both ingress and egress interfaces, as well as Multipath Information, is included in the format and MAY be present.

IF_Num values of zero indicate that no IF_Num applies in the field in which this value appears.

The Multipath Type SHOULD be set to zero (no multipath) when using this address type.

When this address type is used, on receipt of an LSP ping echo request, interface verification MUST be bypassed. Thus, the receiving node SHOULD only perform MPLS label control-plane/data-plane consistency checks. Note that these consistency checks include checking the included identifier information.

The new address type is also applicable to the Detailed Downstream Mapping (DDMAP) TLV defined in [RFC6424].

2.1.1. DSMAP/DDMAP Non-IP Address Information

If the DSMAP (or DDMAP) TLV is included when sending on-demand CV packets using ACH, without IP encapsulation, the following information MUST be included in any DSMAP or DDMAP TLV that is included in the packet. This information forms the address portion of the DSMAP TLV (as defined in [RFC4379]) or DDMAP TLV (as defined in [RFC6424] using one of the address information fields defined in

[RFC4379] and extended to include non-IP identifier types in this document).

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               MTU             | Address Type  |    DS Flags   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|               Ingress IF_Num (4 octets)                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                Egress IF_Num (4 octets)                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Multipath Type| Depth Limit   |        Multipath Length       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 2: New DSMAP/DDMAP Address Format

Address Type will be 5 (as shown in Section 2.1 above).

Ingress IF_Num identifies the ingress interface on the target node. A value of zero indicates that the interface is not part of the identifier.

Egress IF_Num identifies the egress interface on the target node. A value of zero indicates that the interface is not part of the identifier.

The Multipath Type SHOULD be set to zero (no multipath) when using this address type.

Including this TLV, with one or the other IF_Num (but not both) set to a non-zero value, in a request message that also includes a Destination Identifier TLV (as described in Section 2.2), is sufficient to identify the "per-interface" MIP in Section 7.3 of [RFC6370].

Inclusion of this TLV with both IF_Num fields set to zero would be interpreted as specifying neither an ingress, nor an egress, interface. Note that this is the same as not including the TLV; hence, including this TLV with both IF_Num values set to zero is NOT RECOMMENDED.

Including this TLV with both IF_NUM fields set to a non-zero value will result in the responder sending a Return Code of 5 ("Downstream Mapping Mis-match") if either IF_Num is incorrect for this LSP or PW.

2.2. Source/Destination Identifier TLV

2.2.1. Source/Destination Identifier TLV Format

The format for the identifier TLV is the same for both Source and Destination Identifier TLVs (only the type is different). The format is as specified in the figure below.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             Type              | Length = 8                    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                  Global_ID   (4 Octets)                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                   Node_ID   (4 Octets)                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 3: New Source/Destination Identifier Format

Type will be one of either 13 or 14, depending on whether the TLV in question is a Source or Destination Identifier TLV.

Global_ID is as defined in [RFC6370].

Node_ID is as defined in [RFC6370].

2.2.2. Source Identifier TLV

When sending on-demand CV packets using ACH, without IP encapsulation, there MAY be a need to identify the source of the packet. This source identifier (Source ID) will be specified via the Source Identifier TLV, using the Identifier TLV defined in Section 2.2.1, containing the information specified above.

An on-demand CV packet MUST NOT include more than one Source Identifier TLV. The Source Identifier TLV MUST specify the identifier of the originator of the packet. If more than one such TLV is present in an on-demand CV request packet, then error 1 (Malformed echo request received; see Section 3.1 of [RFC4379]) MUST be returned, if it is possible to unambiguously identify the source of the packet.

2.2.3. Destination Identifier TLV

When sending on-demand CV packets using ACH, without IP encapsulation, there MAY be a need to identify the destination of the packet. This destination identifier (Destination ID) will be specified via the Destination Identifier TLV, using the Identifier TLV defined in Section 2.2.1, containing the information specified above.

An on-demand CV packet MUST NOT include more than one Destination Identifier TLV. The Destination Identifier TLV MUST specify the destination node for the packet. If more than 1 such TLV is present in an on-demand CV Request packet, then error 1 (Malformed echo request received; see Section 3.1 of [RFC4379]) MUST be returned, if it is possible to unambiguously identify the source of the packet.

