

L3VPN Working Group
Internet Draft
Intended Status: Standards Track
Expires: April 4, 2014
Updates: [6513](#), 6625

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October 4, 2013

MVPN: Using Bidirectional P-Tunnels

[draft-ietf-l3vpn-mvpn-bidir-06.txt](#)

Abstract

A set of prior RFCs specify procedures for supporting multicast in BGP/MPLS IP VPNs. These procedures allow customer multicast data to travel across a service provider's backbone network through a set of multicast tunnels. The tunnels are advertised in certain BGP "auto-discovery" routes, by means of a BGP attribute known as the "Provider Multicast Service Interface (PMSI) Tunnel attribute". Encodings have been defined that allow the PMSI Tunnel attribute to identify bidirectional (multipoint-to-multipoint) multicast distribution trees. However, the prior RFCs do not provide all the necessary procedures for using bidirectional tunnels to support multicast VPNs. This document updates RFCs 6513 and 6625 by specifying those procedures. In particular, it specifies the procedures for assigning customer multicast flows (unidirectional or bidirectional) to specific bidirectional tunnels in the provider backbone, for advertising such assignments, and for determining which flows have been assigned to which tunnels.

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1. Introduction

The RFCs that specify multicast support for BGP/MPLS IP VPNs ([[MVPN](#)], [[MVPN-BGP](#)], [[MVPN-WILDCARDS](#)]) allow customer multicast data to be transported across a service provider's network through a set of multicast tunnels. These tunnels are advertised in BGP "auto-discovery" (A-D) routes, by means of a BGP attribute known as the "Provider Multicast Service Interface (PMSI) Tunnel attribute". The base specifications allow the use of bidirectional (multipoint-to-multipoint) multicast distribution trees, and describe how to encode the identifiers for bidirectional trees into the PMSI Tunnel attribute. However, those specifications do not provide all the necessary detailed procedures for using bidirectional tunnels; the full specification of these procedures was considered to be outside the scope of those documents. The purpose of this document is to provide all the necessary procedures for using bidirectional trees in a service provider's network to carry the multicast data of VPN customers.

1.1. Terminology

This document uses terminology from [[MVPN](#)] and, in particular, uses the prefixes "C-" and "P-", as specified in Section 3.1 of [[MVPN](#)], to distinguish addresses in the "customer address space" from addresses in the "provider address space". The following terminology and acronyms are particularly important in this document:

- MVPN

Multicast Virtual Private Network -- a VPN [L3VPN] in which multicast service is offered.

- VRF

VPN Routing and Forwarding table [L3VPN].

- PE

A Provider Edge router, as defined in [L3VPN].

- LSP

An MPLS Label Switched Path.

- P2MP Point-to-Multipoint.
- MP2MP

Multipoint-to-multipoint.

- Unidirectional

Adjective for a multicast distribution tree in which all traffic travels downstream from the root of the tree. Traffic can enter a unidirectional tree only at the root. A P2MP LSP is one type of unidirectional tree. Multicast distribution trees set up by PIM-SM [[PIM](#)] are also unidirectional trees.

- Bidirectional

Adjective for a multicast distribution tree in which traffic may travel both upstream (towards the root) and downstream (away from the root). Traffic may enter a bidirectional tree at any node. A MP2MP LSP is one type of bidirectional tree. Multicast distribution trees created by BIDIR-PIM [[BIDIR-PIM](#)] are also bidirectional trees.

- P-tunnel

A tunnel through the network of one or more Service Providers (SPs). In this document, the P-tunnels we speak of are instantiated as bidirectional multicast distribution trees.

- C-S

Multicast Source. A multicast source address, in the address space of a customer network.

- C-G

Multicast Group. A multicast group address (destination address) in the address space of a customer network.

- C-multicast flow or C-flow

A customer multicast flow. A C-flow travels through VPN customer sites on a multicast distribution tree set up by the customer. These trees may be unidirectional or bidirectional, depending upon the multicast routing protocol used by the customer. A C-flow travels between VPN customer sites by traveling through P-tunnels.

A C-flow from a particular customer source is identified by the ordered pair (source address, group address), where each address is in the customer's address space. The identifier of such a C-flow is usually written as (C-S,C-G).

If a customer uses the "Any Source Multicast" (ASM) model, the some or all of the customer's C-flows may be traveling along the same "shared tree". In this case, we will speak of a "(C-*,C-G)" flow to refer to a set of C-flows that travel along the same shared tree in the customer sites.

- C-BIDIR flow or bidirectional C-flow

A C-flow that, in the VPN customer sites, travels along a bidirectional multicast distribution tree. The term "C-BIDIR flow" indicates that the customer's bidirectional tree has been set up by BIDIR-PIM.

- RP

A "Rendezvous Point", as defined in [[PIM](#)].

