LSP-Ping Mechanisms for EVPN and PBB-EVPN
draft-jain-bess-evpn-lsp-ping-03

Abstract

   LSP-Ping is a widely deployed Operation, Administration, and
   Maintenance (OAM) mechanism in MPLS networks. This document
   describes mechanisms for detecting data-plane failures using LSP Ping
   in MPLS based EVPN and PBB-EVPN networks.

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1. Introduction

   [RFC7432] describes MPLS based Ethernet VPN (EVPN) technology. An
   EVPN comprises CE(s) connected to PE(s). The PEs provide layer 2
   EVPN among the CE(s) over the MPLS core infrastructure. In EVPN
   networks, PEs advertise the MAC addresses learned from the locally
   connected CE(s), along with MPLS Label, to remote PE(s) in the
   control plane using multi-protocol BGP. EVPN enables multi-homing of
   CE(s) connected to multiple PEs and load balancing of traffic to and
   from multi-homed CE(s).

   [RFC7623] describes the use of Provider Backbone Bridging [802.1ah]
   with EVPN. PBB-EVPN maintains the C-MAC learning in data plane and
   only advertises Provider Backbone MAC (B-MAC) addresses in control
   plane using BGP.

   Procedures for simple and efficient mechanisms to detect data-plane
   failures using LSP Ping in MPLS network are well defined in

[RFC4379][RFC6425]. This document defines procedures to detect data-plane failures using LSP Ping in MPLS networks deploying EVPN and PBB-EVPN. This draft defines 3 new Sub-TLVs for Target FEC Stack TLV with the purpose of identifying the FEC on the Peer PE.

2. Specification of Requirements

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].

3. Terminology

B-MAC: Backbone MAC Address

CE: Customer Edge Device

C-MAC: Customer MAC Address

DF: Designated Forwarder

ESI: Ethernet Segment Identifier

EVI: EVPN Instance Identifier that globally identifies the EVPN Instance

EVPN: Ethernet Virtual Private Network

MPLS-OAM: MPLS Operations, Administration and Maintenance

P2MP: Point-to-Multipoint

PBB: Provider Backbone Bridge

PE: Provider Edge Device

4. Proposed Target FEC Stack Sub-TLVs

This document introduces four new Target FEC Stack sub-TLVs that are included in the LSP-Ping Echo Request packet sent for detecting faults in data-plane connectivity in EVPN and PBB-EVPN networks. These Target FEC Stack sub-TLVs are described next.

All these TLVs contain 8 bytes EVI value which identifies the EVPN instance globally.

4.1. EVPN MAC Sub-TLV

The EVPN MAC sub-TLV is used to identify the MAC for an EVI under
test at a peer PE.

The EVPN MAC sub-TLV fields are derived from the MAC advertisement
route defined in [RFC4379] and has the format as shown in Figure 1.
This TLV is included in the Echo Request sent to the Peer PE by the
PE that is the originator of the request.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     Route Distinguisher                      |
   |                         (8 octets)                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                  Ethernet Segment Identifier                 |
   |                         (10 octets)                          |
   +                           +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                           |            must be zero           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Ethernet Tag ID                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |              MAC Address                                     |
   +              (6 Octets)       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                               | MAC Addr Len  |  IP Addr Len |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |              IP Address (0, 4 or 16 Octets)                  |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                             |
   +                            EVI                              +
   |                                                             |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: EVPN MAC sub-TLV format

The LSP Ping echo request is sent using the EVPN MPLS label(s)
associated with the MAC route announced by a remote PE and the MPLS
transport label(s) to reach the remote PE.

4.2. EVPN Inclusive Multicast Sub-TLV

The EVPN Inclusive Multicast sub-TLV fields are based on the EVPN
Inclusive Multicast route defined in [RFC7432].