2.3. Identifying Statically Provisioned LSPs and PWs

[RFC4379] specifies how an MPLS LSP under test is identified in an echo request. A Target FEC Stack TLV is used to identify the LSP. In order to identify a statically provisioned LSP and PW, new target FEC Stack sub-TLVs are being defined. The new sub-TLVs are assigned sub-type identifiers as follows and are described in the following sections.

Type #	Sub-Type #	Length	Value Field
1	22	24	Static LSP
1	23	32	Static Pseudowire

Figure 4: New Target FEC Sub-Types

2.3.1. Static LSP Sub-TLV

The format of the Static LSP sub-TLV value field is specified in the following figure. The value fields are taken from the definitions in [RFC6370].

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Source Global ID                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Source Node ID                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Source Tunnel Number      |        LSP Number             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Destination Global ID                     |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Destination Node ID                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Destination Tunnel Number   |        Must be Zero           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 5: Static LSP FEC Sub-TLV

The Source Global ID and Destination Global ID MAY be set to zero. When set to zero, the field is not applicable.

2.3.2. Static Pseudowire Sub-TLV

The format of the Static PW sub-TLV value field is specified in the following figure.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
+                      Service Identifier                       +
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                       Source Global ID                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                        Source Node ID                         |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                         Source AC-ID                          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                    Destination Global ID                      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                     Destination Node ID                       |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                      Destination AC-ID                        |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 6: Static PW FEC Sub-TLV

The Service Identifier is a 64-bit unsigned integer that is included in the first two words, as shown. The Service Identifier identifies the service associated with the transport path under test. The value MAY, for example, be an Attachment Group Identifier (AGI), type 0x01, as defined in [RFC4446].

The Source Global ID and Destination Global ID MAY be set to zero. When either of these fields is set to zero, the corresponding Global ID is not applicable. This might be done in a scenario where local scope is sufficient for uniquely identifying services.

The Global ID and Node ID fields are defined in [RFC6370]. The AC-ID fields are defined in [RFC5003].

3. Performing On-Demand CV over MPLS-TP LSPs

This section specifies how on-demand CV can be used in the context of MPLS-TP LSPs. The on-demand CV function meets the on-demand connectivity verification requirements specified in [RFC5860], Section 2.2.3. This function SHOULD NOT be performed except in the on-demand mode. This function SHOULD be performed between

Maintenance Entity Group End Points (MEPs) and Maintenance Entity Group Intermediate Points (MIPs) of PWs and LSPs, and between End Points of PWs, LSPs, and Sections. In order for the on-demand CV packet to be processed at the desired MIP, the TTL of the MPLS label MUST be set such that it expires at the MIP to be probed.

[RFC5586] defines an ACH mechanism for MPLS LSPs. The mechanism is a generalization of the Associated Channel mechanism that [RFC4385] defined for use with pseudowires. As a result, it is possible to use a single Associated Channel Type for either an LSP or pseudowire.

A new Pseudowire Associated Channel Type (0x0025) is defined for use in performing on-demand connectivity verification. Its use is described in the following sections.

ACH TLVs SHALL NOT be associated with this channel type.

Except as specifically stated in the sections below, message and TLV construction procedures for on-demand CV messages are as defined in [RFC4379].

3.1. LSP Ping with IP Encapsulation

LSP ping packets, as specified in [RFC4379], are sent over the MPLS LSP for which OAM is being performed and contain an IP/UDP packet within them. The IP header is not used for forwarding (since LSP forwarding is done using MPLS). The IP header is used mainly for addressing and can be used in the context of MPLS-TP LSPs. This form of on-demand CV OAM MUST be supported for MPLS-TP LSPs when IP addressing is in use.

The on-demand CV echo response message MUST be sent on the reverse path of the LSP. The reply MUST contain IP/UDP headers followed by the on-demand CV payload. The destination address in the IP header MUST be set to that of the sender of the echo request message. The source address in the IP header MUST be set to a valid address of the replying node.

3.2. On-Demand CV with IP Encapsulation, over ACH

IP encapsulated on-demand CV packets MAY be sent over the MPLS LSP using the control channel (ACH). The IP ACH type specified in [RFC4385] MUST be used in such a case. The IP header is used mainly for addressing and can be used in the context of MPLS-TP LSPs.