- C-RP

A Rendezvous Point whose address is in the customer's address space.

- RPA

A "Rendezvous Point Address", as defined in [[BIDIR-PIM](#)].

- C-RPA

An RPA in the customer's address space.

- P-RPA

An RPA in the Service Provider's address space

- Selective P-tunnel

A P-tunnel that is joined only by Provider Edge (PE) routers that need to receive one or more of the C-flows that are traveling through that P-tunnel.

- Inclusive P-tunnel

A P-tunnel that is joined by all PE routers that attach to sites of a given MVPN.

- Intra-AS I-PMSI A-D route

Intra Autonomous System Inclusive Provider Multicast Service Interface Auto-Discovery route. Carried in BGP Update messages, these routes can be used to advertise the use of Inclusive P-tunnels. See [[MVPN-BGP](#)] [section 4.1](#).

- S-PMSI A-D route

Selective Provider Multicast Service Interface Auto-Discovery route. Carried in BGP Update messages, these routes are used to advertise the fact that a particular C-flow or a particular set of C-flows is bound to (i.e., is traveling through) a particular P-tunnel. See [[MVPN-BGP](#)] [section 4.3](#).

- (C-S,C-G) S-PMSI A-D route

An S-PMSI A-D route whose NLRI ("Network Layer Reachability Information") contains C-S in its "Multicast Source" field and C-G in its "Multicast Group" field.

- (C-*,C-G) S-PMSI A-D route

An S-PMSI A-D route whose NLRI contains the wildcard (C-*) in its "Multicast Source" field and C-G in its "Multicast Group" field. See [[MVPN-WILDCARDS](#)].

- (C-*,C-*) S-PMSI A-D route

An S-PMSI A-D route whose NLRI contains the wildcard C-* in its "Multicast Source" field and the wildcard C-* in its "Multicast Group" field. See [[MVPN-WILDCARDS](#)].

- (C-*,C-*) S-PMSI A-D route

An S-PMSI A-D route whose NLRI contains the wildcard C-* in its "Multicast Source" field and the wildcard C-* in its "Multicast Group" field. See [[MVPN-WILDCARDS](#)].

- (C-*,C-BIDIR) S-PMSI A-D route

An S-PMSI A-D route whose NLRI contains the wildcard C-* in its "Multicast Source" field and the wildcard "C-BIDIR" in its "Multicast Group" field. See [section 2](#) of this document.

- (C-S,C-*) S-PMSI A-D route

An S-PMSI A-D route whose NLRI contains C-S in its "Multicast Source" field and the wildcard C-* in its "Multicast Group" field. See [[MVPN-WILDCARDS](#)].

- Wildcard S-PMSI A-D route

A (C-*,C-G) S-PMSI A-D route, or a (C-*,C-*) S-PMSI A-D route, or a (C-S,C-*) S-PMSI A-D route, or a (C-*,C-BIDIR) S-PMSI A-D route.

- PTA

PMSI Tunnel attribute, a BGP attribute that identifies a P-tunnel. See [[MVPN-BGP](#)] [section 8](#).

The terminology used for categorizing S-PMSI A-D routes will also be used for categorizing the S-PMSIs advertised by those routes. E.g., the S-PMSI advertised by a (C-*,C-G) S-PMSI A-D route will be known as a "(C-*,C-G) S-PMSI".

Familiarity with multicast concepts and terminology [[PIM](#)] is also presupposed.

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document, when and only when appearing in all caps, are to be interpreted as described in [[RFC2119](#)].

[1.2. Overview](#)

The base documents for MVPN ([[MVPN](#)], [[MVPN-BGP](#)]) define a "PMSI Tunnel Attribute" (PTA) that may be carried in the BGP "I-PMSI A-D routes" and "S-PMSI A-D routes" that are defined therein. The base documents define the way in which the identifier of a bidirectional P-tunnel is encoded in the PTA. However, those documents do not contain the full set of specifications governing the use of bidirectional P-tunnels; rather, those documents declare the full set of specifications for using bidirectional P-tunnels to be outside their scope. Similarly, the use of bidirectional P-tunnels advertised in wildcard S-PMSI A-D routes by [[MVPN-WILDCARDS](#)] to be "out of scope."

This document provides the necessary specifications to allow the use of bidirectional P-tunnels to provide MVPN support. This includes

the procedures for assigning C-flows to specific bidirectional P-tunnels, for advertising the fact that a particular C-flow has been assigned to a particular bidirectional P-tunnel, and for determining the bidirectional P-tunnel on which a given C-flow may be expected.

The C-flows carried on bidirectional P-tunnels may themselves be either unidirectional or bidirectional. Procedures are provided for both cases.

This document does not specify any new data encapsulations for bidirectional P-tunnels. Section 12 of [\[MVPN\]](#) applies unchanged.

