Network Working Group   Siva Sivabalan (Ed.)
Internet Draft   Sami Boutros (Ed.)
Intended status: Standards Track   Luca Martini
Expires: September 11, 2012   Cisco Systems

Frederic Jounay   Maciek Konstantynowicz
Philippe Niger   Juniper
France Telecom
                                          Gianni Del Vecchio
Thomas D. Nadeau   Swisscom
CA Technologies
                                                  Yuji Kamite
Simon Delord   NTT Communications
Telstra
                                                  Lizhong Jin
Laurent Ciavaglia   ZTE
Martin Vigoureux
Alcatel-Lucent
                                              March 11, 2012

Signaling Root-Initiated Point-to-Multipoint Pseudowire using LDP
draft-ietf-pwe3-p2mp-pw-04.txt

Status of this Memo

Abstract

   This document specifies a mechanism to signal Point-to-Multipoint
   (P2MP) Pseudowires (PW) tree using LDP. Such a mechanism is suitable
   for any Layer 2 VPN service requiring P2MP connectivity over an IP or
   MPLS enabled PSN. A P2MP PW established via the proposed mechanism is
   root initiated.

Table of Contents

1. Introduction

   A Point-to-Multipoint (P2MP) Pseudowire (PW) emulates the
   essential attributes of a unidirectional P2MP Telecommunications
   service such as P2MP ATM over PSN. A major difference between a
   Point-to-Point (P2P) PW outlined in [RFC3985] and a P2MP PW is that
   the former is intended for bidirectional service whereas the latter

is intended for both unidirectional, and optionally bidirectional
service. Requirements for P2MP PW are described in [P2MP-PW-REQ].

P2MP PW can be constructed as either Single Segment (P2MP SS-PW) or
Multi Segment (P2MP MS-PW) Pseudowires as mentioned in [P2MP-PW-
REQ]. P2MP MS-PW is outside the scope of this document. A reference
model for P2MP PW is depicted in Figure 1 below. A transport LSP
associated with a P2MP SS-PW SHOULD be a P2MP MPLS LSP (i.e., P2MP
TE tunnel established via RSVP-TE [RFC4875] or P2MP LSP established
via mLDP [RFC6388]) spanning from the Root-PE to the Leaf-PE(s) of
the P2MP SS-PW tree. For example, in Figure 1, PW1 can be associated
with a P2MP TE tunnel or P2MP LSP setup using mLDP originating from
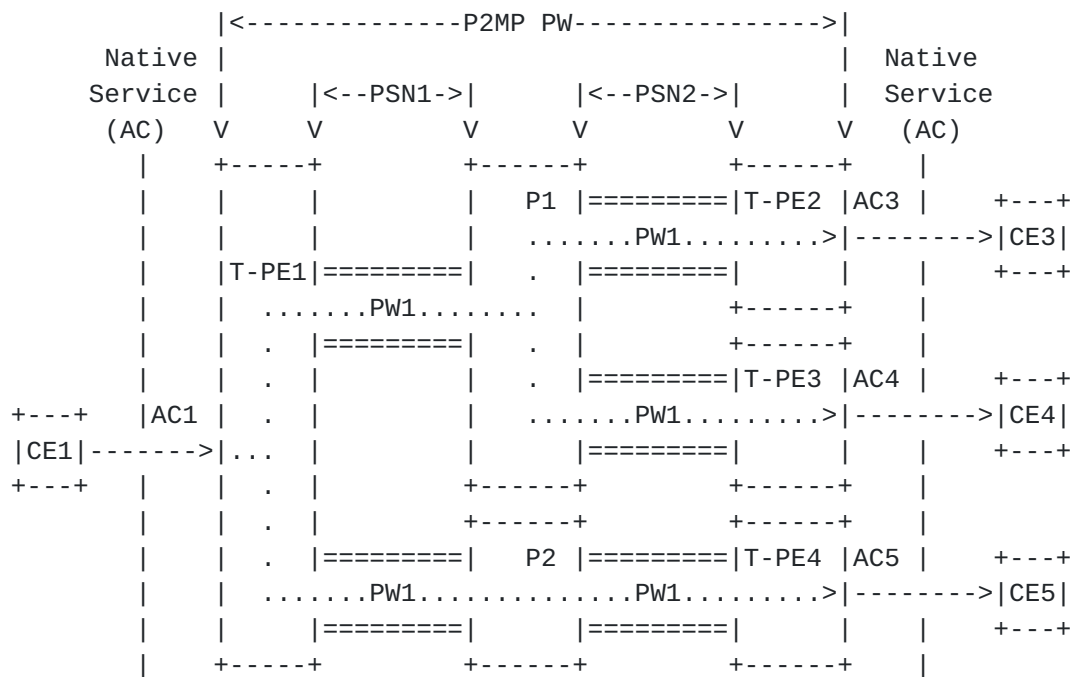PE1 and terminating at PE2 and PE3.

