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            LDP extensions for Pseudowire Binding to LSP Tunnels
              draft-cao-pwe3-mpls-tp-pw-over-bidir-lsp-07.txt

Abstract

   Many transport services require that user traffic, in the forms of
   Pseudowires (PW), to be delivered on a single co-routed bidirectional
   LSP or two LSPs that share the same routes. In addition, the user
   traffic may traverse through multiple transport networks.

   This document specifies an optional extension in LDP that enable the
   binding between PWs and the underlying LSPs.

Requirements Language

   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 [RFC2119].

Status of this Memo

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Table of Contents

1. Introduction

   Pseudo Wire (PW) Emulation Edge-to-Edge (PWE3) [RFC3985] is a
   mechanism to emulate layer 2 services, such as Ethernet p2p circuits.
   Such services are emulated between two Attachment Circuits (ACs) and
   the PW encapsulated layer 2 service payload is carried through Packet
   Switching Network (PSN) tunnels between Provider Edges (PEs). PWE3
   typically uses Label Distribution Protocol (LDP) [RFC5036] or
   Resource ReserVation Protocol-Traffic Engineering (RSVP-TE) [RFC3209]
   LSPs as PSN tunnels. The PEs select and bind the Pseudowires to PSN
   tunnels independently. Today, there is no protocol-based
   provisioning mechanism to associate PW's to PSN tunnels.

   PW-to-PSN Tunnel binding has become increasingly common and important
   in many deployment scenarios. For instance, when connecting two
   remotely located sites, such as data centers, over the backbone, each
   site may deploy a high-performance router or switch to aggregate
   thousands of Ethernet VLAN flows. The aggregating routers and
   switches are interconnected via one or multiple MPLS/GMPLS LSP's,
   which may traverse through different routes or networks. Further,
   each Ethernet flow is offered to the customers as a bidirectional
   circuits with certain SLA attributes, such as bandwidth and latency.
   Hence, it's important for the operators to map the forwarding and
   reverse-direction traffic from an Ethernet circuit to the LSP's that
   are either bidirectional (e.g. GMPLS-initiated optical path) or co-
   routed.

   The requirement for explicit control of PW-to-LSP mapping has been
   described in Section 5.3.2 ("Support for Explicit Control of PW-to-
   LSP Binding") of [RFC6373]. The following figure (Figure 1)
   provides the illustration.

```
                +------+                    +------+
         ---AC1 ---|...............PWs...............|---AC1---
         ---...----| PE1   |=======LSPs=======| PE2   |---...---
         ---ACn ---|       |-------Links------|       |---ACn---
                +------+                    +------+
```
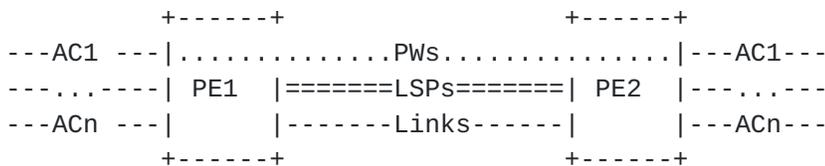
                 Figure 1: Explicit PW-to-LSP binding scenario

   There are two PEs (PE1 and PE2) connected through multiple parallel
   links that may be on different fibers. Each link is managed and
   controlled as a bi-directional LSP. At each PE, there are a large
   number of bi-directional user flows from multiple Ethernet
   interfaces. Each user flow uses PW's to carry traffic on forwarding
   and reverse direction. The operators need to make sure that the user

flows (that is, the PW-pairs) to be carried on the same fiber (or, bidirectional LSP).

As mentioned above, there are a number of reasons behind this requirement. First, due to delay and latency constraints, traffic going over different fibers may require large amount of expensive buffer memory to compensate for the differential delay at the headend nodes. Further, the operators may apply different protection mechanisms on different parts of the network. As such, for optimal traffic management, traffic belongs to a particular user should traverse over the same fiber. That implies that both forwarding and reserve direction PW's that belong to the same user flow need to be mapped to the same co-routed bi-directional LSP or two LSPs with the same route.

