Internet Engineering Task Force (IETF)
Request for Comments: 8339
Category: Standards Track
ISSN: 2070-1721

P. Jain, Ed.
Cisco Systems, Inc.
S. Boutros
VMWare, Inc.
S. Aldrin
Google Inc.

March 2018

Definition of P2MP PW TLV for Label Switched Path (LSP) Ping Mechanisms

Abstract

Label Switched Path (LSP) Ping is a widely deployed Operation, Administration, and Maintenance (OAM) mechanism in MPLS networks. This document describes a mechanism to verify connectivity of Point-to-Multipoint (P2MP) Pseudowires (PWs) using LSP Ping.

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1. Introduction

A Point-to-Multipoint (P2MP) Pseudowire (PW) emulates the essential attributes of a unidirectional P2MP Telecommunications service such as P2MP ATM over a Public Switched Network (PSN). Requirements for P2MP PWs are described in [RFC7338]. P2MP PWs are carried over a P2MP MPLS LSP. The procedures for P2MP PW signaling using BGP are described in [RFC7117]; LDP for single segment P2MP PWs is described in [RFC8338]. Many P2MP PWs can share the same P2MP MPLS LSP; this arrangement is called an "Aggregate P2MP Tree". An Aggregate P2MP Tree requires an upstream-assigned label so that on the Leaf PE (L-PE), the traffic can be associated with a Virtual Private Network (VPN) or a Virtual Private LAN Service (VPLS) instance. When a P2MP MPLS LSP carries only one VPN or VPLS service instance, the arrangement is called an "Inclusive P2MP Tree". For an Inclusive P2MP Tree, the P2MP MPLS LSP label itself can uniquely identify the VPN or VPLS service being carried over the P2MP MPLS LSP. The P2MP MPLS LSP can also be used in the Selective P2MP Tree arrangement to carry multicast traffic. In a Selective P2MP Tree arrangement, traffic to each multicast group in a VPN or VPLS instance is carried by a separate unique P2MP LSP. In an Aggregate Selective P2MP Tree arrangement, traffic to a set of multicast groups from different VPN or VPLS instances is carried over the same shared P2MP LSP.

The P2MP MPLS LSPs are setup using either P2MP RSVP-TE [RFC4875] or Multipoint LDP (mDLP) [RFC6388]. Mechanisms for fault detection and isolation for data-plane failures for P2MP MPLS LSPs are specified in [RFC6425]. This document describes a mechanism to detect data-plane failures for P2MP PW carried over P2MP MPLS LSPs.

This document defines a new P2MP Pseudowire sub-TLV for the Target Forwarding Equivalence Class (FEC) Stack for P2MP PWs. The P2MP Pseudowire sub-TLV is added in the Target FEC Stack TLV by the originator of the echo request at the Root PE (R-PE) to inform the receiver at the Leaf PE (L-PE) of the P2MP PW being tested.

Support for multi-segment PWs is out of scope of this document.

2. Terminology

2.1. Specification of Requirements

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 BCP 14 [RFC2119] [RFC8174] when, and only when, they appear in all capitals, as shown here.

2.2. Abbreviations

ACH: Associated Channel Header

AGI: Attachment Group Identifier

ATM: Asynchronous Transfer Mode

CE: Customer Edge

FEC: Forwarding Equivalence Class

GAL: Generic Associated Channel Label

LDP: Label Distribution Protocol

L-PE: Leaf PE (one of many destinations of the P2MP MPLS LSP, i.e., egress PE)

LSP: Label Switched Path

LSR: Label Switching Router

mLDP: Multipoint LDP

MPLS-OAM: MPLS Operations, Administration, and Maintenance

P2MP: Point-to-Multipoint

P2MP-PW: Point-to-Multipoint Pseudowire

PE: Provider Edge

PSN: Public Switched Network

PW: Pseudowire

R-PE: Root PE (ingress PE, PE initiating P2MP PW setup)

RSVP: Resource Reservation Protocol

TE: Traffic Engineering

TLV: Type, Length, Value

VPLS: Virtual Private LAN Service

3. Identifying a P2MP PW

This document introduces a new LSP Ping Target FEC Stack sub-TLV, the P2MP Pseudowire sub-TLV, to identify the P2MP PW under test at the P2MP Leaf PE (L-PE).

3.1. P2MP Pseudowire Sub-TLV

The P2MP Pseudowire sub-TLV has the format shown in Figure 1. This TLV is included in the echo request sent over P2MP PW by the originator of the request.

The Attachment Group Identifier (AGI), as described in Section 3.4.2 of [RFC4446], in P2MP Pseudowire sub-TLV identifies the VPLS instance. The Originating Router's IP address is the IPv4 or IPv6 address of the P2MP PW root. The address family of the IP address is determined by the IP Addr Len field.

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| AGI Type      |    AGI Length |                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                               |
~                           AGI Value                           ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| IP Addr Len |                                                 |
+-+-+-+-+-+-+-+                                                 |
~                Originating Routers IP Addr                    ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: P2MP Pseudowire Sub-TLV Format

For Inclusive and Selective P2MP Trees, the echo request is sent using the P2MP MPLS LSP label.