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

                        Figure 1: P2MP PW

Mechanisms for establishing P2P SS-PW using LDP are described in

[RFC4447]. In this document, we specify a method to signal P2MP PW using LDP. In particular, we define new FEC, TLVs, parameters, and status codes to facilitate LDP to signal and maintain P2MP PWs.

As outlined in [P2MP-PW-REQ], even though the traffic flow from a Root-PE (R-PE) to Leaf-PE(s) (L-PEs) is P2MP in nature, it may be desirable for any L-PE to send unidirectional P2P traffic destined only to the R-PE. The proposed mechanism takes such option into consideration.

The P2MP PW requires an MPLS LSP to carry the PW traffic, and the MPLS packets carried over the PW will be encapsulated according to the methods described in [RFC5332].

Conventions used in this document

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC-2119 Error! Reference source not found..

2. Terminology

FEC: Forwarding Equivalence Class

LDP: Label Distribution Protocol

mLDP: Label Distribution Protocol for P2MP/MP2MP LSP

LSP: Label Switching Path

MS-PW: Multi-Segment Pseudowire

P2P: Point to Point

P2MP: Point to Multipoint

PE: Provider Edge

PSN: Packet Switched Network

PW: Pseudowire

SS-PW: Single-Segment Pseudowire

S-PE: Switching Provider Edge Node of MS-PW

TE: Traffic Engineering

R-PE: Root-PE - ingress PE, PE initiating P2MP PW setup.

L-PE: Leaf-PE - egress PE.

3. Signaling P2MP PW

In order to advertise labels as well as exchange PW related LDP
messages, PEs must establish LDP sessions among themselves using the
Extended Discovery Mechanisms. A PE discovers other PEs that are to
be connected via P2MP PWs either via manual configuration or
autodiscovery [RFC6074].

R-PE and each L-PE MUST be configured with the same FEC as defined
in the following section.

P2MP PW requires that there is an active P2MP PSN LSP set up between
R-PE and L-PE(s). Note that the procedure to set up the P2MP PSN LSP
is different depending on the signaling protocol used (RSVP-TE or
mLDP).

In case of mLDP, a Leaf-PE can decide to join the P2MP LSP at any
time; whereas in the case of RSVP-TE, the P2MP LSP is set up by the
R-PE, generally at the initial service provisioning time. It should
be noted that local policy can override any decision to join, add or
prune existing or new L-PE(s) from the tree. In any case, the PW
setup can ignore these differences, and simply assume that the P2MP
PSN LSP is available when needed.

A P2MP PW signaling is initiated by the R-PE simply by sending a
P2MP-PW LDP label mapping message to the L-PE(s) belonging to that
P2MP PW. This label mapping message will contain the following:

      1. A FEC TLV containing P2MP PW Upstream FEC element that
         includes Transport LSP sub TLV.
      2. An Interface Parameters TLV, as described in [RFC4447].
      3. A PW Grouping TLV, as described in [RFC4447].
      4. A label TLV for the upstream-assigned label used by R-PE
         for the traffic going from R-PE to L-PE(s).

The R-PE imposes the upstream-assigned label on the outbound packets
sent over the P2MP-PW, and using this label an L-PE identifies the
inbound packets arriving over the P2MP PW.

Additionally, the R-PE MAY send label mapping message(s) to one or
more L-PE(s) to signal unidirectional P2P PW(s). The L-PE(s) can use
such PW(s) to send traffic to the R-PE. This optional label mapping
message will contain the following:

      1. P2P PW Downstream FEC element.
      2. A label TLV for the down-stream assigned label used by the
         corresponding L-PE to send traffic to the R-PE.

The LDP liberal label retention mode is used, and per requirements
specified in [RFC5036], the Label Request message MUST also be
supported.

The upstream-assigned label is allocated according to the rules in
[RFC5331].