Figure 2 illustrates a scenario where PW-LSP binding is not applied.

```
                  +----+    +--+ LSP1 +--+    +----+
      +-----+      | PE1|===|P1|======|P2|===| PE2|     +-----+
      |     |----| |    |    +--+       +--+   |    |----|     |
      | CE1 |      |...........PW................|     | CE2 |
      |     |----| |      +--+                |    |----|     |
      +-----+      |    |=====|P3|=========|     |    +-----+
                  +----+       +--+ LSP2      +----+
```
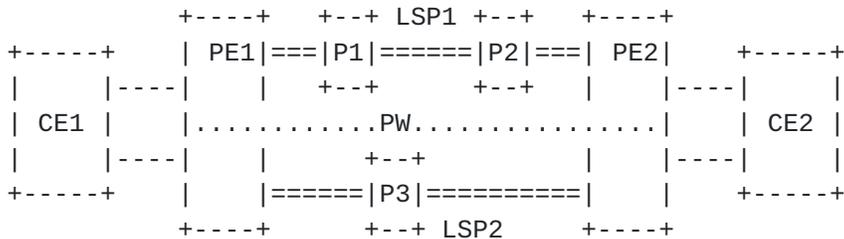
            Figure 2: Inconsistent SS-PW to LSP binding scenario

LSP1 and LSP2 are two bidirectional connections on diverse paths.
The operator is to deliver a bi-directional flow between PE1 and PE2.
Using the existing mechanisms, it's possible that PE1 may select LSP1
(PE1-P1-P2-PE2) as the PSN tunnel for traffic from PE1 to PE2, while
selecting LSP2 (PE1-P3-PE2) as the PSN tunnel for traffic from PE2 to
PE1.

Consequently, the user traffic is delivered over two disjoint LSPs
that may have very different service attributes in terms of latency
and protection. This may not be acceptable as a reliable and
effective transport service to the customers.

The similar problems may also exist in multi-segment PWs (MS-PWs),
where user traffic on a particular PW may hop over different networks
on forward and reverse directions.

One way to solve this problem is by introducing manual configuration
at each PE to bind the PWs to the underlying PSN tunnels. However,
this is prone to configuration errors and won't scale.

In this documentation, we will introduce an automatic solution by
extending FEC 128/129 PW based on [RFC4447].

2. LDP Extensions

This document defines a new TLV, PSN Tunnel Binding TLV, to
communicate tunnel/LSPs selection and binding requests between PEs.
The TLV carries PW's binding profile and provides explicit or
implicit information for the underlying PSN tunnel binding operation.

The binding TLV is optional, and MUST NOT affect the existing PW
operation when not present in the messages.

The binding operation applies in both single-segment (SS) and multi-
segment (MS) scenarios.

The extension supports two types of binding requests:

1. Strict binding: the requesting PE will choose and explicitly
    indicate the LSP information in the requests.

2. Congruent binding: a requesting PE will suggest an underlying LSP
    to a remote PE. On receive, the remote PE has the option to use
    the suggested LSP, or reply the information for an alternative.

In this document, the terminology of "tunnel" is identical to the "TE
Tunnel" defined in Section 2.1 of [RFC3209], which is uniquely
identified by a SESSION object that includes Tunnel end point
address, Tunnel ID and Extended Tunnel ID. The terminology "LSP" is
identical to the "LSP tunnel" defined in Section 2.1 of [RFC3209],
which is uniquely identified by the SESSION object together with
SENDER_TEMPLATE (or FILTER_SPEC) object that consists of LSP ID and
Tunnel endpoint address.

2.1. PSN Tunnel Binding TLV

PSN Tunnel Binding TLV is an optional TLV and MUST be carried in the
LDP Label Mapping message if PW to LSP binding is required. The
format is as follows:

```
     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
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |1|0| PSN Tunnel Binding (TBA)  |               Length          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |               Flag            |             Reserved          |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    ~                      PSN Tunnel Sub-TLV                        ~
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
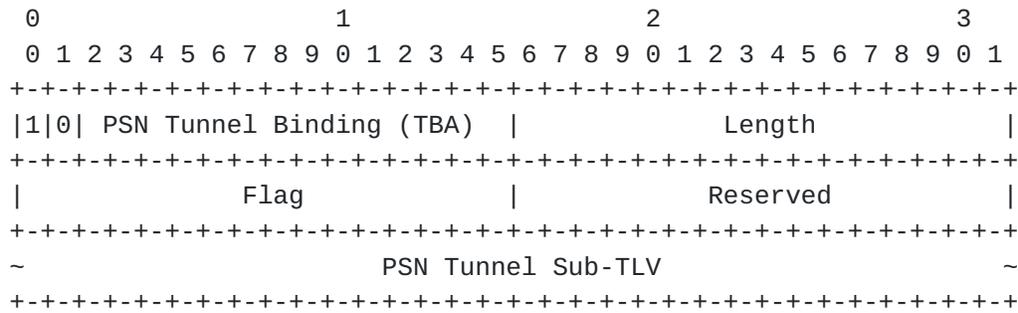
                  Figure 3: PSN Tunnel Binding TLV

   The PSN Tunnel Binding TLV type is to be allocated by IANA

   The Length field is 2 octets in length. It defines the length in
   octets of the entire TLV

   The Flag field describes the binding requests, and has following
   format:

```
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |C|S|T|     MUST be Zero       |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
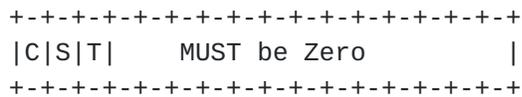
   The flags are defined as the following:

   C (Congruent path) bit: This informs the remote T-PE/S-PEs about the
   properties of the underlying LSPs. When set, the remote T-PE/S-PEs
   need to select LSPs with routes with the similar chariciteristics
   (that is, bidirectional or co-routed path). If there is no such
   tunnel available, the node may trigger the remote T-PE/S-PEs to
   establish a new LSP.

   S (Strict) bit: This instructs the PEs with respect to the handling
   of the underlying LSPs. When set, the remote PE MUST use the tunnel/
   LSPs specified in the PSN Tunnel Sub-TLV as the PSN tunnel on the
   reverse direction of the PW, or the PW will fail to be established.

   T (Tunnel Representation) bit: This indicates the format of the LSP
   tunnels. When the bit is set, the tunnel uses the tunnel information
   to identify itself, and the LSP Number fields in the PSN Tunnel sub-
   TLV (Section 2.1.1) MUST be set to zero. Otherwise, both tunnel and
   LSP information of the PSN tunnel are required. The default is set.
   The motivation for the T-bit is to support the MPLS protection
   operation where the LSP Number fields may be ignored.

   C-bit and S-bit are mutually exclusive from each other, and cannot be
   set in the same message.

2.1.1. PSN Tunnel Sub-TLV

PSN Tunnel Sub-TLVs are designed for inclusion in the PSN Tunnel
Binding TLV to specify the tunnel/LSPs to which a PW is required to
bind.