With regard to the procedures for using bidirectional P-tunnels to instantiate PMSIs, if there is any conflict between the procedures specified in this document and the procedures of [\[MVPN\]](#), [\[MVPN-BGP\]](#), or [\[MVPN-WILDCARDS\]](#), the procedures of this document take precedence.

The use of bidirectional P-tunnels in extranets [\[MVPN_XNET\]](#) is outside the scope of this document. The use of bidirectional P-tunnels as "segmented P-tunnels" (see [\[MVPN\]](#) [section 8](#) and various sections of [\[MVPN-BGP\]](#)) is also outside the scope of this document.

[1.2.1](#). Bidirectional P-tunnel Technologies

This document supports two different technologies for creating and maintaining bidirectional P-tunnels:

- Multipoint-to-multipoint Label Switched Paths (MP2MP LSPs) that are created through the use of the Label Distribution Protocol (LDP) Multipoint-to-Multipoint extensions [\[mLDP\]](#).
- Multicast distribution trees that are created through the use of BIDIR-PIM [\[BIDIR-PIM\]](#).

An implementation may be considered compliant with this document if it provides either one of these tunneling technologies. Other bidirectional tunnel technologies are outside the scope of this document.

[1.2.2](#). Reasons for Using Bidirectional P-tunnels

Bidirectional P-tunnels can be used to instantiate I-PMSIs and/or S-PMSIs. An SP may decide to use bidirectional P-tunnels to instantiate certain I-PMSIs and/or S-PMSIs in order to provide its customers with C-BIDIR support, using the "Partitioned Set of PEs" technique discussed in [\[MVPN\]](#) [section 11.2](#) and [\[RFC6517\]](#) [section 3.6](#).

This technique can be used whether the C-BIDIR flows are being carried on an I-PMSI or an S-PMSI.

An SP that does not need to provide C-BIDIR support may still decide to use bidirectional P-tunnels, in order to save state in the network's transit nodes. For example, if an MVPN has *n* PEs attached to sites with multicast sources, and there is an I-PMSI for that MVPN, instantiating the I-PMSI with unidirectional P-tunnels (i.e., with P2MP multicast distribution trees) requires *n* multicast distribution trees, each one rooted at a different PE. If the I-PMSI is instantiated by a bidirectional P-tunnel, a single multicast distribution tree can be used. (It must be noted though that this particular use of bidirectional P-tunnels is not compatible with the duplicate prevention scheme of [MVPN] [section 9.1.1](#), and thus would only be used if the duplication prevision schemes of [MVPN] sections 9.1.2 or 9.1.3 are suitable.)

An SP may decide to use bidirectional P-tunnels for either or both of these reasons.

These two reasons for using bidirectional P-tunnels are somewhat in conflict with each other, since (as will be seen in subsequent sections), the use of bidirectional P-tunnels for C-BIDIR support may require multiple bidirectional P-tunnels. Each such P-tunnel is associated with a particular "distinguished PE", and can only carry those C-BIDIR flows whose C-RPAs are reachable through its distinguished PE. However, on platforms that support MPLS upstream-assigned labels [[RFC5331](#)], "PE Distinguisher Labels" can be used to aggregate multiple bidirectional P-tunnels onto a single "outer" bidirectional P-tunnel, thereby allowing one to provide C-BIDIR support with minimal state at the transmit nodes.

Since there are two fundamentally different reasons for using bidirectional P-tunnels, and since many deployed router platforms do not support upstream-assigned labels at the current time, this document specifies several different methods of using bidirectional P-tunnels to instantiate PMSIs. We refer to these as "PMSI Instantiation Methods". The method or methods deployed by any particular SP will depend upon that SP's goals and engineering tradeoffs, and upon the set of platforms deployed by that SP.

The rules for using bidirectional P-tunnels in I-PMSI or S-PMSI A-D routes are not exactly the same as the rules for using unidirectional P-tunnels, and the rules are also different for the different PMSI instantiation methods. Subsequent sections of this document specify the rules in detail.

Note that even if the reason for using bidirectional P-tunnels is to

provide C-BIDIR support, the same P-tunnels can also be used to carry unidirectional C-flows, if that is the choice of the SP.

1.2.3. Knowledge of Group-to-RP and/or Group-to-RPA Mappings

If a VPN customer is making use of a particular "Any Source Multicast" (ASM) group address, the PEs of that VPN generally need to know the group-to-RP mappings that are used within the VPN. If a VPN customer is making use of BIDIR-PIM group addresses, the PEs need to know the group-to-RPA mappings that are used within the VPN. Commonly, the PEs obtain this knowledge either through provisioning or by participating in a dynamic "group-to-RP(A) mapping discovery protocol" that runs within the VPN. However, the way in which this knowledge is obtained is outside the scope of this document.