When an L-PE receives a PW Label Mapping Message, it MUST verify the
associated P2MP PSN LSP is in place. If the associated P2MP PSN LSP
is not in place, and its type is LDP P2MP LSP, the L-PE SHOULD
attempt to join the P2MP LSP associated with the P2MP PW. If the
associated P2MP PSN LSP is not in place, and its type is RSVP-TE
P2MP LSP, the L-PE SHOULD wait till the P2MP transport LSP is
signaled.

3.1. PW ingress to egress incompatibility issues

If an R-PE signals a PW with a pw type, CW mode, or interface
parameters that a particular L-PE cannot accept, then the L-PE must

   not enable the PW, and notify the user. In this case, a PW status
   message with status code of 0x00000001 (Pseudowire Not Forwarding)
   MUST also be sent to the R-PE.

   Note that this procedure does not apply if the L-PE had not been
   provisioned with this particular P2MP PW. In this case according to
   the LDP liberal label retention rules, no action is taken.

3.2. P2MP PW FEC

   [RFC4447] specifies two types of LDP FEC elements called "PWid FEC
   Element" and "Generalized PWid FEC Element" used to signal P2P PWs.
   We define two new types of FEC elements called "P2MP PW Upstream FEC
   Element" and "P2P PW Downstream FEC Element". These FEC elements are
   associated with a mandatory upstream assigned label and an optional
   downstream assigned label respectively.

   FEC type of the P2MP PW Upstream FEC Element is 0x82 (pending IANA
   allocation) and is encoded 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| P2MP PW Up    |C|         PW Type           | PW Info Length|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   AGI Type    |    Length     |          AGI Value          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                     AGI Value (contd.)                       ~
|                                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    AII Type   |    Length     |         SAII Value           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                    SAII Value (contd.)                       ~
|                                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|PMSI Tunnel typ|    Length     |                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+                              +
+                                                              +
~                     Transport LSP ID                         ~
|                                                              |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                              |
|                   Optional Parameters                        |
~                                                              ~
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
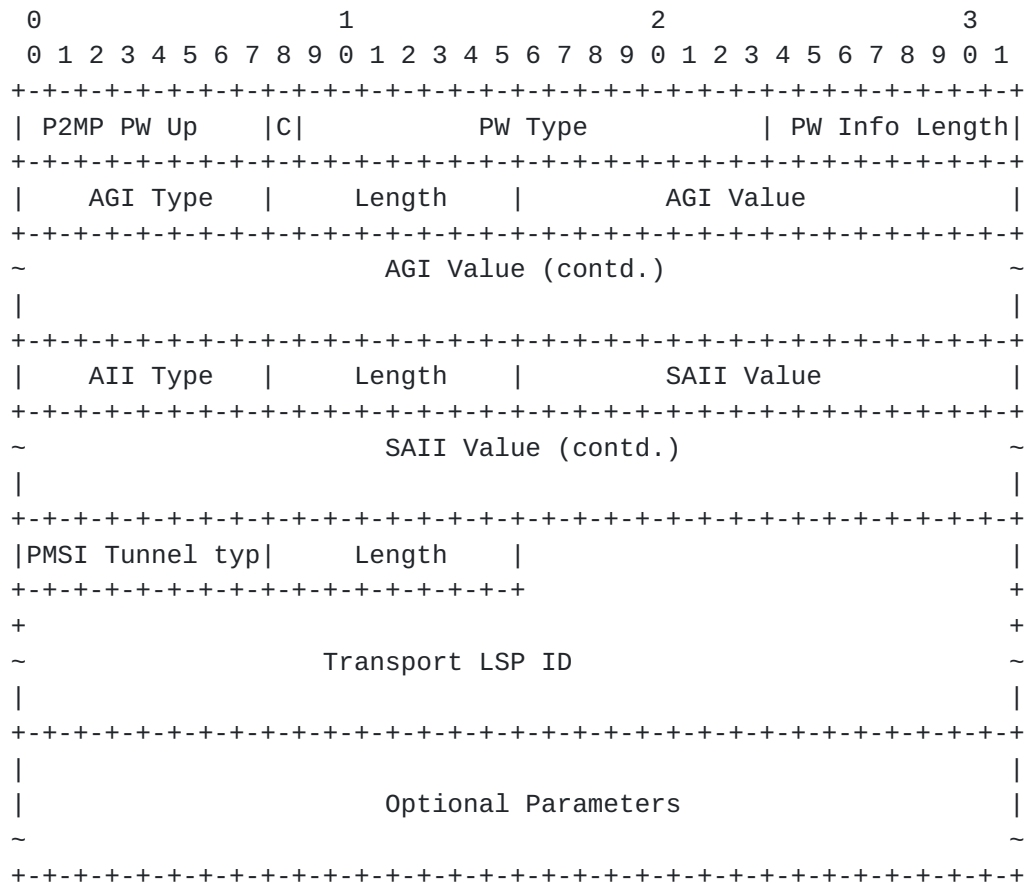
Figure 2: P2MP PW Upstream FEC Element

  * PW Type:

   15-bit representation of PW type, and the assigned values are
   assigned by IANA.