Two sub-TLVs are defined: the IPv4 and IPv6 Tunnel sub-TLVs.

```
    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     |             Reserved          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Source Global ID                         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                      Source Node ID                           |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |     Source Tunnel Number      |     Source LSP Number         |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Destination Global ID                      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                    Destination Node ID                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |  Destination Tunnel Number    |   Destination LSP Number      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    0                   1                   2                   3
```
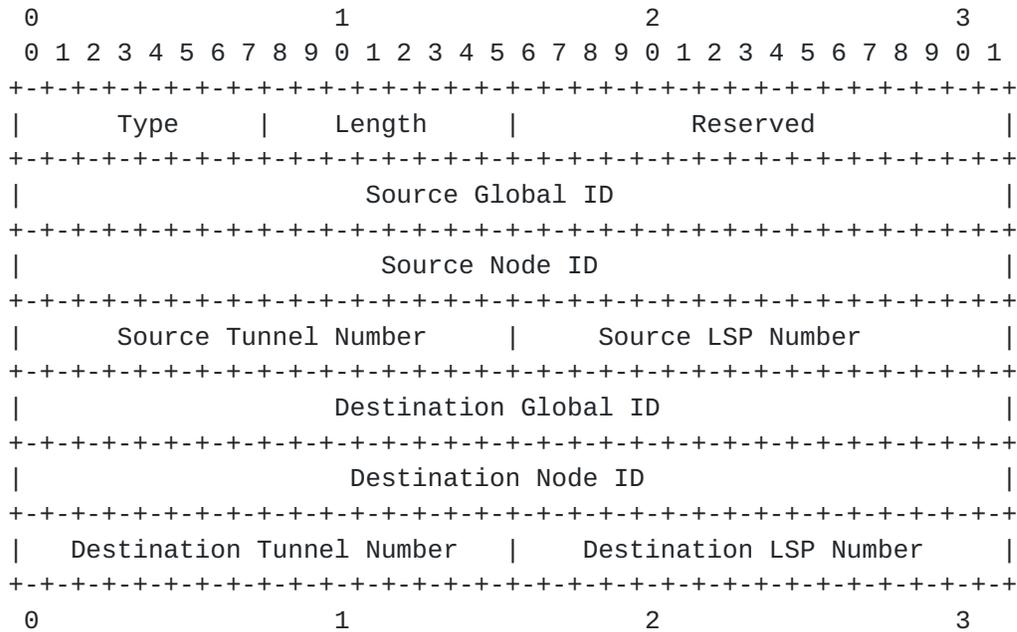
Figure 4: IPv4 PSN Tunnel sub-TLV format

```
    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     |             Reserved          |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                       Source Global ID                        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                       Source Node ID                          ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |      Source Tunnel Number     |      Source LSP Number        |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |                     Destination Global ID                     |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   ~                     Destination Node ID                       ~
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
   |   Destination Tunnel Number   |   Destination LSP Number      |
   +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
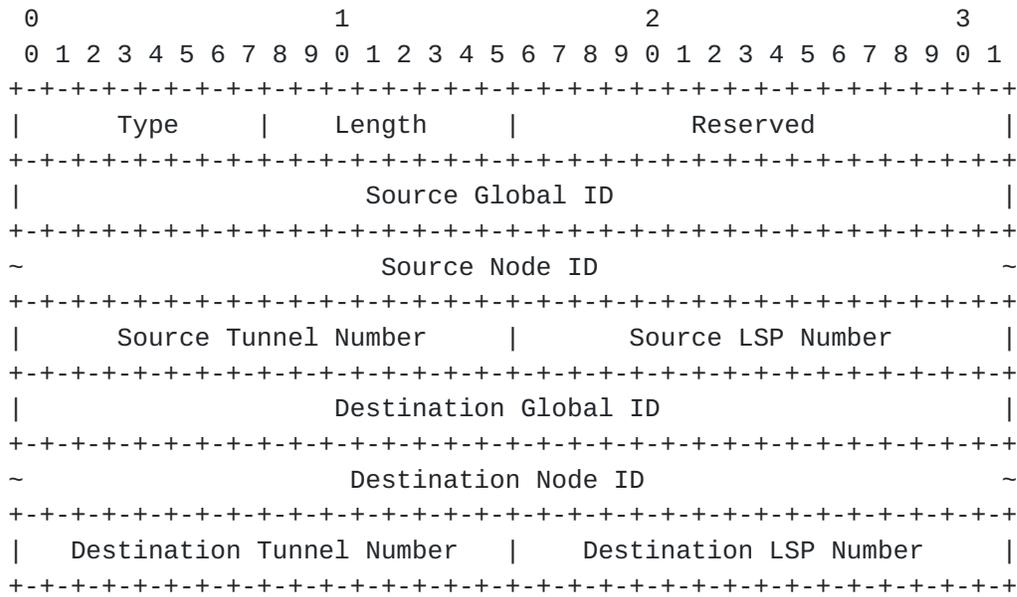
                   Figure 5: IPv6 PSN Tunnel sub-TLV format

   The definition of Source and Destination Global/Node IDs and Tunnel/
   LSP Numbers are derived from [RFC6370]. This is to describe the
   underlying LSP's. Note that the LSP's in this notation is globally
   unique.

   As defined in Section 4.6.1.2 and Section 4.6.2.2 of [RFC3209], the
   "Tunnel endpoint address" is mapped to Destination Node ID, and
   "Extended Tunnel ID" is mapped to Source Node ID. Both IDs can be