The PEs also need to be able to forward traffic towards the C-RPs and/or C-RPAs, and to determine whether the next hop "interface" of the route to a particular C-RP(A) is a VRF interface or a PMSI. This is done by applying the procedures of [[MVPN](#)] [section 5.1](#).

1.2.4. PMSI Instantiation Methods

This document specifies three methods for using bidirectional P-tunnels to instantiate PMSIs: the Flat Partitioned Method, the Hierarchical Partitioned Method, and the Unpartitioned Method.

- Partitioned Methods

In the Partitioned Methods, a particular PMSI is instantiated by a set of bidirectional P-tunnels. These P-tunnels may be aggregated (as "inner" P-tunnels) into a single "outer" bidirectional P-tunnel ("Hierarchical Partitioning"), or they may be unaggregated ("Flat Partitioning"). Any PE that joins one of these P-tunnels can transmit a packet on it, and the packet will be received by all the other PEs that have joined the P-tunnel. For each such P-tunnel (each "inner" P-tunnel, in the case of Hierarchical Partitioning) there is one PE that is its "distinguished PE". When a PE receives a packet from a given P-tunnel, the PE can determine from the packet's encapsulation the P-tunnel it has arrived on, and can thus infer the identity of the distinguished PE associated with the packet. This association plays an important role in the treatment of the packet, as specified later on in this document.

The number of P-tunnels needed (the number of "inner" P-tunnels needed, if Hierarchical Partitioning is used) depends upon a

number of factors that are described later in this document.

The Hierarchical Partitioned Method requires the use of upstream-assigned MPLS labels ("PE Distinguisher Labels"), and requires the use of the PE Distinguisher Labels attribute in BGP. The Flat Partitioned Method requires neither of these.

The Partitioned Method is a pre-requisite for implementing the "Partitioned Sets of PEs" technique of supporting C-BIDIR, as discussed in [[MVPN](#)] [section 11.2](#).

The Flat Partitioned Method is a pre-requisite for implementing the "Partial Mesh of MP2MP P-tunnels" technique for carrying customer bidirectional (C-BIDIR) traffic, as discussed in [[MVPN](#)] [Section 11.2.3](#).

Note that a particular deployment may choose to use the Partitioned Method for carrying the C-BIDIR traffic on bidirectional P-tunnels, while carrying other traffic either on unidirectional P-tunnels, or on bidirectional P-tunnels using the Unpartitioned Method.

- Unpartitioned Method

In the Unpartitioned Method, a particular PMSI can be instantiated by a single bidirectional P-tunnel. Any PE that joins the tunnel can transmit a packet on it, and the packet will be received by all the other PEs that have joined the tunnel. The receiving PEs can determine the tunnel on which the packet was transmitted, but they cannot determine which PE transmitted the packet, nor can they associate the packet with any particular "distinguished PE".

When the Unpartitioned Method is used, this document does not mandate that only one bidirectional P-tunnel be used to instantiate each PMSI. It allows for the case where more than one P-tunnel is used. In this case, the transmitting PEs will have a choice of which such P-tunnel to use when transmitting, and the receiving PEs must be prepared to receive from any of those P-tunnels. The use of multiple P-tunnels in this case provides additional robustness, but no additional functionality.

I-PMSIs may be instantiated by bidirectional P-tunnels using either the Partitioned (either Flat or Hierarchical) or the Unpartitioned Method. The method used for a given MVPN is determined by provisioning. It SHOULD be possible to provision this on a per-MVPN basis, but all the VRFs of a single MVPN MUST be provisioned to use the same method for the given MVPN's I-PMSI.

If a bidirectional P-tunnel is used to instantiate an S-PMSI (including the case of a (C-*,C-*) S-PMSI), either the Partitioned Method (either Flat or Hierarchical) or the Unpartitioned Method may be used. The method used by a given VRF used is determined by provisioning. It SHOULD be possible to provision this on a per-MVPN basis, but all the VRFs of a single MVPN MUST be provisioned to use the same method for those of their S-PMSIs that are instantiated by bidirectional P-tunnels.

If the Partitioned Method is used, all the VRFs of a single MVPN MUST be provisioned to use the same variant of the Partitioned Method, i.e., either they must all use the Flat Partitioned Method, or they must all use the Hierarchical Partitioned Method.

It is valid to use the Unpartitioned Method to instantiate the I-PMSIs, while using one of the Partitioned Methods to instantiate the S-PMSIs.

It is valid to instantiate some S-PMSIs by unidirectional P-tunnels and others by bidirectional P-tunnels.

The procedures for the use of bidirectional P-tunnels, specified in subsequent sections of this document, depend on both the tunnel technology and on the PMSI instantiation method. Note that this document does not necessarily specify procedures for every possible combination of tunnel technology and PMSI instantiation method.