  * C bit:

   A value of 1 or 0 indicates whether control word is present or
   absent for the P2MP PW.

  * PW Info Length:

Sum of the lengths of AGI, SAII, PMSI Tunnel info, and Optional
Parameters field in octets. If this value is 0, then it
references all PWs using the specified grouping ID. In this case,
there are neither other FEC element fields (AGI, SAII, etc.)
present, nor any interface parameters TLVs. Alternatively, we can
use typed WC FEC described in section 3.3 to achieve the same or
to have better filtering.

* AGI:

 Attachment Group Identifier can be used to uniquely identify VPN
 or VPLS instance associated with the P2MP PW. This has the same
 format as the Generalized PWid FEC element [RFC4447].

* SAII:

 Source Attachment Individual Identifier is used to identify the
 root of the P2MP PW. The root is represented using AII type 2
 format specified in [RFC5003]. Note that the SAII can be omitted
 by simply setting the length and type to zero.

 P2MP PW is identified by the Source Attachment Identifier (SAI).
 If the AGI is non-null, the SAI is the combination of the SAII
 and the AGI, if the AGI is null, the SAI is the SAII.

* PMSI Tunnel Type and Transport LSP ID:

 A P2MP PW MUST be associated with a transport LSP which can be
established using RSVP-TE or mLDP.

* PMSI Tunnel Type:

 The PMSI tunnel type is defined in [L3VPN-MCAST].

 When the type is set to mLDP P2MP LSP, the Tunnel Identifier is
 a P2MP FEC Element as defined in [RFC6388]. A new mLDP Opaque
 Value Element type for L2VPN-MCAST application needs to be
 allocated.

   * Transport LSP ID:
     This is the Tunnel Identifier which is defined in [L3VPN-MCAST].

     An R-PE sends Label Mapping Message as soon as the transport LSP
     ID associated with the P2MP PW is known (e.g., via configuration)
     regardless of the operational state of that transport LSP.
     Similarly, an R-PE does not withdraw the labels when the
     corresponding transport LSP goes down. Furthermore, an L-PE
     retains the P2MP PW labels regardless of the operational status
     of the transport LSP.

   Note that a given transport LSP can be associated with more than one
   P2MP PWs and all P2MP PWs will be sharing the same R-PE and L-PE(s).

   In the case of LDP P2MP LSP, when an L-PE receives the Label
   Mapping Message, it can initiate the process of joining the P2MP LSP
   tree associated with the P2MP PW.

   In the case of RSVP-TE P2MP LSP, only the R-PE initiates the
   signaling of P2MP LSP.

   * Optional Parameters:

     The Optional Parameter field can contain some TLVs that are not
     part of the FEC, but are necessary for the operation of the PW.
     This proposed mechanism uses two such TLVs: Interface Parameters
     TLV, and Group ID TLV.

     The Interface Parameters TLV and Group ID TLV specified in
     [RFC4447] can also be used in conjunction with P2MP PW FEC in a
     label message. For Group ID TLV, the sender and receiver of these
     TLVs should follow the same rules and procedures specified in
     [RFC4447]. For Interface Parameters TLV, the procedure differs
     from the one specified in [RFC4447] due to specifics of P2MP
     connectivity. When the interface parameters are signaled by a R-
     PE, each L-PE must check if its configured value(s) is less than
     or equal to the threshold value provided by the R-PE (e.g. MTU
     size (Ethernet), max number of concatenated ATM cells, etc)). For

other interface parameters like CEP/TDM Payload bytes (TDM), the
value MUST exactly match the values signaled by the R-PE.