The EVPN Inclusive Multicast sub-TLV has the format as shown in
Figure 2. This TLV is included in the echo request sent to the EVPN

peer PE by the originator of request to verify the multicast
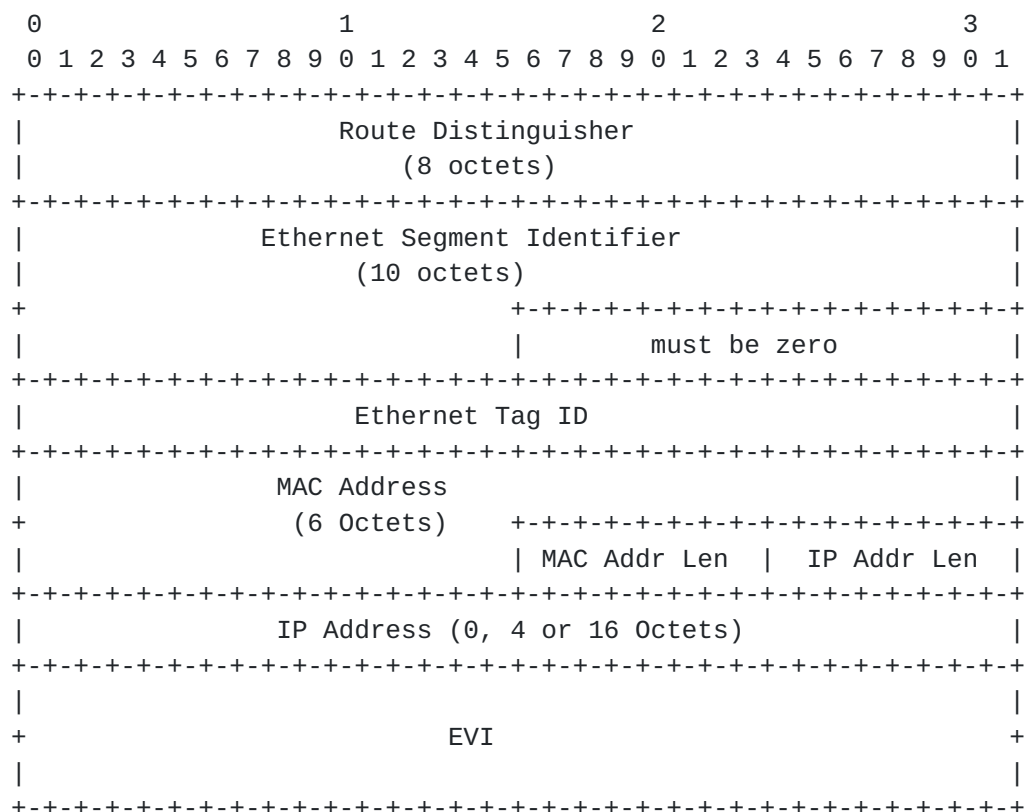connectivity state on the peer PE(s) in EVPN and PBB-EVPN.

```
    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
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     Route Distinguisher                       |
   |                          (8 octets)                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Ethernet Tag ID                          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   | IP Addr Len |                                                 |
   +-+-+-+-+-+-+-+-+                                               |
   ~                 Originating Router's IP Addr                 ~
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                                                               |
   +                             EVI                               +
   |                                                               |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
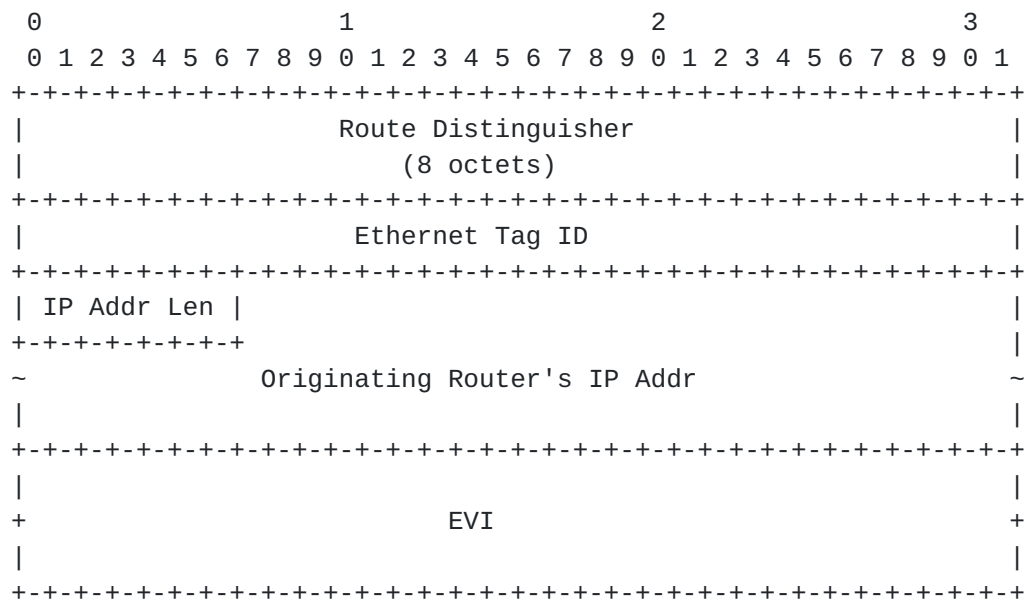
Figure 2: EVPN Inclusive Multicast sub-TLV format