2. The All BIDIR-PIM Wild Card

When an MVPN customer is using BIDIR-PIM, it is useful to be able to advertise an S-PMSI A-D route whose semantics are: "by default, all BIDIR-PIM C-multicast traffic (within a given VPN) that has not been bound to any other P-tunnel is bound to the bidirectional P-tunnel identified by the PTA of this route". This can be especially useful if one is using a bidirectional P-tunnel to carry the C-BIDIR flows, while using unidirectional P-tunnels to carry other C-flows. To do this, it is necessary to have a way to encode a (C-*,C-*) wildcard that is restricted to BIDIR-PIM C-groups.

We therefore define a special value of the group wildcard, whose meaning is "all BIDIR-PIM groups". The "BIDIR-PIM groups wildcard" is encoded as a group field whose length is 8 bits and whose value is zero. That is, the "multicast group length" field contains the value 0x08, and the "multicast group" field is a single octet containing the value 0x00. We will use the notation (C-*,C-BIDIR) to refer to the "all BIDIR-PIM groups" wildcard.

3. Using Bidirectional P-Tunnels

A bidirectional P-tunnel may be advertised in the PTA of an Intra-AS I-PMSI A-D route or in the PTA of an S-PMSI A-D route. The advertisement of a bidirectional P-tunnel in the PTA of an Inter-AS I-PMSI A-D route is outside the scope of this document.

3.1. Procedures Specific to the Tunneling Technology

This section discusses the procedures that are specific to a given tunneling technology (BIDIR-PIM or MP2MP mLDP), but that are independent of the method (Unpartitioned, Flat Partitioned, or Hierarchical Partitioned) used to instantiate a PMSI.

3.1.1. BIDIR-PIM P-Tunnels

Each BIDIR-PIM P-Tunnel is identified by a unique P-group address [MVPN, [section 3.1](#)]. (The P-group address is called a "P-Multicast Group" in [[MVPN-BGP](#)]). Section 5 of [[MVPN-BGP](#)] specifies the way to identify a particular BIDIR-PIM P-tunnel in the PTA of an I-PMSI or S-PMSI A-D route.

Ordinary BIDIR-PIM procedures are used to set up the BIDIR-PIM P-tunnels. A BIDIR-PIM P-group address is always associated with a unique "Rendezvous Point Address" (RPA) in the SP's address space. We will refer to this as the "P-RPA". Every PE needing to join a particular BIDIR-PIM P-tunnel must be able to determine the P-RPA that corresponds to the P-tunnel's P-group address. To construct the P-tunnel, PIM Join/Prune messages are sent along the path from the PE to the P-RPA. Any P routers along that path must also be able to determine the P-RPA, so that they too can send PIM Join/Prune messages towards it. The method of mapping a P-group address to an RPA may be static configuration, or some automated means of RPA discovery that is outside the scope of this specification.

If a BIDIR-PIM P-tunnel is used to instantiate an I-PMSI or an S-PMSI, it is RECOMMENDED that the path from each PE in the tunnel to the RPA consist entirely of point-to-point links. On a point-to-point link, there is no ambiguity in determining which router is upstream towards a particular RPA, so the BIDIR-PIM "Designated Forwarder Election" is very quick and simple. Use of a BIDIR-PIM P-tunnel containing multiaccess links is possible, but considerably more complex.

The use of BIDIR-PIM P-tunnels to support the Hierarchical Partitioned Method is outside the scope of this document.

When the PTA of an Intra-AS I-PMSI A-D route or an S-PMSI A-D route identifies a BIDIR-PIM tunnel, the originator of the route SHOULD NOT include a PE Distinguisher Labels attribute. If it does, that attribute MUST be ignored. When we say the attribute is "ignored", we do not mean that its normal BGP processing is not done, but that the attribute has no effect on the data plane. It MUST however be treated by BGP as if it were an unsupported optional transitive attribute. (PE Distinguisher Labels are used for the Hierarchical Partitioning Method, but this document does not provide support for the Hierarchical Partitioning Method with BIDIR-PIM P-tunnels.)

[3.1.2. MP2MP LSPs](#)

Each MP2MP LSP is identified by a unique "MP2MP FEC (Forwarding Equivalence Class) element" [[mLDP](#)]. The FEC element contains the IP address of the "root node", followed by an "opaque value" that identifies the MP2MP LSP uniquely in the context of the root node's IP address. This opaque value may be configured or autogenerated, and within an MVPN, there is no need for different root nodes to use the same opaque value. The mLDP specification supports the use of several different ways of constructing the tunnel identifiers. The current specification does not place any restriction on the type of tunnel identifier that might be used. However, a given implementation might not support every possible type of tunnel identifier.

Section 5 of [[MVPN-BGP](#)] specifies the way to identify a particular MP2MP P-tunnel in the PTA of an I-PMSI or S-PMSI A-D route.

Ordinary mLDP procedures for MP2MP LSPs are used to set up the MP2MP LSP.