Multicast traffic stream associated with a P2MP PW can be
selective or inclusive. To support the former, this document
defines a new optional Selective Tree Interface Parameter sub-TLV
(type is pending IANA allocation) according to the format
described in [RFC4447]. The value of the sub-TLV contains the
source and the group for a given multicast tree as shown in Figure
3. Also, if a P2MP PW is associated with multiple selective trees,
the corresponding label mapping message will carry more than one
instance of this Sub-TLV. Furthermore, in the absence of this sub-
TLV, the P2MP PW is associated with all multicast traffic stream
originating from the root.

```
           +----------------------------------------- +
           | Multicast Source Length (1 Octet)        |
           +----------------------------------------- +
           | Multicast Source (variable length)       |
           +----------------------------------------- +
           | Multicast Group Length (1 Octet)         |
           +----------------------------------------- +
           | Multicast Group (variable length)        |
           +----------------------------------------- +
```

Figure 3: Selective Tree Interface Parameter Sub-TLV Value

Note that since the LDP label mapping message is only sent by the R-
PE to all the L-PEs, it is not possible to negotiate any interface
parameters.

The type of optional P2P PW Downstream FEC Element is 0x83 (pending
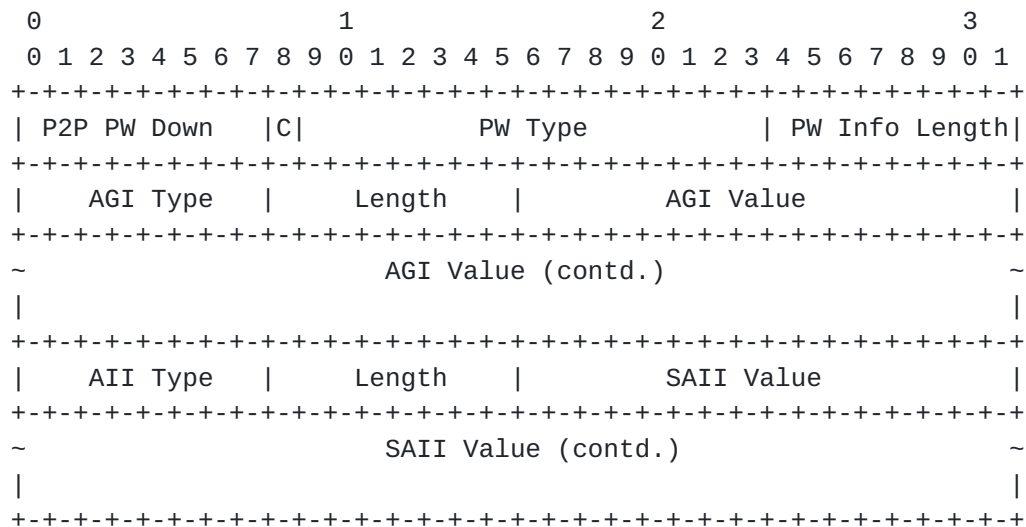IANA allocation), and is encoded as follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| P2P PW Down   |C|           PW Type           | PW Info Length|
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   AGI Type    |    Length     |         AGI Value             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                       AGI Value (contd.)                      ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   AII Type    |    Length     |         SAII Value            |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
~                       SAII Value (contd.)                     ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 4: P2P PW Downstream FEC Element

The definition of the fields in the P2P PW Downstream FEC Element is
the same as those of P2MP PW Upstream FEC Element.

3.3. Typed Wildcard FEC Format for new FEC

[RFC5918] defines the general notion of a "Typed Wildcard" FEC
Element, and requires FEC designer to specify a typed wildcard FEC
element for newly defined FEC element types. This document defines
two new FEC elements, "P2MP PW Upstream" and "P2P PW Downstream" FEC
element, and hence requires us to define their Typed Wildcard
format.