Broadcast, multicast and unknown unicast traffic can be sent using
ingress replication or P2MP P-tree in EVPN and PBB-EVPN network. In
case of ingress replication, the Echo Request is sent using a label
stack of [Transport label, Inclusive Multicast label] to each remote
PE participating in EVPN or PBB-EVPN. The inclusive multicast label
is the downstream assigned label announced by the remote PE to which
the Echo Request is being sent. The Inclusive Multicast label is the
inner label in the MPLS label stack.

When using P2MP P-tree in EVPN or PBB-EVPN, the Echo Request is sent
using P2MP P-tree transport label for inclusive P-tree arrangement or
using a label stack of [P2MP P-tree transport label, upstream
assigned EVPN Inclusive Multicast label] for aggregate inclusive P2MP
P-tree arrangement as described in Section 6.

In case of EVPN, an additional, EVPN Auto-Discovery sub-TLV and ESI
MPLS label as the bottom label, may also be included in the Echo
Request as is described in Section 6.

4.3. **EVPN Auto-Discovery Sub-TLV**

   The EVPN Auto-Discovery (AD) sub-TLV fields are based on the Ethernet
   AD route advertisement defined in [RFC7432]. EVPN AD sub-TLV applies
   to only EVPN.

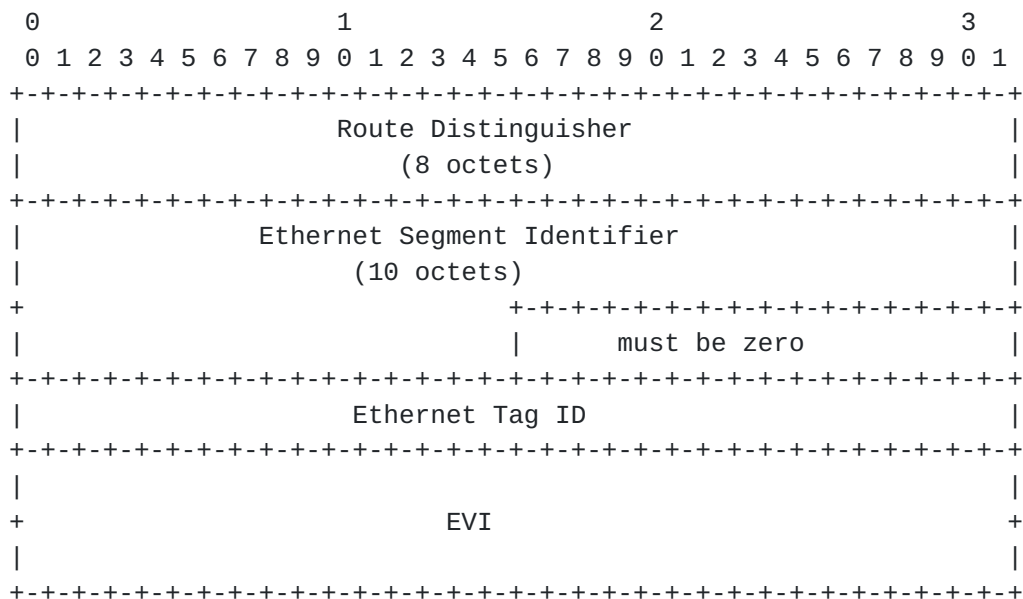   The EVPN AD sub-TLV has the format shown in Figure 3.