[3.2. Procedures Specific to the PMSI Instantiation Method](#)

[3.2.1. Flat Partitioning](#)

The procedures of this section and its sub-sections apply when (and only when) the Flat Partitioned Method is used. This method is introduced in [[MVPN](#)] [Section 11.2.3](#), where it is called "Partial Mesh of MP2MP P-tunnels". This method can be used with MP2MP LSPs or with BIDIR-PIM P-tunnels.

The Flat Partitioned Method may be used to instantiate the following types of PMSI: I-PMSI, (C-*,C-*) S-PMSI, (C-*,C-BIDIR) S-PMSI, or (C-*,C-G) S-PMSI where C-G is a bidirectional C-group.

When a PE originates an I-PMSI or S-PMSI A-D route whose PTA specifies a bidirectional P-tunnel, the PE MUST be the root node of the specified P-tunnel. It follows that two different PEs may not advertise the same bidirectional P-tunnel. Any PE that receives a packet from the P-tunnel can infer the identity of the P-tunnel from the packet's encapsulation. Once the identity of the P-tunnel is known, the root node of the P-tunnel is also known. The root node of the P-tunnel on which the packet arrived is treated as the "distinguished PE" for that packet.

If MP2MP LSPs are used, each P-tunnel MUST have have a distinct MP2MP FEC (i.e., distinct combination of "root node" and "opaque value"). The PE advertising the tunnel MUST be the same PE identified in the "root node" field of the MP2MP FEC that is encoded in the PTA.

If BIDIR-PIM P-tunnels are used, each advertised P-tunnel MUST have a distinct P-group address. The PE advertising the tunnel will be considered to be the root node of the tunnel. Note that this creates a unique mapping from P-group address to "root node".

The Flat Partitioned Method does not use upstream-assigned labels in the data plane, and hence does not use the BGP PE Distinguisher Labels attribute. When this method is used, I-PMSI and/or S-PMSI A-D routes SHOULD NOT contain a PE Distinguisher Labels attribute; if such an attribute is present in a received I-PMSI or S-PMSI A-D route, it MUST be ignored. (When we say the attribute is "ignored", we do not mean that its normal BGP processing is not done, but that the attribute has no effect on the data plane. It MUST however be treated by BGP as if it were an unsupported optional transitive attribute.)

When the Flat Partitioned Method is used to implement the "Partitioned Sets of PEs" method of supporting C-BIDIR, as discussed in section 11.2 of [\[MVPN\]](#) and [section 3.6 of \[RFC6517\]](#), a C-BIDIR flow MUST be carried only on an I-PMSI or on a (C-*,C-G), (C-*,C-BIDIR), or (C-*,C-*) S-PMSI. A PE MUST NOT originate a (C-S,C-G) S-PMSI A-D route for any C-G that is a C-BIDIR group. Packets of a C-BIDIR flow MUST NOT be carried on a (C-S,C-*) S-PMSI.

When the Flat Partitioned Method is used to instantiate the I-PMSIs of a given MVPN, every PE in that MVPN that originates an Intra-AS I-PMSI A-D route MUST include a PTA that specifies a bidirectional P-tunnel. If the intention is to carry C-BIDIR traffic on the I-PMSI, a PE MUST originate an Intra-AS I-PMSI A-D route if one of its VRF interfaces is the next hop interface on its best path to the C-RPA of any bidirectional C-group of the MVPN.

When the Flat Partitioned Method is used to instantiate a (C-*,C-*)

S-PMSI, a (C-*,C-BIDIR) S-PMSI, or a (C-*,C-G) S-PMSI, a PE that originates the corresponding S-PMSI A-D route MUST include in that route a PTA specifying a bidirectional P-tunnel. Per the procedures of [\[MVPN\]](#) and [\[MVPN-BGP\]](#), a PE will originate such an S-PMSI A-D route only if one of the PE's VRF interfaces is the next hop interface of the PE's best path to the C-RPA of a C-BIDIR group that is to be carried on the specified S-PMSI.

PMSIs that are instantiated via the Flat Partitioned Method may carry customer bidirectional traffic AND customer unidirectional traffic. The rules of sections [3.2.1.1](#) and [3.2.1.2](#) determine when a given customer multicast packet is a "match for transmission" to a given PMSI. However, if the "Partitioned Set of PEs" method of supporting C-BIDIR traffic is being used, the PEs must be provisioned in such a way that packets from a C-BIDIR flow never match any PMSI that is not instantiated by a bidirectional P-tunnel. (For example, if the (C-*,C-*) S-PMSI were not instantiated by a bidirectional P-tunnel, one could meet this requirement by carrying all C-BIDIR traffic on a (C-*,C-BIDIR) S-PMSI.)