[PW-TWC-FEC] defines Typed Wildcard FEC element format for other PW
FEC Element types (PWid and Gen. PWid FEC Element) in section 2 as
follows:
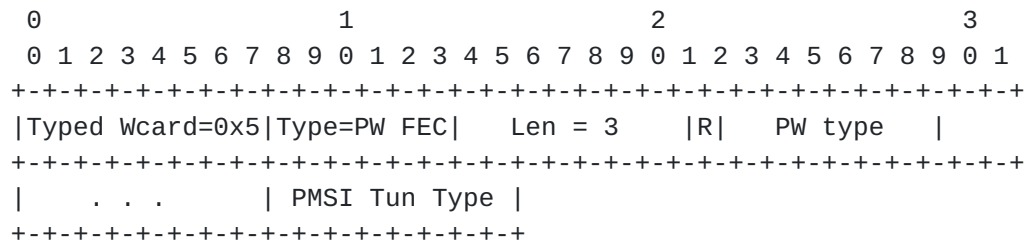
```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|Typed Wcard=0x5|Type=PW FEC|   Len = 3     |R|    PW type      |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|    . . .      | PMSI Tun Type |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```
       Figure 5: Typed Wildcard Format for P2MP PW FEC Elements

[PW-TWC-FEC] specifies that "Type" field can be either "PWid" (0x80)
or "Generalized PWid" (0x81) FEC element type. This document reuses
the existing typed wildcard format as specified in [PW-TWC-FEC] and
illustrated in Figure 5. We extend the definition of "Type" field to
also include "P2MP PW Upstream" and "P2P PW Downstream" FEC element
types, as well as add an additional field "PMSI Tun Type". We
reserve PMSI tunnel Type 0xFF to mean "wildcard" transport tunnel
type. This "wildcard" transport tunnel type can be used in a typed
wildcard p2mp FEC for further filtering. This field only applies to
Typed wildcard P2MP PW Upstream FEC and MUST be set to "wildcard"
for "P2P PW Downstream FEC" typed wildcard element.

3.4. Group ID usage

The Grouping TLV as defined in [RFC4447] contains a group ID capable
of indicating an arbitrary group membership of a P2MP-PW. This group
ID can be used in LDP "wild card" status, and withdraw label
messages, as described in [RFC4447].

3.5. Generic Label TLV

As in the case of P2P PW signaling, P2MP PW labels are carried
within Generic Label TLV contained in LDP Label Mapping Message. A
Generic Label TLV is formatted and processed as per the rules and
procedures specified in [RFC4447]. For a given P2MP PW, a single
upstream-assigned label is allocated by the R-PE, and is advertised
to all L-PEs using the Generic Label TLV in label mapping message
containing the P2MP PW Upstream FEC element.

The R-PE can also allocate a unique label for each L-PE from which
it intends to receive P2P traffic. Such a label is advertised to the
L-PE using Generic Label TLV and P2P PW Downstream FEC in label
mapping message.

4. LDP Capability Negotiation

The capability of supporting P2MP PW must be advertised to all LDP
peers. This is achieved by using the methods in [RFC5561] and

advertising the LDP "P2MP PW Capability" TLV. If an LDP peer
supports the dynamic capability advertisement, this can be done by
sending a new Capability message with the S bit set for the P2MP PW
capability TLV. If the peer does not supports dynamic capability
advertisement, then the P2MP PW Capability TLV MUST be included in
the LDP Initialization message during the session establishment. An
LSR having P2MP PW capability MUST recognize both P2MP PW Upstream
FEC Element and P2P PW Downstream FEC Element in LDP label messages.

In line with requirements listed in [RFC5561], the following TLV is
defined to indicate the P2MP PW capability:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|U|F| P2MP PW Capability (0x703)|            Length             |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|S| Reserved    |    Reserved   |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

                Figure 7: LDP P2MP PW Capability TLV

Note: TLV number pending IANA allocation.

  * U-bit:

    SHOULD be 1 (ignore if not understood).

  * F-bit:

    SHOULD be 0 (don't forward if not understood).

  * P2MP PW Capability TLV Code Point:

   The TLV type, which identifies a specific capability. The P2MP PW
   capability code point is requested in the IANA allocation section
   below.

  * S-bit:

The State Bit indicates whether the sender is advertising or
withdrawing the P2MP PW capability. The State bit is used as
follows:
     1 - The TLV is advertising the capability specified by the
         TLV Code Point.

     0 - The TLV is withdrawing the capability specified by the
         TLV Code Point.

* Length:
   MUST be set to 2 (octet).

5. P2MP PW Status

In order to support the proposed mechanism, a node MUST be capable
of handling PW status. As such, PW status negotiation procedure
described in [RFC4447] is not applicable to P2MP PW.

Once an L-PE successfully processes a Label Mapping Message for a
P2MP PW, it MUST send appropriate PW status according to the
procedure specified [RFC4447] to notify the PW status. If there is
no PW status notification required, then no PW status notification
is sent (for example if the P2MP PW is established and operational
with a status code of Success (0x00000000), pw status message is
not necessary). PW status message sent from any L-PE to R-PE
contains P2P PW Downstream FEC to identify the PW.

An R-PE also sends PW status to L-PE(s) to reflect its view of a
P2MP PW state. Such PW status message contains P2MP PW Upstream FEC
to identify the PW.

Connectivity status of the underlying P2MP LSP that P2MP PW is
associated with, can be verified using LSP Ping and Traceroute
procedures described in [P2MP-LSP-PING].

6. Security Considerations

The security measures described in [RFC4447] is adequate for the
proposed mechanism.

7. IANA Considerations

7.1. FEC Type Name Space

This document uses two new FEC element types, number 0x82 and 0x83
will be requested as an allocation from the registry "FEC Type Name
Space" for the Label Distribution Protocol (LDP RFC5036):

