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## Signaling Root-Initiated Point-to-Multipoint Pseudowire Using LDP

### Abstract

This document specifies a mechanism to signal Point-to-Multipoint (P2MP) Pseudowire (PW) trees 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. This document updates RFC 7385 by reassigning the reserved value 0xFF to be the wildcard transport tunnel type.

### Status of This Memo

This is an Internet Standards Track document.

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Information about the current status of this document, any errata, and how to provide feedback on it may be obtained at <https://www.rfc-editor.org/info/rfc8338>.

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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 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 PWs are described in [RFC7338]. P2MP PWs can be constructed as either Single Segment Pseudowires (P2MP SS-PWs) or Multi-Segment Pseudowires (P2MP MS-PWs) as mentioned in [RFC7338]. P2MP MS-PW is outside the scope of this document. A reference model or a P2MP PW is depicted in Figure 1. A transport Label Switched Path (LSP) associated with a P2MP SS-PW SHOULD be a P2MP MPLS LSP (i.e., P2MP Traffic Engineering (TE) tunnel established via RSVP-TE [RFC4875] or P2MP LSP established via Multipoint LDP (mLDP) [RFC6388]) spanning from the Root PE (Provider Edge) 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, PE3, and PE4.

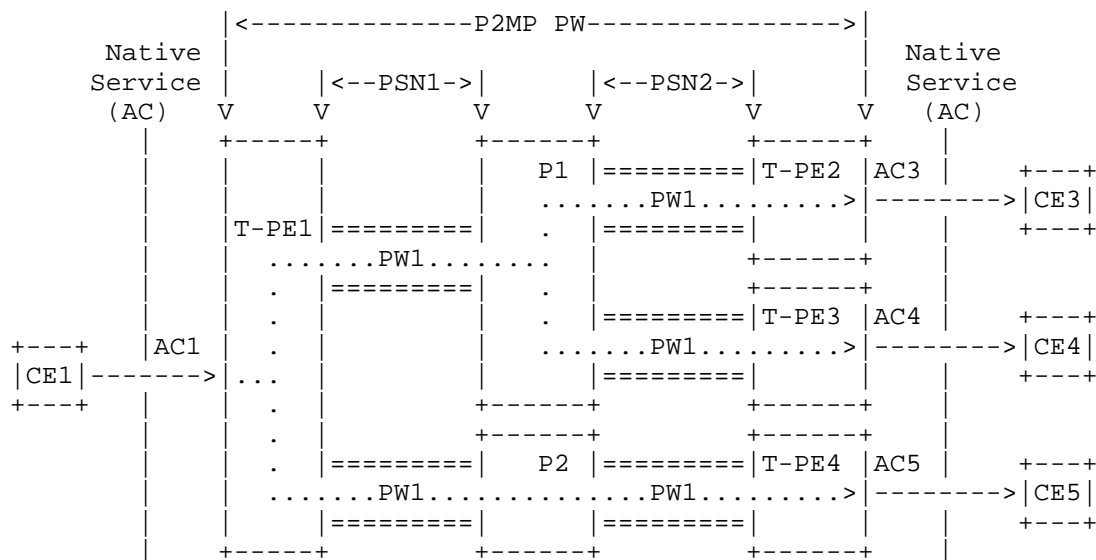


Figure 1: P2MP PW

Mechanisms for establishing a P2P SS-PW using LDP are described in [RFC8077]. This document specifies a method of signaling P2MP PW using LDP. In particular, this document defines a new Forwarding Equivalence Class (FEC), TLVs, parameters, and status codes to facilitate LDP signaling and maintaining P2MP PWs.

As outlined in [RFC7338], 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 an option into consideration.

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

## 2. Terminology

### 2.1. Requirements Language

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

AGI: Attachment Group Identifier

CE: Customer Edge

FEC: Forwarding Equivalence Class

L-PE: Leaf PE (egress PE)

LDP: Label Distribution Protocol

LSP: Label Switched Path

mLDP: Multipoint Label Distribution Protocol (for P2MP/MP2MP LSP)

MS-PW: Multi-Segment Pseudowire

P2MP: Point-to-Multipoint

P2P: Point-to-Point

PE: Provider Edge

PSN: Packet Switched Network

PW: Pseudowire

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

S-PE: Switching Provider Edge (of MS-PW)

SS-PW: Single-Segment Pseudowire

TE: Traffic Engineering

### 3. Signaling P2MP PW

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

An R-PE and each L-PE MUST be configured with the same FEC as defined in Section 3.2.