   IPv6 addresses.

   A PSN Tunnel sub-TLV could be used to either identify a tunnel or a
   specific LSP. The T-bit in the Flag field defines the distinction as
   such that, when the T-bit is set, the Source/Destination LSP Number
   fields MUST be zero and ignored during processing. Otherwise, both
   Source/Destination LSP Number fields MUST have the actual LSP IDs of
   specific LSPs.

   Each PSN Tunnel Binding TLV can only have one such sub-TLV.

3. Theory of Operation

   During PW setup, the PEs may select desired forwarding tunnels/LSPs,
   and inform the remote T-PE/S-PEs about the desired reverse tunnels/
   LSPs.

   Specifically, to set up a PW (or PW Segment), a PE may select a

candidate tunnel/LSP to act as the PSN tunnel. If none is available
or satisfies the constraints, the PE will trigger and establish a new
tunnel/LSP. The selected tunnel/LSP information is carried in the
PSN Tunnel Binding TLV and sent with the Label Mapping message to the
target PE.

Upon the reception of the Label Mapping message, the receiving PE
will process the PSN Tunnel Binding TLV, determine whether it can
accept the suggested tunnel/LSP or to find the reverse tunnel/LSP
that meets the request, and respond with a Label Mapping message,
which contains the corresponding PSN Tunnel Binding TLV.

It is possible that two PEs may request PSN binding to the same PW or
PW segment over different tunnels/LSPs at the same time. There may
cause collisions of tunnel/LSPs selection as both PEs assume the
active role.

As defined in (Section 7.2.1, [RFC6073]), each PE may be generally
categorized into active and passive roles:

1. Active PE: the PE which initiates the selection of the tunnel/
    LSPs and informs the remote PE;

2. Passive PE: the PE which obeys the active PE's suggestion.

In the remaining of this document, we will elaborate the operation
for SS-PW and MS-PW:

1. SS-PW: In this scenario, both PE's for a particular PE may assume
    the active roles

2. MS-PW: One PE is active, while the other is passive. The PW's
    are setup using FEC 129

4. PSN Binding Operation for SS-PW

As illustrated in Figure-5, both PEs (say, PE1 and PE2) of a PW may
independently initiate the setup. To perform PSN binding, the Label
Mapping messages MUST carry a PSN Tunnel Binding TLV, and the PSN
Tunnel sub-TLV MUST contains the desired tunnel/LSPs of the sender.