```
Value    Hex    Name                            Reference
-------  -----  ------------------------------  ---------
 130     0x82   P2MP PW Upstream FEC Element     RFCxxxx
 131     0x83   P2P PW Downstream FEC Element    RFCxxxx
```

7.2. LDP TLV Type

This document uses a new LDP TLV types, IANA already maintains a
registry of name "TLV TYPE NAME SPACE" defined by RFC5036. The
following values are suggested for assignment:

```
   TLV type  Description:

   0x0703   P2MP PW Capability TLV
```

7.3. mLDP Opaque Value Element TLV Type

This document requires allocation of a new mLDP Opaque Value Element
Type from the LDP MP Opaque Value Element type name space defined in
[mLDP].

The following value is suggested for assignment:

```
   TLV type  Description
   0x3       L2VPN-MCAST application TLV
```

7.4. Selective Tree Interface Parameter sub-TLV Type

This document requires allocation of a sub-TLV from the registry
"Pseudowire Interface Parameters Sub-TLV Type".

The following value is suggested for assignment:

```
TLV type   Description
0x0D       Selective Tree Interface Parameter.
```

7.5. WildCard PMSI tunnel type.

This document requires the allocation of PMSI tunnel Type 0xFF to
mean wildcard transport tunnel type

8. Acknowledgment

Authors would like thank Andre Pelletier and Parag Jain for their
valuable suggestions.

9. References

9.1. Normative References

[RFC2119] Bradner. S, "Key words for use in RFCs to Indicate
Requirement Levels", RFC 2119, March, 1997.

[RFC4447] "Transport of Layer 2 Frames Over MPLS", Martini, L.,
et al., RFC 4447, April 2006.

[RFC5036] Andersson, L., Minei, I., and B. Thomas, "LDP
Specification", RFC 5036, October 2007.

[RFC5003] C. Metz, L. Martini, F. Balus, J. Sugimoto, "Attachment
Individual Identifier (AII) Types for Aggregation", RFC5003,
September 2007.

[RFC5331] R. Aggarwal, Y. Rekhter, E. Rosen, "MPLS Upstream Label
Assignment and Context-Specific Label Space", RFC 5331, August 2008.

[RFC5332] T. Eckert, E. Rosen, Ed.,R. Aggarwal, Y. Rekhter, "MPLS
Multicast Encapsulations", RFC 5332, August 2008.

[RFC6388] I. Minei, K. Kompella, I. Wijnands, B. Thomas, "Label
Distribution Protocol Extensions for Point-to-Multipoint and

Multipoint-to-Multipoint Label Switched Paths", RFC 6388, November
2011.

[RFC4875] R. Aggarwal, Ed., D. Papadimitriou, Ed., S. Yasukawa, Ed.,
"Extensions to Resource Reservation Protocol - Traffic Engineering
(RSVP-TE) for Point-to-Multipoint TE Label Switched Paths (LSPs).",
RFC 4875, May 2007.

[L3VPN-MCAST] R. Aggarwal, E. Rosen, T. Morin, Y. Rekhter, "BGP
Encodings and Procedures for Multicast in MPLS/BGP IP VPNs", draft-
ietf-l3vpn-2547bis-mcast-bgp-08.txt, Work in Progress, October 2009.

[RFC5561] B.Thomas, K.Raza, S.Aggarwal, R.Agarwal, JL. Le Roux, "LDP
Capabilities", RFC 5561, July 2009.

[RFC5918] R. Asati, I. Minei, and B. Thomas, "LDP Typed Wildcard
Forwarding Equivalence Class", RFC 5918, August 2010.

[PW-TWC-FEC] K. Raza, S. Boutros, and C. Pignataro, "LDP Typed
Wildcard FEC for PWid and Generalized PWid FEC Elements",
draft-ietf-pwe3-pw-types-wc-fec-03.txt, work in progress,
February 2012.

9.2. Informative References

[RFC3985] Stewart Bryant, et al., "PWE3 Architecture", RFC3985

[RFC6074] E. Rosen,W. Luo,B. Davie,V. Radoaca "Provisioning, Auto-
Discovery, and Signaling in Layer 2 Virtual Private Networks
(L2VPNs)", RFC6074, January 2011.

[P2MP-PW-REQ]   F. Jounay, et. al, "Requirements for Point to
Multipoint Pseudowire", draft-ietf-pwe3-p2mp-pw-requirements-03.txt,
Work in Progress, August 2010.

[P2MP-LSP-PING] A. Farrel, S. Yasukawa, "Detecting Data Plane
Failures in Point-to-Multipoint Multiprotocol Label Switching (MPLS)
- Extensions to LSP Ping", draft-ietf-mpls-p2mp-lsp-ping-15.txt,