Note that the application-level control channel in this case is the reverse path of the LSP (or Pseudowire) using ACH.

The on-demand CV echo response message MUST be sent on the reverse path of the LSP. The response in this case SHOULD use ACH and SHOULD be IP encapsulated.

If IP encapsulated, the destination address in the IP header MUST be set to that of the sender of the echo request message, and the source address in the IP header MUST be set to a valid address of the replying node.

3.3. Non-IP-Based On-Demand CV, Using ACH

The OAM procedures defined in [RFC4379] require the use of IP addressing, and in some cases IP routing, to perform OAM functions.

When the ACH header is used, IP addressing and routing is not needed. This section describes procedures for performing on-demand CV without a dependency on IP addressing and routing.

In the non-IP case, when using on-demand CV via LSP ping with the ACH header, the on-demand CV request payload MUST directly follow the ACH header, and the LSP ping Reply mode [RFC4379] in the LSP ping echo request SHOULD be set to 4 (Reply via application level control channel).

Note that the application-level control channel in this case is the reverse path of the LSP (or pseudowire) using ACH.

The requesting node MAY attach a Source Identifier TLV (Section 2.2) to identify the node originating the request.

If the Reply mode indicated in an on-demand CV Request is 4 (Reply via application level control channel), the on-demand CV reply message MUST be sent on the reverse path of the LSP using ACH. The on-demand CV payload MUST directly follow the ACH header, and IP and/or UDP headers MUST NOT be attached. The responding node MAY attach a Source Identifier TLV to identify the node sending the response.

If a node receives an MPLS echo request packet over ACH, without IP/ UDP headers, with a reply mode of 4, and if that node does not have a return MPLS LSP path to the echo request source, then the node SHOULD drop the echo request packet and not attempt to send a response.

If a node receives an MPLS echo request with a reply mode other than 4 (Reply via application level control channel), and if the node supports that reply mode, then it MAY respond using that reply mode. If the node does not support the reply mode requested, or is unable to reply using the requested reply mode in any specific instance, the node MUST drop the echo request packet and not attempt to send a response.

3.4. Reverse-Path Connectivity Verification

3.4.1. Requesting Reverse-Path Connectivity Verification

A new Global flag, Validate Reverse Path (R), is being defined in the LSP ping packet header. When this flag is set in the echo request, the Responder SHOULD return reverse-path FEC information, as described in Section 3.4.2.

The R flag MUST NOT be set in the echo response.