```
                  +----+          LSP1          +----+
        +-----+   | PE1|==================| PE2|    +-----+
        |     |----|    |                  |    |----|     |
        | CE1 |    |............PW...............|    | CE2 |
        |     |----|    |                  |    |----|     |
        +-----+   |    |==================|    |    +-----+
                  +----+          LSP2          +----+
```
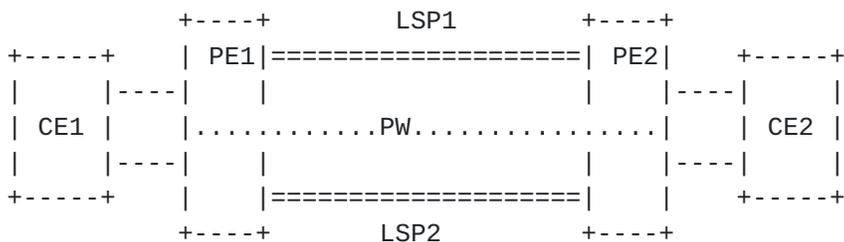
        Figure 6: PSN binding operation in SS-PW environment

   As outlined previously, there are two types of binding request:
   congruent and strict.

   In strict binding, a PE (e.g., PE1) will mandate the other PE (e.g.,
   PE2) to use a specified tunnel/LSP (e.g. LSP1) as the PSN tunnel on
   the reverse direction. In the PSN Tunnel Binding TLV, the S-bit MUST
   be set, the C-bit MUST be reset, and the Source and Destination IDs/
   Numbers MUST be filled.

   On receive, if the S-bit is set, other than following the processing
   procedure defined in Section 5.3.3 of [RFC4447], the receiving PE
   (i.e. PE2) needs to determine whether to accept the indicated
   tunnel/LSP in PSN Tunnel Sub-TLV.

   If the receiving PE (PE2) is also an active PE, and may have
   initiated the PSN binding requests to the other PE (PE1), if the
   received PSN tunnel/LSP is the same as it has been sent in the Label
   Mapping message by PE2, then the signaling has converged on a
   mutually agreed Tunnel/LSP. The binding operation is completed.

   Otherwise, the receiving PE (PE2) MUST compare its own Node ID
   against the received Source Node ID. If it is numerically lower, the
   PE (PE2) will reply a Label Mapping message to complete the PW setup
   and confirm the binding request. The PSN Tunnel Binding TLV in the
   message MUST contain the same Source and Destination IDs/Numbers as
   in the received binding request, in the appropriate order. On the
   other hand, if the receiving PE (PE2) has a Node ID that is
   numerically higher than the Source Node ID carried in the PSN Tunnel
   Binding TLV, it MUST reply a Label Release message with status code
   set to "Reject to use the suggested tunnel/LSPs" and the received PSN
   Tunnel Binding TLV, and the PW will not be established.

   To support congruent binding, the receiving PE can select the
   appropriated PSN tunnel/LSP for the reverse direction of the PW, so
   long as the forwarding and reverse PSNs share the same route.

   Initially, a PE (PE1) sends a Label Mapping message to the remote PE
   (PE2) with the PSN Tunnel Binding TLV, with C-bit set, S-bit reset,
   and the appropriate Source and Destination IDs/Numbers. In case of

unidirectional LSPs, the PSN Tunnel Binding TLV may only contain the
Source IDs/Numbers, the Destination IDs/Numbers are set to zero and
left for PE2 to fill when responding the Label Mapping message.

On receive, since PE2 is also an active PE, and may have initiated
the PSN binding requests to the other PE (PE1), if the received PSN
tunnel/LSP has the same route as the one that has been sent in the
Label Mapping message to PE1, then the signaling has converged. The
binding operation is completed.

Otherwise, it needs to compare its own Node ID against the received
Source Node ID. If it's numerically lower, PE2 needs to find/
establish a tunnel/LSP that meets the congruent constraint, and reply
a Label Mapping message with a PSN Binding TLV that contains the
Source and Destination IDs/Numbers in the appropriate order. On the
other hand, if the receiving PE (PE2) has a Node ID that is
numerically higher than the Source Node ID carried in the PSN Tunnel
Binding TLV, it MUST reply a Label Release message with status code
set to "Reject to use the suggested tunnel/LSPs" and the received PSN
Tunnel Binding TLV.

In both strict and congruent bindings, if T-bit is set, the LSP
Number field MUST be set to zero. Otherwise, the field MUST contain
the actual LSP number for the associated PSN LSP.

After a PW established, the operators may choose to move the PW's
from the current tunnel/LSPs. Or, the underlying PSN is broken due
to network failure. In this scenario, a new Label Mapping message
MUST be sent to update the changes. Note that when T-bit is set, the
working LSP broken will not trigger to update the changes if there
are protection LSP's.

The message may carry a new PSN Tunnel Binding TLV, which contains
the new Source and Destination Numbers/IDs. The handling of the new
message should be identical to what has been described in this
section.

However, if the new Label Binding message does not contain the PSN
Tunnel Binding TLV, it declares the removal of any congruent/strict
constraints. The PEs may not map the PW to the underlying PSN on
purpose, the current independent PW to PSN binding will be used.

Further, as an implementation option, the PEs should not remove the
traffic from an operational PW, until the completion of the
underlying PSN tunnel/LSP changes.

5. PSN Binding Operation for MS-PW

   MS-PW uses FEC 129 for PW setup. We refer the operation to Figure-6.


           +-----+ LSP1 +-----+ LSP2 +-----+ LSP3 +-----+
    +---+ |T-PE1|======|S-PE1|======|S-PE2|======|T-PE2| +---+