```
     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
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                    Route Distinguisher                        |
     |                        (8 octets)                             |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                  Ethernet Segment Identifier                  |
     |                        (10 octets)                            |
     +                           +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                           |         must be zero              |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                      Ethernet Tag ID                          |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                                               |
     +                           EVI                                 +
     |                                                               |
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                 Figure 3: EVPN Auto-Discovery sub-TLV format

4.4. **EVPN IP Prefix Sub-TLV**

   The EVPN IP Prefix sub-TLV is used to identify the IP Prefix for an
   EVI under test at a peer PE.

   The EVPN IP Prefix sub-TLV fields are derived from the IP Prefix
   Route (RT-5) advertisement defined in
   [I-D.ietf-bess-evpn-prefix-advertisement] and has the format as shown
   in Figure 4. This TLV is included in the Echo Request sent to the
   Peer PE by the PE that is the originator of the request.

```
  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
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                     Route Distinguisher                       |
 |                         (8 octets)                            |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                   Ethernet Segment Identifier                 |
 |                         (10 octets)                           |
 +                           +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                           | must be zero  | IP Prefix Len |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                       Ethernet Tag ID                         |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 ~                   IP Prefix  (4 or 16 Octets)                 ~
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 ~                   GW IP Address (4 or 16 Octets)              ~
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
 |                                                               |
 +                              EVI                              +
 |                                                               |
 +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
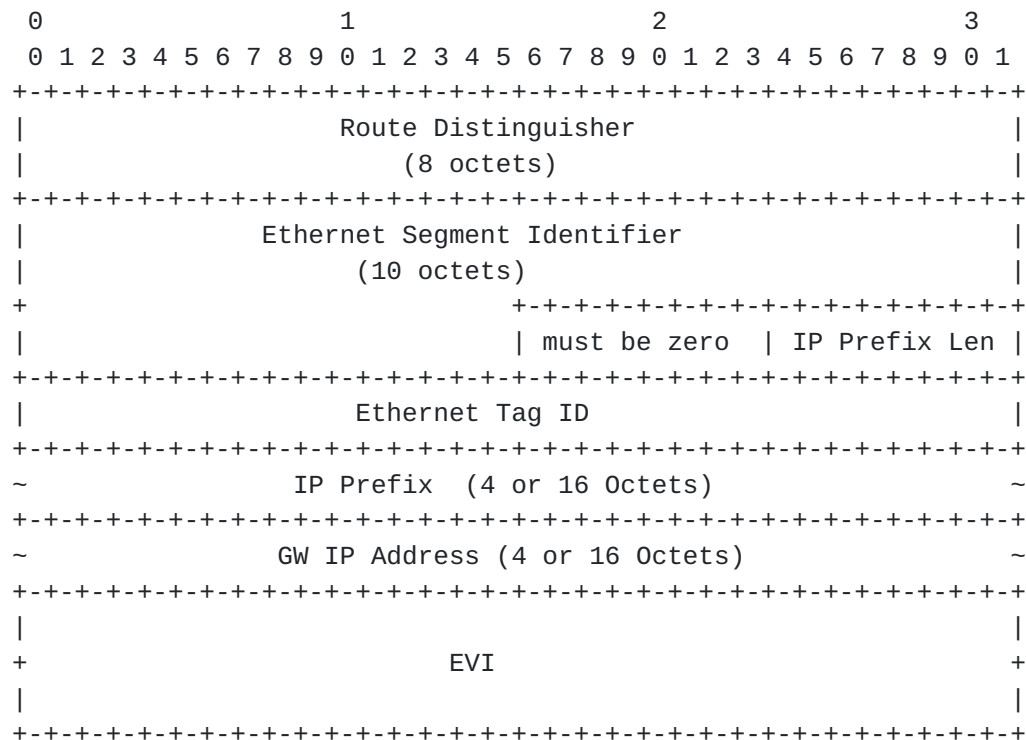
                 Figure 4: EVPN IP Prefix sub-TLV format

   The LSP Ping echo request is sent using the EVPN MPLS label(s)
   associated with the IP Prefix route announced by a remote PE and the
   MPLS transport label(s) to reach the remote PE.

5. Encapsulation of OAM Ping Packets

   The LSP Ping Echo request IPv4/UDP packets will be encapsulated with
   the Transport and EVPN Label(s) followed by the Generic Associated
   Channel Label (GAL) [RFC6426]. The GAL label will be followed by the
   Associated Channel Header (ACH) with the Pseudowire Associated
   Channel Type 16 bit value in the ACH set to IPv4 indicating that the
   carried packet is an IPv4 packet respectively.

6. Operations

6.1. Unicast Data-plane connectivity checks

   Figure 5 is an example of a PBB-EVPN network. CE1 is dual-homed to
   PE1 and PE2. Assume, PE1 announced a MAC route with RD 1.1.1.1:00
   and B-MAC 00aa.00bb.00cc and with MPLS label 16001 for EVI 10.
   Similarly PE2 announced a MAC route with RD 2.2.2.2:00 and B-MAC
   00aa.00bb.00cc and with MPLS label 16002.

On PE3, when a operator performs a connectivity check for the B-MAC
address 00aa.00bb.00cc on PE1, the operator initiates an LSP Ping
request with the target FEC stack TLV containing EVPN MAC sub-TLV in
the Echo Request packet. The Echo Request packet is sent with the
{Transport Label(s) to reach PE1 + EVPN Label = 16001 + GAL} MPLS
label stack and IP ACH Channel header. Once the echo request packet
reaches PE1, PE1 will use the GAL label and the IP ACH Channel header
to determine that the packet is IPv4 OAM Packet. The PE1 will
process the packet and perform checks for the EVPN MAC sub-TLV
present in the Target FEC Stack TLV as described in Section 4.4 in
[RFC4379] and respond according to [RFC4379] processing rules.