P2MP PW requires that there be an active P2MP PSN LSP set up between an 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 the case of mLDP, a Leaf PE can decide to join the P2MP LSP at any time. 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-PEs 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.

P2MP PW signaling is initiated by the R-PE, which sends a separate P2MP PW LDP Label Mapping Message to each of the L-PE(s) belonging to that P2MP PW. This Label Mapping Message will contain the following:

1. A FEC TLV containing a P2MP PW Upstream FEC Element that includes a Transport LSP sub-TLV.
2. An Interface Parameters TLV, as described in [RFC8077].
3. A PW Group ID TLV, as described in [RFC8077].
4. A label TLV for the upstream-assigned label used by an R-PE for the traffic going from the R-PE to L-PE(s).

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

Additionally, the R-PE MAY send Label Mapping Messages to one or more L-PEs to signal a unidirectional P2P PW(s). The L-PE(s) can use such a PW(s) to send traffic to the R-PE. This optional Label Mapping Message will contain the following:

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

The LDP liberal label retention mode MUST be used; 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 MUST 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. If an L-PE fails to join the P2MP PSN LSP, that L-PE MUST not enable the PW and MUST notify the user. In this case, a PW status message with status code of 0x00000008 (Local PSN-facing PW (ingress) Receive Fault) MUST also be sent to the R-PE.

### 3.1. PW Ingress-to-Egress Incompatibility Issues

If an R-PE signals a PW with a PW Type, Control Word (CW) mode, or interface parameters that a particular L-PE cannot accept, then the L-PE MUST NOT enable the PW and should 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 was not 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

[RFC8077] specifies two types of LDP FEC elements used to signal P2P PWs: "Pwid FEC Element" and "Generalized Pwid FEC Element". This document uses two FEC elements: "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.

## 3.2.1. P2MP PW Upstream FEC Element

The FEC type for the P2MP PW Upstream FEC Element is encoded as follows:

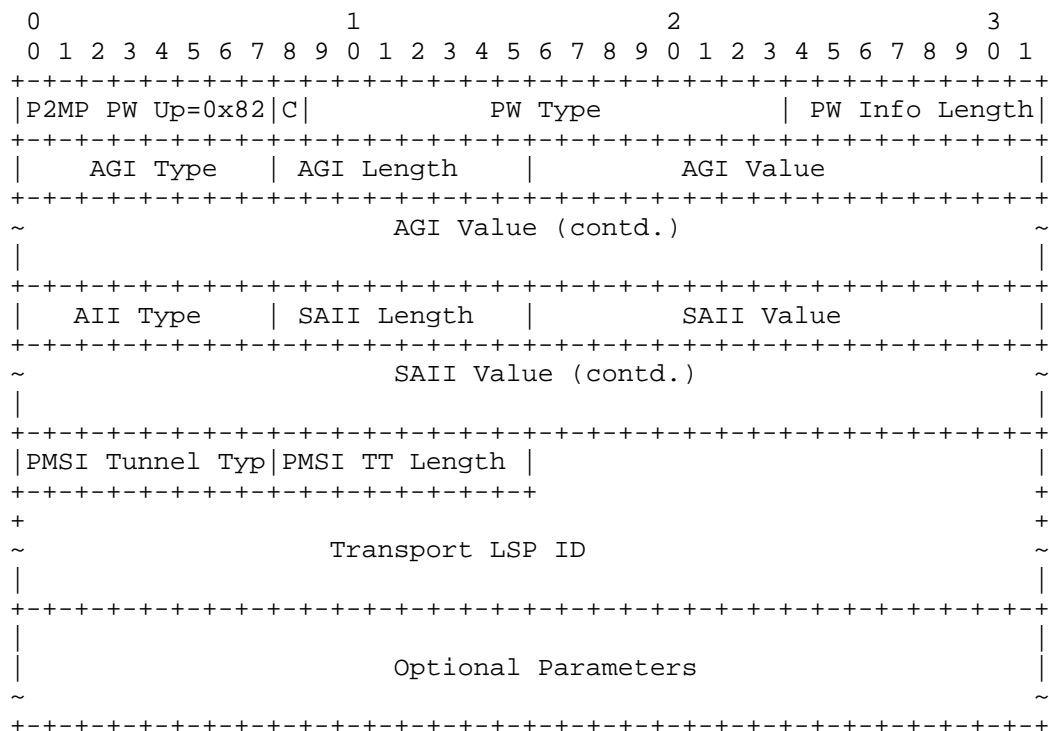


Figure 2: P2MP PW Upstream FEC Element

## \* P2MP PW Up:

8-bit representation for the P2MP PW Upstream FEC type.

## \* C bit:

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

## \* PW Type:

15-bit representation of PW Type as specified in [RFC8077].

\* PW Info Length:

Sum of the AGI Length, SAII Length, PMSI Tunnel Type Length, and Optional Parameters fields in octets. If this value is 0, then it references all PWs using the specified group ID. In this case, there are neither other FEC element fields (AGI Type, SAII Value, etc.) present, nor any interface parameters TLVs. Alternatively, typed wildcard FEC described in Section 2.3, can be used to achieve the same or to have better filtering.

\* AGI:

An Attachment Group Identifier TLV can be used to uniquely identify a VPN or Virtual Private LAN Service (VPLS) instance associated with the P2MP PW. This has the same format as the Generalized PWid FEC Element [RFC8077].

\* SAII Value:

A 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.

The 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 Info:

The PMSI Tunnel Info is the combination of the PMSI Tunnel Type, PMSI Tunnel Type Length (shown in the figure as PMSI TT Length), and Transport LSP ID fields.

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 [RFC6514].

When the type is set to mLDP P2MP LSP, the Tunnel Identifier is a P2MP FEC Element as defined in [RFC6388]. The new mLDP Opaque Value Element type for the L2VPN-MCAST application TLV (as specified in the IANA Considerations section (Section 7)) MUST be used.



\* Transport LSP ID:

This is the Tunnel Identifier that is defined in [RFC6514].

An R-PE sends a 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 PW; in which case, P2MP PWs will be sharing the same R-PE and L-PE(s). An R-PE may also have many P2MP PWs with disjoint L-PE sets.

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: the Interface Parameters TLV and the PW Group ID TLV.

The Interface Parameters TLV and PW Group ID TLV specified in [RFC8077] can also be used in conjunction with P2MP PW FEC in a label message. For the PW Group ID TLV, the sender and receiver of these TLVs should follow the same rules and procedures specified in [RFC8077]. For the Interface Parameters TLV, the procedure differs from the one specified in [RFC8077] due to specifics of P2MP connectivity. When the interface parameters are signaled by an 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, the value MUST exactly match the values signaled by the R-PE.

A 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, as described in the IANA Considerations section (Section 7) and according to the format described in [RFC8077]. 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 streams originating from the root.

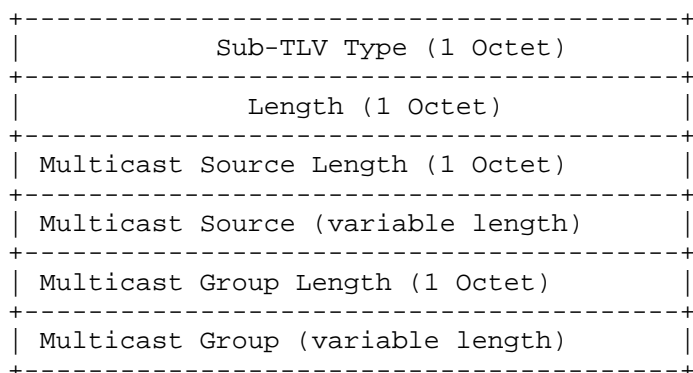


Figure 3: Selective Tree Interface Parameter Sub-TLV Value

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.