The Global Flags field is now a bit vector with the following format:

```
 0                   1
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|             MBZ         |R|T|V|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 7: Global Flags Field

The V flag is defined in [RFC4379]. The T flag is defined in [RFC6425]. The R flag is defined in this document.

The Validate FEC Stack (V) flag MAY be set in the echo response when reverse-path connectivity verification is being performed.

3.4.2. Responder Procedures

When the R flag is set in the echo request, the responding node SHOULD attach a Reverse-path Target FEC Stack TLV in the echo response. The requesting node (on receipt of the response) can use the Reverse-path Target FEC Stack TLV to perform reverse-path connectivity verification. For co-routed bidirectional LSPs, the Reverse-path Target FEC Stack used for the on-demand CV will be the same in both the forward and reverse path of the LSP. For associated bidirectional LSPs, the Target FEC Stack MAY be different for the reverse path.

The format of the Reverse-path Target FEC Stack TLV is the same as that of the Target FEC Stack TLV defined in [RFC4379]. The rules for creating a Target FEC Stack TLV also apply to the Reverse-path Target FEC Stack TLV.

Type	Meaning
16	Reverse-path Target FEC Stack

Figure 8: Reverse-Path Target FEC Stack TLV Type

3.4.3. Requester Procedures

On receipt of the echo response, the requesting node MUST perform the following checks:

1. Perform interface and label-stack validation to ensure that the packet is received on the reverse path of the bidirectional LSP.

2. If the Reverse-path Target FEC Stack TLV is present in the echo response, then perform FEC validation.

The verification in this case is performed as described for the Target FEC Stack in Section 3.6 of [RFC4379].

If any of the validations fail, then the requesting node MUST drop the echo response and SHOULD log and/or report an error.

3.5. P2MP Considerations

[RFC6425] describes how LSP ping can be used for OAM on P2MP LSPs with IP encapsulation. This MUST be supported for MPLS-TP P2MP LSPs when IP addressing is used. When IP addressing is not used, then the procedures described in Section 3.3 can be applied to P2MP MPLS-TP LSPs as well.

3.6. Management Considerations for Operation with Static MPLS-TP

Support for on-demand CV on a static MPLS-TP LSP or pseudowire MAY require manageable objects to allow, for instance, configuring operating parameters such as identifiers associated with the statically configured LSP or PW.

The specifics of this manageability requirement are out-of-scope in this document and SHOULD be addressed in appropriate management specifications.

3.7. Generic Associated Channel Label (GAL) Processing

At the Requester, when encapsulating the LSP echo request (LSP ping) packet (with the IP ACH, or the Non IP ACH, codepoint), a GAL MUST be added before adding the MPLS LSP label, and sending the LSP Ping echo request packet in-band in the MPLS LSP.

The GAL MUST NOT be considered as part of the MPLS label stack that requires verification by the Responder. For this reason, a Nil FEC TLV MUST NOT be added or associated with the GAL.

The GAL MUST NOT be included in DSMAP or DDMAP TLVs.

Interface and Label Stack TLVs MUST include the whole label stack including the GAL.

4. Performing On-Demand Route Tracing over MPLS-TP LSPs

This section specifies how on-demand CV route tracing can be used in the context of MPLS-TP LSPs. The on-demand CV route tracing function meets the route tracing requirement specified in [RFC5860], Section 2.2.3.

This function SHOULD be performed on-demand. This function SHOULD be performed between End Points and Intermediate Points of PWs and LSPs, and between End Points of PWs, LSPs and Sections.

When performing on-demand CV route tracing, the requesting node inserts a Downstream Mapping TLV to get the downstream node information and to enable LSP verification along the transit nodes. The Downstream Mapping TLV can be used as is for performing route tracing. If IP addressing is not in use, then the Address Type field in the Downstream Mapping TLV can be set to "Non IP" (Section 2.1). The Downstream Mapping TLV address type field can be extended to include other address types as needed.

4.1. On-Demand LSP Route Tracing with IP Encapsulation

The mechanics of on-demand CV route tracing are similar to those described for ping in Section 3.1. On-demand route tracing packets sent by the Requester MUST follow procedures described in [RFC4379]. This form of on-demand CV OAM MUST be supported for MPLS-TP LSPs, when IP addressing is used.

4.2. Non-IP-Based On-Demand LSP Route Tracing, Using ACH

This section describes procedures for performing LSP route tracing when using LSP ping with the ACH header and without any dependency on IP addressing. The procedures specified in Section 3.3 with regards to the Source Identifier TLV apply to LSP route tracing as well.

4.2.1. Requester Procedure for Sending Echo Request Packets

On-demand route tracing packets sent by the Requester MUST adhere to the format described in Section 3.3. MPLS-TTL expiry (as described in [RFC4379]) will be used to direct the packets to specific nodes along the LSP path.

4.2.2. Requester Procedure for Receiving Echo Response Packets

The on-demand CV route tracing responses will be received on the LSP itself, and the presence of an ACH header with channel type of on-demand CV is an indicator that the packet contains an on-demand CV payload.