```
                 BEB  +----------------+  BEB
                  ||  |                |  | ||
                  \/  |                |  | \/
         +----+ AC1  +-----+               +-----+    +----+
         | CE1|------|     |               | PE 3|-----| CE2|
         +----+\     | PE1 |   IP/MPLS      |     |    +----+
               \     +-----+   Network     +-----+
                \       |                    |
            AC2\  +-----+                    |
               \ |     |                    |
                \| PE2 |                    |
                 +-----+                    |
                  /\  |                    |
                  ||  +----------------+
                 BEB

       <-802.1Q->  <------PBB over MPLS------>   <-802.1Q->
```
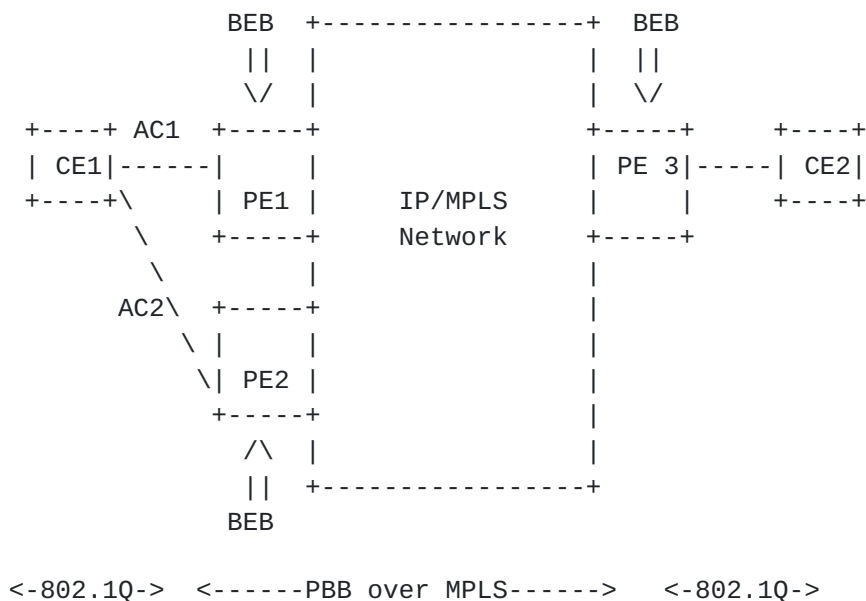
                       Figure 5: PBB EVPN network

Similarly, on PE3, when an operator performs a connectivity check for
the B-MAC address 00aa.00bb.00cc on PE2, the operator initiates an
LSP Ping request with the target FEC stack TLV containing EVPN MAC
sub-TLV in the echo request packet. The echo request packet is sent
with the {MPLS transport Label(s) to reach PE2 + EVPN Label = 16002 +
GAL} MPLS label stack and IP ACH Channel header.

LSP Ping operation for unicast data-plane connectivity checks in E-
VPN, are similar to those described above for PBB-EVPN except that
the checks are for C-MAC addresses instead of B-MAC addresses.

6.2. **Inclusive Multicast Data-plane Connectivity Checks**

6.2.1. **Ingress Replication**

   Assume PE1 announced an Inclusive Multicast route for EVI 10, with RD
   1.1.1.1:00, Ethernet Tag (ISID 10), PMSI tunnel attribute Tunnel type
   set to ingress replication and downstream assigned inclusive
   multicast MPLS label 17001. Similarly PE2 announced an Inclusive
   Multicast route for EVI 10, with RD 2.2.2.2:00, Ethernet Tag (ISID
   10), PMSI tunnel attribute Tunnel type set to ingress replication and
   downstream assigned inclusive multicast MPLS label 17002.

   Given CE1 is dual homed to PE1 and PE2, assume that PE1 is the DF for
   ISID 10 for the port corresponding to the ESI 11aa.22bb.33cc.
   44dd.5500.

   When an operator at PE3 initiates a connectivity check for the
   inclusive multicast on PE1, the operator initiates an LSP Ping
   request with the target FEC stack TLV containing EVPN Inclusive
   Multicast sub-TLV in the Echo Request packet. The Echo Request
   packet is sent with the {Transport Label(s) to reach PE1 + EVPN Incl.
   Multicast Label = 17001 + GAL} MPLS label stack and IP ACH Channel
   header. Once the echo request packet reaches PE1, PE1 will use the
   GAL label and the IP ACH Channel header to determine that the packet
   is IPv4 OAM Packet. The packet will have EVPN Inclusive multicast
   label. PE1 will process the packet and perform checks for the EVPN
   Inclusive Multicast sub-TLV present in the Target FEC Stack TLV as
   described in Section 4.4 in [RFC4379] and respond according to
   [RFC4379] processing rules.

   Operator at PE3, may similarly also initiate an LSP Ping to PE2 with
   the target FEC stack TLV containing EVPN Inclusive Multicast sub- TLV
   in the echo request packet. The echo request packet is sent with the
   {transport Label(s) to reach PE2 + EVPN Incl. Multicast Label =
   17002 + GAL} MPLS label stack and IP ACH Channel header. Once the
   echo request packet reaches PE2, PE2 will use the GAL label and the