When a PE receives a customer multicast data packet from a bidirectional P-tunnel, it associates that packet with a "distinguished PE". The distinguished PE for a given packet is the root node of the tunnel from which the packet is received. The rules of [section 3.2.1.1](#) and 3.2.2.2 ensure that:

- If the received packet is part of a unidirectional C-flow, its "distinguished PE" is the PE that transmitted the packet onto the P-tunnel.
- If the received packet is part of a bidirectional C-flow, its "distinguished PE" is not necessarily the PE that transmitted it, but rather the transmitter's "upstream PE" for the C-RPA of the bidirectional C-group.

The rules of sections [3.2.1.3](#) and [3.2.1.4](#) allow the receiving PEs to determine the expected distinguished PE for each C-flow, and ensure that a packet will be discarded if its distinguished PE is not the expected distinguished PE for the C-flow to which the packet belongs. This prevents duplication of data for both bidirectional and unidirectional C-flows.

[3.2.1.1](#). When an S-PMSI is a 'Match for Transmission'

Given the need for a PE, say PE1, to transmit multicast data packets of a particular C-flow, [\[MVPN-WILDCARDS\]](#) [Section 3.1](#) gives a four-step algorithm for determining the S-PMSI A-D route, if any,

that "matches" that C-flow for transmission.

If the C-flow is not a BIDIR-PIM C-flow, these rules apply unchanged.

If the C-flow is a BIDIR-PIM C-flow, the rules as applied by a particular PE, say PE1, are given below:

- If the C-RPA for C-G is a C-address of PE1, or if PE1's route to the C-RPA is via a VRF interface, then:
 - * if there is an S-PMSI A-D route, currently originated by PE1, whose NLRI contains (C-*,C-G) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route
 - * otherwise, if there is an S-PMSI A-D route, currently originated by PE1, whose NLRI contains (C-*,C-BIDIR) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route
 - * otherwise, if there is an S-PMSI A-D route, currently originated by PE1, whose NLRI contains (C-*,C-*) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route
- If PE1 determines the upstream PE for C-G's C-RPA to be some other PE, say PE2, then the following rules apply:
 - * if there is an installed S-PMSI A-D route, originated by PE2, whose NLRI contains (C-*,C-G) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route
 - * otherwise, if there is an installed S-PMSI A-D route, originated by PE2, whose NLRI contains (C-*,C-BIDIR) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route
 - * otherwise, if there is an S-PMSI A-D route, currently originated by PE2, whose NLRI contains (C-*,C-*) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route

If there is an S-PMSI A-D route that matches a given C-flow, and if PE1 needs to transmit packets of that C-flow or other PEs, then it MUST transmit those packets on the P-tunnel identified in the PTA of the matching S-PMSI A-D route.

3.2.1.2. When an I-PMSI is a 'Match for Transmission'

If a PE needs to transmit packets of a given C-flow (of a given MVPN) to other PEs, and if, according to the conditions of [section 3.2.1.1](#), that C-flow does not match any S-PMSI A-D route, then the packets of the C-flow need to be transmitted on the MVPN's I-PMSI.

If the C-flow is not a BIDIR-PIM C-flow, the P-tunnel on which the C-flow MUST be transmitted is the one identified in the PTA of the Intra-AS I-PMSI A-D route originated by the PE for the given MVPN.

If the C-flow is a BIDIR-PIM C-flow, the rules as applied by a particular PE, say PE1, are given below:

- If the C-RPA for C-G is a C-address of PE1, or if PE1's route to the C-RPA is via a VRF interface, then if there is an I-PMSI A-D route, currently originated by PE1, and whose PTA identifies a bidirectional P-tunnel, then the C-flow MUST be transmitted on that P-tunnel
- If PE1 determines the upstream PE for C-G's C-RPA to be some other PE, say PE2, then if there is an installed I-PMSI A-D route, originated by PE2, whose PTA identifies a bidirectional P-tunnel, then the C-flow MUST be transmitted on that P-tunnel

Note that if a VRF is configured to provide C-BIDIR support using the Flat Partitioned Method, but there is no matching S-PMSI A-D route (according to [section 3.2.1.1](#)) and there is no such I-PMSI A-D route meeting the conditions of this section, then a provisioning error has occurred, and the C-flow will not be transmitted.

3.2.1.3. When an S-PMSI is a 'Match for Reception'

Given the need for a PE to receive multicast data packets of a particular C-flow, [[MVPN-WILDCARDS](#)] [Section 3.2](#) specifies procedures for determining the S-PMSI A-D route, if any, that "matches" that C-flow for reception. Those rules apply unchanged for C-flows that are not BIDIR-PIM C-flows.

For BIDIR-PIM C-flows, the rules of [[MVPN-WILDCARDS](#)] [Section 3.2.1](#) do not apply.

The rules of [[MVPN-WILDCARDS](#)] [Section 3.2.2](#) are replaced by the following rules.