### 3.2.2. P2P PW Downstream FEC Element

The optional P2P PW Downstream FEC Element is encoded as follows:

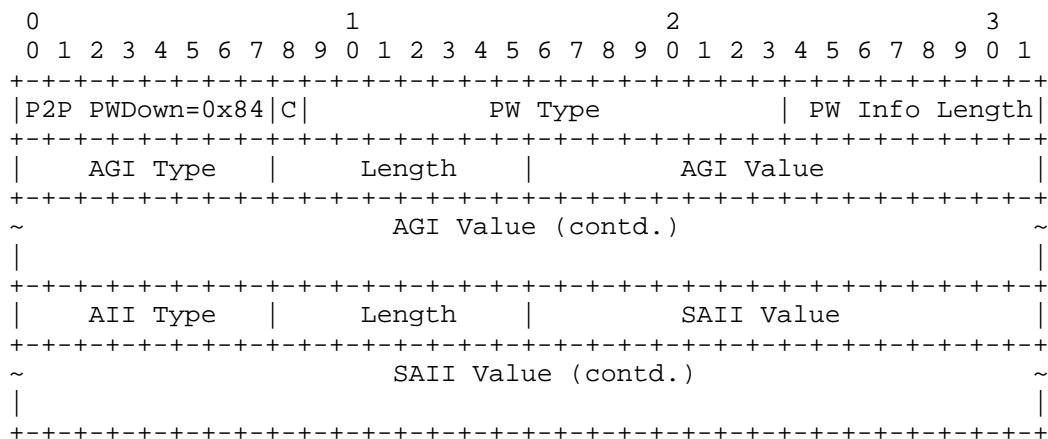


Figure 4: P2P PW Downstream FEC Element

The definition of the fields in the P2P PW Downstream FEC Element is the same as those of P2MP PW Upstream FEC Element, shown in Figure 2.

### 3.3. Typed Wildcard FEC Format for a New FEC

[RFC5918] defines the general notion of a Typed Wildcard FEC Element; it requires FEC designers to specify a Typed Wildcard FEC Element for newly defined FEC element types. This document uses two FEC elements: "P2MP PW Upstream" and "P2P PW Downstream". Hence, definition of their Typed Wildcard format is required.

[RFC6667] defines the Typed Wildcard FEC Element format for other PW FEC Element types (PWid and Generalized PWid FEC Element) in Section 3 as follows:

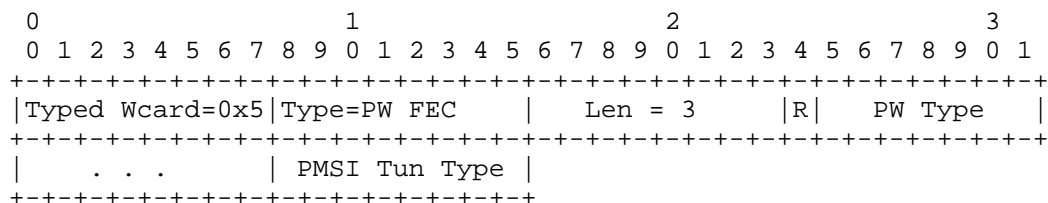


Figure 5: Typed Wildcard Format for P2MP PW FEC Elements

[RFC6667] specifies that the Type field can be either the "Pwid" (0x80) or "Generalized PWid" (0x81) FEC Element type. This document reuses the existing Typed Wildcard format specified in [RFC6667] and illustrated in Figure 5 and extends the definition of the Type field to also include the P2MP PW Upstream FEC Element and P2P PW Downstream FEC Element types. This document adds an additional field called the "PMSI Tunnel Type". This document reserves PMSI Tunnel Type 0xFF to mean "wildcard transport tunnel type". The PMSI Tunnel Type field only applies to the Typed Wildcard P2MP PW Upstream FEC Element and MUST be set to "wildcard" for "P2P PW Downstream FEC Element" typed wildcard.

### 3.4. Group ID Usage

The PW Group ID TLV as defined in [RFC8077] contains a group ID capable of indicating an arbitrary group membership of a P2MP PW. This group ID can be used in LDP "wildcard" status and withdraw label messages, as described in [RFC8077].