   IP ACH Channel header to determine that the packet is IPv4 OAM
   Packet. Since PE2 is not the DF for ISID 10 for the port
   corresponding to the ESI value in the Inclusive Multicast sub- TLV in
   the Echo Request, PE2 will reply with special code indicating that
   FEC exists on the router and the behavior is to drop the packet
   because of not DF as described in Section 8.

   In case of EVPN, in the Echo Request packet, an Ethernet AD sub-TLV
   and the associated MPLS Split Horizon Label above the GAL label in
   the MPLS label stack, may be added to emulate traffic coming from a
   MH site, this label is used by leaf PE(s) attached to the same MH
   site not to forward packets back to the MH site. If the behavior on

a leaf PE is to drop the packet because of Split Horizon filtering,
the PE2 will reply with special code indicating that FEC exists on
the router and the behavior is to drop the packet because of Split
Horizon Filtering as described in Section 8.

6.2.2. Using P2MP P-tree

Both inclusive P-Tree and aggregate inclusive P-tree can be used in
EVPN or PBB-EVPN networks.

When using an inclusive P-tree arrangement, p2mp p-tree transport
label itself is used to identify the L2 service associated with the
Inclusive Multicast Route, this L2 service could be a customer
Bridge, or a Provider Backbone Bridge.

For an Inclusive P-tree arrangement, when an operator performs a
connectivity check for the multicast L2 service, the operator
initiates an LSP Ping request with the target FEC stack TLV
containing EVPN Inclusive Multicast sub-TLV in the echo request
packet. The echo request packet is sent over P2MP LSP with the {P2MP
P-tree label, GAL} MPLS label stack and IP ACH Channel header.

When using Aggregate Inclusive P-tree, a PE announces an upstream
assigned MPLS label along with the P-tree ID, in that case both the
p2mp p-tree MPLS transport label and the upstream MPLS label can be
used to identify the L2 service.

For an Aggregate Inclusive P-tree arrangement, when an operator
performs a connectivity check for the multicast L2 service, the
operator initiates an LSP Ping request with the target FEC stack TLV
containing EVPN Inclusive Multicast sub-TLV in the echo request
packet. The echo request packet is sent over P2MP LSP using the IP-
ACH Control channel with the {P2MP P-tree label, EVPN Upstream
assigned Multicast Label, GAL} MPLS label stack and IP ACH Channel
header.

The Leaf PE(s) of the p2mp tree will process the packet and perform
checks for the EVPN Inclusive Multicast sub-TLV present in the Target
FEC Stack TLV as described in Section 4.4 in [RFC4379] and respond
according to [RFC4379] processing rules. A PE that is not the DF for
the EVI on the ESI in the Inclusive Multicast sub-TLV, will reply
with a special code indicating that FEC exists on the router and the
behavior is to drop the packet because of not DF as described in
Section 8.

In case of EVPN, in the Echo Request packet, an Ethernet AD sub-TLV
and the associated MPLS Split Horizon Label above the GAL Label in
MPLS label stack, may be added to emulate traffic coming from a MH

site, this label is used by leaf PE(s) attached to the same MH site
not to forward packets back to the MH site. If the behavior on a
leaf PE is to drop the packet because of Split Horizon filtering, the
PE2 will reply with special code indicating that FEC exists on the
router and the behavior is to drop the packet because of Split