Work In Progress, January 2011.

Author's Addresses

   Siva Sivabalan
   Cisco Systems, Inc.
   2000 Innovation Drive
   Kanata, Ontario, K2K 3E8
   Canada
   Email: msiva@cisco.com

   Sami Boutros
   Cisco Systems, Inc.
   3750 Cisco Way
   San Jose, California 95134
   USA
   Email: sboutros@cisco.com

   Luca Martini
   Cisco Systems, Inc.
   9155 East Nichols Avenue, Suite 400
   Englewood, CO, 80112
   United States
   Email: lmartini@cisco.com

   Maciek Konstantynowicz
   Juniper Networks
   UNITED KINGDOM
   e-mail: maciek@juniper.net

   Gianni Del Vecchio
   Swisscom (Schweiz) AG
   Zentweg 9
   CH-3006 Bern
   Switzerland
   e-mail: Gianni.DelVecchio@swisscom.com

   Thomas D. Nadeau
   CA Technologies
   273 Corporate Drive
   Portsmouth, NH 03801
   USA
   e-mail: thomas.nadeau@ca.com

   Frederic Jounay
   France Telecom

2, avenue Pierre-Marzin
22307 Lannion Cedex
FRANCE
Email: frederic.jounay@orange-ftgroup.com

Philippe Niger
France Telecom
2, avenue Pierre-Marzin
22307 Lannion Cedex
FRANCE
Email: philippe.niger@orange-ftgroup.com

Yuji Kamite
NTT Communications Corporation
Tokyo Opera City Tower
3-20-2 Nishi Shinjuku, Shinjuku-ku
Tokyo 163-1421
Japan
Email: y.kamite@ntt.com

Lizhong Jin
ZTE
889 Bibo Road,
Shanghai, 201203
P.R.China
Email: lizhong.jin@zte.com.cn

Martin Vigoureux
Alcatel-Lucent
Route de Villejust
Nozay,   91620
France
Email: martin.vigoureux@alcatel-lucent.com

Laurent Ciavaglia
Alcatel-Lucent
Route de Villejust
Nozay,   91620
France
Email: Laurent.Ciavaglia@alcatel-lucent.com

     Simon Delord
     Alcatel-Lucent
     E-mail: simon.a.delord@team.telstra.com

     Kamran Raza
     Cisco Systems, Inc.
     2000 Innovation Drive
     Kanata, Ontario, K2K 3E8
     Canada
     Email: skraza@cisco.com

might or might not be available; nor does it represent that it has
made any independent effort to identify any such rights.

Copies of Intellectual Property disclosures made to the IETF
Secretariat and any assurances of licenses to be made available, or
the result of an attempt made to obtain a general license or
permission for the use of such proprietary rights by implementers or
users of this specification can be obtained from the IETF on-line IPR
repository at http://www.ietf.org/ipr.

The IETF invites any interested party to bring to its attention any
copyrights, patents or patent applications, or other proprietary
rights that may cover technology that may be required to implement
any standard or specification contained in an IETF Document. Please
address the information to the IETF at ietf-ipr@ietf.org.

The definitive version of an IETF Document is that published by, or
under the auspices of, the IETF. Versions of IETF Documents that are
published by third parties, including those that are translated into
other languages, should not be considered to be definitive versions
of IETF Documents. The definitive version of these Legal Provisions
is that published by, or under the auspices of, the IETF. Versions of
these Legal Provisions that are published by third parties, including
those that are translated into other languages, should not be
considered to be definitive versions of these Legal Provisions.

For the avoidance of doubt, each Contributor to the UETF Standards
Process licenses each Contribution that he or she makes as part of
the IETF Standards Process to the IETF Trust pursuant to the
provisions of RFC 5378. No language to the contrary, or terms,
conditions or rights that differ from or are inconsistent with the
rights and licenses granted under RFC 5378, shall have any effect and
shall be null and void, whether published or posted by such
Contributor, or included with or in such Contribution.

Acknowledgment