    | |---| | | | | | | |---| |
    |CE1| |....................PW....................| |CE2|
    | |---| | | | | | | |---| |
    +---+ | |======| |======| |======| | +---+
           +-----+ LSP4 +-----+ LSP5 +-----+ LSP6 +-----+
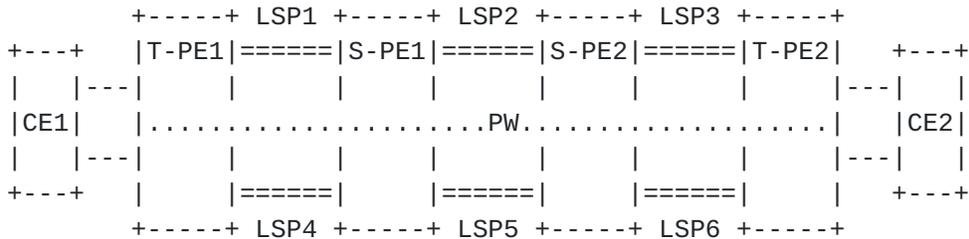
         Figure 7: PSN binding operation in MS-PW environment

   When an active PE (that is, T-PE1) starts to signal for a MS-PW, a
   PSN Tunnel Binding TLV MUST be carried in the Label Mapping message
   and sent to the adjacent S-PE (that is, S-PE1). The PSN Tunnel
   Binding TLV includes the PSN Tunnel sub-TLV that carries the desired
   tunnel/LSP of T-PE1's.

   For strict binding, the initiating PE MUST set the S-bit, reset the
   C-bit and indicates the binding tunnel/LSP to the next-hop S-PE.

   When S-PE1 receives the Label Mapping message, S-PE1 needs to
   determine if the signaling is for forward or reverse direction, as
   defined in Section 6.2.3 of [I-D.ietf-pwe3-dynamic-ms-pw].

   If the Label Mapping message is for forward direction, and S-PE1
   accepts the requested tunnel/LSPs from T-PE1, S-PE1 must save the
   tunnel/LSP information for reverse-direction processing later on. If
   the PSN binding request is not acceptable, S-PE1 MUST reply a Label
   Release Message to the upstream PE (T-PE1) with Status Code set to
   "Reject to use the suggested tunnel/LSPs".

   Otherwise, S-PE1 relays the Label Mapping message to the next S-PE
   (that is, S-PE2), with the PSN Tunnel sub-TLV carrying the
   information of the new PSN tunnel/LSPs selected by S-PE1. S-PE2 and
   subsequent S-PEs will repeat the same operation until the Label
   Mapping message reaches to the remote T-PE (that is, T-PE2).

   If T-PE2 agrees with the requested tunnel/LSPs, it will reply a Label
   Mapping message to initiate to the binding process on the reverse
   direction. The Label Mapping message contains the received PSN
   Tunnel Binding TLV for confirmation purposes.

When its upstream S-PE (S-PE2) receives the Label Mapping message,
the S-PE relays the Label Mapping message to its upstream adjacent
S-PE (S-PE1), with the previously saved PSN tunnel/LSP information in
the PSN Tunnel sub-TLV. The same procedure will be applied on
subsequent S-PEs, until the message reaches to T-PE1 to complete the
PSN binding setup.

During the binding process, if any PE does not agree to the requested
tunnel/LSPs, it can send a Label Release Message to its upstream
adjacent PE with Status Code set to "Reject to use the suggested
tunnel/LSPs".

For congruent binding, the initiating PE (T-PE1) MUST set the C-bit,
reset the S-bit and indicates the suggested tunnel/LSP in PSN Tunnel
sub-TLV to the next-hop S-PE (S-PE1).

During the MS-PW setup, the PEs have the option to ignore the
suggested tunnel/LSP, and select another tunnel/LSP for the segment
PW between itself and its upstream PE on reverse direction only if
the tunnel/LSP is congruent with the forwarding one. Otherwise, the
procedure is the same as the strict binding.

The tunnel/LSPs may change after a MS-PW being established. When a
tunnel/LSP has changed, the PE that detects the change SHOULD select
an alternative tunnel/LSP for temporary use while negotiating with
other PEs following the procedure described in this section.

6. Security Considerations

The ability to control which LSP to carry traffic from a PW can be a
potential security risk both for denial of service and traffic
interception. It is RECOMMENDED that PEs do not accept the use of
LSPs identified in the PSN Tunnel Binding TLV unless the LSP end
points match the PW or PW segment end points. Furthermore, where
security of the network is believed to be at risk, it is RECOMMENDED
that PEs implement the LDP security mechanisms described in [RFC5036]
and [RFC5920].

7. IANA Considerations

7.1. LDP TLV Types

This document defines new TLV [Section 2.1 of this document] for
inclusion in LDP Label Mapping message. IANA is required to assign
TLV type value to the new defined TLVs from LDP "TLV Type Name Space"
registry.

7.1.1. PSN Tunnel Sub-TLVs

This document defines two sub-TLVs [Section 2.1.1 of this document]
for PSN Tunnel Binding TLV. IANA is required to create a new
registry ("PSN Tunnel Sub-TLV Name Space") for PSN Tunnel sub-TLVs
and to assign Sub-TLV type values to the following sub-TLVs.

IPv4 PSN Tunnel sub-TLV - 0x01 (to be confirmed by IANA)

IPv6 PSN Tunnel sub-TLV - 0x02 (to be confirmed by IANA)

7.2. LDP Status Codes

This document defines a new LDP status codes, IANA is required to
assigned status codes to these new defined codes from LDP "STATUS
CODE NAME SPACE" registry.

"Reject to use the suggested tunnel/LSPs" - 0x0000003B (to be
confirmed by IANA)

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Villamizar and Luca Martini.

9. References

9.1. Normative References

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               Requirement Levels", BCP 14, RFC 2119, March 1997.

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   [RFC6370]   Bocci, M., Swallow, G., and E. Gray, "MPLS Transport
               Profile (MPLS-TP) Identifiers", RFC 6370, September 2011.

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