Horizon Filtering as described in Section 8.

6.2.3. Controlling Echo Responses when using P2MP P-tree

The procedures described in [RFC6425] for preventing congestion of
Echo Responses (Echo Jitter TLV) and limiting the echo reply to a
single egress node (Node Address P2MP Responder Identifier TLV) can
be applied to LSP Ping in PBB EVPN and EVPN when using P2MP P-trees
for broadcast, multicast and unknown unicast traffic.

6.3. EVPN Aliasing Data-plane connectivity check

Assume PE1 announced an Ethernet Auto discovery Route with the ESI
set to CE1 system ID and MPLS label 19001, and PE2 an Ethernet Auto
discovery Route with the ESI set to CE1 system ID and MPLS label
19002.

When an operator performs at PE3 a connectivity check for the
aliasing aspect of the Ethernet AD route to PE1, the operator
initiates an LSP Ping request with the target FEC stack TLV
containing EVPN Ethernet AD sub-TLV in the echo request packet. The
echo request packet is sent with the {Transport label(s) to reach PE1
+ EVPN Ethernet AD Label 19001 + GAL} MPLS label stack and IP ACH
Channel header.

When PE1 receives the packet it will process the packet and perform
checks for the EVPN Ethernet AD sub-TLV present in the Target FEC
Stack TLV as described in Section 4.4 in [RFC4379] and respond
according to [RFC4379] processing rules.

6.4. EVPN IP Prefix (RT-5) Data-plane connectivity check

Assume PE1 announced an IP Prefix Route (RT-5) with an IP prefix
reachable behind CE1 and MPLS label 19001. When an operator on PE3
performs a connectivity check for the IP prefix on PE1, the operator
initiates an LSP Ping request with the target FEC stack TLV
containing EVPN IP Prefix sub-TLV in the echo request packet. The
echo request packet is sent with the {Transport label(s) to reach PE1
+ EVPN IP Prefix Label 19001 + GAL} MPLS label stack and IP ACH
Channel header.

When PE1 receives the packet it will process the packet and perform
checks for the EVPN IP Prefix sub-TLV present in the Target FEC Stack

TLV as described in [Section 4.4 in [RFC4379]](#) and respond according to
[RFC4379] processing rules.

7. Security Considerations

The proposal introduced in this document does not introduce any new
security considerations beyond that already apply to [RFC7432],
[RFC7623] and [RFC6425].

8. IANA Considerations

This document defines 3 new sub-TLV type to be included in Target FEC
Stack TLV (TLV Type 1) [RFC4379] in LSP Ping.

IANA is requested to assign a sub-TLV type value to the following
sub-TLV from the "Multiprotocol Label Switching (MPLS) Label Switched
Paths (LSPs) Parameters - TLVs" registry, "TLVs and sub- TLVs" sub-
registry:

o EVPN MAC route sub-TLV

o EVPN Inclusive Multicast route sub-TLV

o EVPN Auto-Discovery Route sub-TLV

o EVPN IP Prefix Route sub-TLV

Proposed new Return Codes

[RFC4379] defines values for the Return Code field of Echo Reply.
This document proposes two new Return Codes, which SHOULD be included
in the Echo Reply message by a PE in response to LSP Ping Echo
Request message:

1. The FEC exists on the PE and the behavior is to drop the packet
because of not DF.

2. The FEC exists on the PE and the behavior is to drop the packet
because of Split Horizon Filtering.

9. Acknowledgments

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their comments.

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10.1. Normative References

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