4.2.3. Responder Procedure

When an echo request reaches the Responder, the presence of the ACH channel type of on-demand CV will indicate that the packet contains on-demand CV data. The on-demand CV data, the label stack, and the destination identifier are sufficient to identify the LSP associated with the echo request packet. If there is an error and the node is unable to identify the LSP on which the echo response would be sent, the node MUST drop the echo request packet and not send any response back. All responses MUST always be sent on an LSP path using the ACH header and ACH channel type of on-demand CV.

4.3. P2MP Considerations

[RFC6425] describes how LSP ping can be used for OAM on P2MP LSPs. This MUST be supported for MPLS-TP P2MP LSPs when IP addressing is used. When IP addressing is not used, then the procedures described in Section 4.2 can be applied to P2MP MPLS-TP LSPs as well.

4.4. ECMP Considerations

On-demand CV using ACH SHOULD NOT be used when there is ECMP (Equal Cost Multi-Path) for a given LSP. The inclusion of the additional ACH header can modify the hashing behavior for OAM packets that could result in incorrect monitoring of the path taken by data traffic.

5. Applicability

The procedures specified in this document for non-IP encapsulation apply to MPLS-TP transport paths. This includes LSPs and PWs when IP encapsulation is not desired. However, when IP addressing is used, as in non MPLS-TP LSPs, procedures specified in [RFC4379] MUST be used.

6. Security Considerations

This document does not itself introduce any new security considerations. Those discussed in [RFC4379] are applicable to this document.

Unlike typical deployment scenarios identified in [RFC4379], however, likely deployments of on-demand CV for transport paths involves a strong possibility that the techniques in this document may be used across MPLS administrative boundaries. Where this may occur, it is RECOMMENDED that on-demand OAM is configured as necessary to ensure that Source Identifier TLVs are included in on-demand CV messages. This will allow implementations to filter OAM messages arriving from an unexpected or unknown source.

7. IANA Considerations

7.1. New Source and Destination Identifier TLVs

IANA has assigned the following TLV types from the "Multi-Protocol Label Switching (MPLS) Label Switched Paths (LSPs) Ping Parameters" registry, "TLVs and sub-TLVs" sub-registry (from the "Standards Action" TLV type range):

Type #	TLV Name	Length Octets	Reference
13	Source ID	8	this document (Section 2.2)
14	Destination ID	8	this document (Section 2.2)

Figure 9: New Source and Destination Identifier TLV Types

7.2. New Target FEC Stack Sub-TLVs

Section 2.3 defines 2 new sub-TLV types for inclusion within the LSP ping [RFC4379] Target FEC Stack TLV (1).

IANA has assigned sub-type values to the following sub-TLVs from the "Multi-Protocol Label Switching Architecture (MPLS) Label Switched Paths (LSPs) Ping Parameters" registry, "TLVs and sub-TLVs" sub-registry.

Value	Meaning	Reference
22	Static LSP	this document (Section 2.4.1)
23	Static Pseudowire	this document (Section 2.4.2)

7.3. New Reverse-Path Target FEC Stack TLV

Section 3.4.2 defines a new TLV type for inclusion in the LSP ping packet.

IANA has assigned a type value to the TLV from the "Multi-Protocol Label Switching Architecture (MPLS) Label Switched Paths (LSPs) Ping Parameters" registry, "TLVs and sub-TLVs" sub-registry.

Type	Meaning	Reference
16	Reverse-path Target FEC Stack TLV	this document (Section 3.4)

The sub-TLV space and assignments for this TLV will be the same as that for the Target FEC Stack TLV. Sub-types for the Target FEC Stack TLV and the Reverse-path Target FEC Stack TLV MUST be kept the same. Any new sub-type added to the Target FEC Stack TLV MUST apply to the Reverse-path Target FEC Stack TLV as well.

7.4. New Pseudowire Associated Channel Type

On-demand connectivity verification requires a unique Associated Channel Type. IANA has assigned a PW ACH Type from the "Pseudowire Associated Channel Types" registry as described below:

Value	Description	TLV Follows	Reference
0x0025	On-Demand CV	No	this document (Section 3)

ACH TLVs SHALL NOT be associated with this channel type.

7.5. New Downstream Mapping Address Type Registry

[RFC4379] defined several registries. It also defined some value assignments without explicitly asking for IANA to create a registry to support additional value assignments. One such case is in defining address types associated with the Downstream Mapping (DSMAP) TLV.

This document extends RFC 4379 by defining a new address type for use with the Downstream Mapping and Downstream Detailed Mapping TLVs.

Recognizing that the absence of a registry makes it possible to have collisions of "address-type" usages, IANA has established a new registry -- associated with both [RFC4379] and this document -- that initially allocates the following assignments:

Type #	Address Type	K Octets	Reference
1	IPv4 Numbered	16	RFC 4379
2	IPv4 Unnumbered	16	RFC 4379
3	IPv6 Numbered	40	RFC 4379
4	IPv6 Unnumbered	28	RFC 4379
5	Non IP	12	this document (Sect. 2.1.1)

Downstream Mapping Address Type Registry

Because the field in this case is an 8-bit field, the allocation policy for this registry is "Standards Action."

8. Contributing Authors and Acknowledgements

The following individuals contributed materially to this document:

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