For Aggregate Inclusive and Aggregate Selective P2MP Trees, the echo request is sent using a label stack of [P2MP MPLS LSP label, upstream assigned P2MP PW label]. The P2MP MPLS LSP label is the outer label and the upstream assigned P2MP PW label is the inner label.

4. Encapsulation of OAM Ping Packets

The LSP Ping echo request packet is encapsulated with the MPLS label stack as described in previous sections, followed by one of the two encapsulation options:

- o GAL [RFC6426] followed by an IPv4 (0x0021) or IPv6 (0x0057) type Associated Channel Header (ACH) [RFC4385]

- o PW ACH [RFC4385]

To ensure interoperability, implementations of this document MUST support both encapsulations.

5. Operations

In this section, we explain the operation of the LSP Ping over a P2MP PW. Figure 2 shows a P2MP PW PW1 setup from Root PE R-PE1, to Leaf PEs (L-PE2, L-PE3, and L-PE4). The transport LSP associated with the P2MP PW1 can be mLDP P2MP MPLS LSP or P2MP TE tunnel.

```
                 |<--------------P2MP PW---------------->|
         Native  |                                       |  Native
        Service  |     |<--PSN1->|      |<--PSN2->|      |  Service
         (AC)    V     V         V      V         V      V   (AC)
           |     +-----+         +------+         +------+    |
           |     |     |         |  P1  |=========|L-PE2 |AC3 |    +---+
           |     |     |         |   .......PW1.........>|-------->|CE3|
           |     |R-PE1|=========|   .  |=========|      |    |    +---+
           |     |  .......PW1........  |         +------+    |
           |     |  .  |=========|   .  |         +------+    |
           |     |  .  |         |   .  |=========|L-PE3 |AC4 |    +---+
 +---+     |AC1  |  .  |         |   .......PW1.........>|-------->|CE4|
 |CE1|------->|...  |         |      |=========|      |    |    +---+
 +---+     |     |  .  |         +------+         +------+    |
           |     |  .  |         +------+         +------+    |
           |     |  .  |=========|  P2  |=========|L-PE4 |AC5 |    +---+
           |     |  .......PW1.............PW1.........>|-------->|CE5|
           |     |     |=========|      |=========|      |    |    +---+
           |     +-----+         +------+         +------+    |
```

Figure 2: P2MP PW

When an operator wants to perform a connectivity check for the P2MP PW1, the operator initiates an LSP Ping echo request from Root PE R-PE1, with the Target FEC Stack TLV containing the P2MP Pseudowire sub-TLV in the echo request packet. For an Inclusive P2MP Tree arrangement, the echo request packet is sent over the P2MP MPLS LSP with one of the following two encapsulation options:

- o {P2MP LSP label, GAL} MPLS label stack and IPv4 or IPv6 ACH.

- o {P2MP LSP label} MPLS label stack and PW ACH.

For an Aggregate Inclusive Tree arrangement, the echo request packet is sent over the P2MP MPLS LSP with one of the following two encapsulation options:

- o {P2MP LSP label, P2MP PW upstream assigned label, GAL} MPLS label stack and IPv4 or IPv6 ACH.

- o {P2MP LSP label, P2MP PW upstream assigned label} MPLS label stack and PW ACH.

The intermediate P routers do MPLS label swap and replication based on the incoming MPLS LSP label. Once the echo request packet reaches L-PEs, L-PEs use the GAL and the IPv4/IPv6 ACH Channel header or PW ACH as the case may be, to determine that the packet is an OAM Packet. The L-PEs process the packet and perform checks for the P2MP Pseudowire sub-TLV present in the Target FEC Stack TLV as described in Section 4.4 in [RFC8029] and respond according to the processing rules in that document.

6. Controlling Echo Responses

The procedures described in [RFC6425] for preventing congestion of Echo Responses (Echo Jitter TLV in Section 3.3 of [RFC6425]) and limiting the echo reply to a single L-PE (Node Address P2MP Responder Identifier TLV in Section 3.2 of [RFC6425]) should be applied to P2MP PW LSP Ping.

7. Security Considerations

The proposal introduced in this document does not introduce any new security considerations beyond those that already apply to [RFC6425].

8. IANA Considerations

This document defines a new sub-TLV type included in the Target FEC Stack TLV (TLV Type 1) [RFC8029] in LSP Ping.

IANA has assigned the following sub-TLV type value from the "Sub-TLVs for TLV Types 1, 16, and 21" sub-registry within the "Multiprotocol Label Switching (MPLS) Label Switched Paths (LSPs) Ping Parameters" registry:

37 P2MP Pseudowire

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Acknowledgments

The authors would like to thank Shaleen Saxena, Greg Mirsky, Andrew G. Malis, and Danny Prairie for their valuable input and comments.

Authors' Addresses

Parag Jain (editor)
Cisco Systems, Inc.
2000 Innovation Drive
Kanata, ON K2K-3E8
Canada

Email: paragj@cisco.com

Sami Boutros
VMWare, Inc.
United States of America

Email: sboutros@vmware.com

Sam Aldrin
Google Inc.
United States of America

Email: aldrin.ietf@gmail.com