### 3.5. Generic Label TLV

As in the case of P2P PW signaling, P2MP PW labels are carried within the Generic Label TLV contained in the LDP Label Mapping Message. A Generic Label TLV is formatted and processed as per the rules and procedures specified in [RFC8077]. 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 Messages 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 the Generic Label TLV and P2P PW Downstream FEC Element in Label Mapping Messages.

## 4. LDP Capability Negotiation

The capability of supporting P2MP PWs MUST be advertised to all LDP peers. This is achieved by using the methods in [RFC5561] to advertise 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 support dynamic capability advertisement, then the P2MP PW Capability TLV MUST be included in the LDP Initialization message during session establishment. A Label Switched Router (LSR) having P2MP PW capability MUST recognize both the P2MP PW Upstream FEC Element and P2P PW Downstream FEC Element in LDP label messages.



## 5. P2MP PW Status

In order to support the proposed mechanism, an LSR MUST be capable of handling PW status. As such, the PW status negotiation procedures described in [RFC8077] are not applicable to P2MP PW. An LSR MUST NOT claim to be P2MP PW capable by sending an LDP P2MP PW Capability TLV if it is not also capable of handling PW status.

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 [RFC8077] to report the PW status. If no PW status notification is required, then no PW status notification is sent (for example, if the P2MP PW is established and operational with a status code of 0x00000000 (Success), a PW status message is not necessary). A PW status message sent from an L-PE to an R-PE MUST contain the P2P PW Downstream FEC Element 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 a PW status message contains a P2MP PW Upstream FEC Element to identify the PW.

Connectivity status of the underlying P2MP LSP that the P2MP PW is associated with can be verified using LSP ping and traceroute procedures described in [RFC6425].

## 6. Security Considerations

In general, the security measures described in [RFC8077] are adequate for this protocol. However, the use of MD5 as the method of securing an LDP control plane is no longer considered adequately secure. Implementations should be written in such a way that they can migrate to a more secure cryptographic hash function when the next authentication method to be used in the LDP might not be a simple hash-based authentication algorithm.

## 7. IANA Considerations

### 7.1. FEC Type Name Space

This document uses two FEC element types, 0x82 and 0x84, in the "Forwarding Equivalence Class (FEC) Type Name Space" registry for the Label Distribution Protocol (LDP) [RFC5036]. IANA has added this document as a reference for the following entries:

Value	Hex	Name	Reference
-----	-----	-----	-----
130	0x82	P2MP PW Upstream FEC Element	[RFC8338] [RFC7358]
132	0x84	P2P PW Downstream FEC Element	[RFC8338] [RFC7358]

## 7.2. LDP TLV Type

This document defines a new LDP TLV type in the "TLV Type Name Space" registry [RFC5036]. IANA has assigned the following value:

TLV Type	Description
-----	-----
0x0703	P2MP PW Capability TLV

## 7.3. mLDP Opaque Value Element TLV Type

IANA has assigned a new mLDP Opaque Value Element Type in the "LDP MP Opaque Value Element basic type" registry [RFC6388] as follows:

TLV Type	Description
-----	-----
13	L2VPN-MCAST application TLV

Length: 4

Value: A 32-bit integer, unique in the context of the root, as identified by the root's address.

## 7.4. Selective Tree Interface Parameter Sub-TLV Type

IANA has assigned a sub-TLV from the "Pseudowire Interface Parameters Sub-TLV type Registry" [RFC4446] as follows:

TLV Type	Description
-----	-----
0x1B	Selective Tree Interface Parameter

## 7.5. Wildcard PMSI Tunnel Type

IANA has modified an entry in the "P-Multicast Service Interface Tunnel (PMSI Tunnel) Tunnel Types" registry within the "Border Gateway Protocol (BGP) Parameters" registry [RFC7385]. Value 0xFF, which was previously marked as "Reserved", has been updated as follows:

Value	Meaning	Reference
-----	-----	-----
0xFF	wildcard transport tunnel type	[RFC8338]

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