Suppose that a PE router (call it PE1) needs to receive (C-*,C-G) traffic, where C-G is a C-BIDIR group. Suppose also that PE1 has

determined that PE2 is the "upstream PE" [[MVPN](#)] for the C-RPA of C-G. Then:

- if PE1 has an installed S-PMSI A-D route originated by PE2, whose NLRI contains (C-*,C-G), then (C-*,C-G) matches this route.
- otherwise, if PE1 has an installed (C-*,C-BIDIR) route from PE2, then (C-*,C-G) matches this route.
- otherwise, if PE1 has an installed (C-*,C-*) S-PMSI A-D route from PE2, then (C-*,C-G) matches this route.

If there is an S-PMSI A-D route matching (C-*,C-G), according to these rules, its PTA must specify a bidirectional P-tunnel. The root node of that P-tunnel is considered to be the "distinguished PE" for the (C-*,C-G) flow. If a (C-*,C-G) packet is received on a P-tunnel whose root node is not the distinguished PE for the C-flow, the packet MUST be discarded.

[3.2.1.4](#). When an I-PMSI is a 'Match for Reception

If a PE needs to receive packets of a given C-flow (of a given MVPN) from another PE, and if, according to the conditions of [Section 3.2.1.3](#), that C-flow does not match any S-PMSI A-D route, then the packets of the C-flow need to be received on the MVPN's I-PMSI.

If the C-flow is not a BIDIR-PIM C-flow, the rules for determining the P-tunnel on which packets of the C-flow are expected are given in [[MVPN](#)].

Suppose that a PE router (call it PE1) needs to receive (C-*,C-G) traffic from other PEs, where C-G is a C-BIDIR group. Suppose also that PE1 has determined that PE2 is the "upstream PE" [[MVPN](#)] for the C-RPA of C-G. PE2 is considered to be the "distinguished PE" for (C-*,C-G). If PE1 has an installed Intra-AS I-PMSI A-D route originated by PE2, PE1 will expect to receive packets of the C-flow from the tunnel specifies in that route's PTA. (If all VRFs of the MVPN have been properly provisioned to use the Flat Partitioned Method for the I-PMSI, the PTA will specify a bidirectional P-tunnel.)

If a (C-*,C-G) packet is received on a P-tunnel whose root node is not the distinguished PE for the C-flow, the packet MUST be discarded.

3.2.2. Hierarchical Partitioning

The procedures of this section and its sub-sections apply when (and only when) the Hierarchical Partitioned Method is used. This method is introduced in [\[MVPN\] Section 11.2.2](#). This document only provides procedures for using this method when using MP2MP LSPs as the P-tunnels.

The Hierarchical Partitioned Method provides the same functionality as the Flat Partitioned Method, but requires a smaller amount of state to be maintained in the core of the network. However, it requires the use of upstream-assigned MPLS labels ("PE Distinguisher Labels"), which are not necessarily supported by all hardware platforms. The upstream-assigned labels are used to provide an LSP hierarchy, in which an "outer" MP2MP LSP carries multiple "inner" MP2MP LSPs. Transit routers along the path between PE routers then only need to maintain state for the outer MP2MP LSP.

When this method is used to instantiate a particular PMSI, the bidirectional P-tunnel advertised in the PTA of the corresponding I-PMSI or S-PMSI A-D route is the "outer" P-tunnel. When a packet is received from a P-tunnel, the PE that receives it can infer the identity of the outer P-tunnel from the MPLS label that has risen to the top of the packet's label stack. However, the packet's "distinguished PE" is not necessarily the root node of the the outer P-tunnel. Rather, the identity of the packet's distinguished PE is inferred from the PE Distinguisher Label further down in the label stack. (See [\[MVPN\] Section 12.3](#).) The PE Distinguisher Label may be thought of as identifying an "inner" MP2MP LSP whose root is the PE corresponding to that label.

The Hierarchical Partitioned Method may be used to instantiate an I-PMSI, a (C-*,C-*) S-PMSI, or a (C-*,C-BIDIR) S-PMSI. In this case, every PE that originates an Intra-AS I-PMSI A-D route, a (C-*,C-*) S-PMSI A-D route, or a (C-*,C-BIDIR) S-PMSI A-D route MUST be provisioned with the mLDP FEC of the outer P-tunnel that is to be used to instantiate the PMSI in question, and the A-D route advertising that PMSI MUST be originated with a PTA that identifies the the outer bidirectional P-tunnel.

The PEs that are required to originate the routes mentioned in the previous paragraph are those that satisfy one of the following conditions:

- There is a C-BIDIR group for which the best path from the PE to the C-RPA of that C-group is via a VRF interface, or

- The PE might have to transmit customer multicast traffic on the PMSI identified in the route,
- The PE is the root node of the MP2MP LSP that is used to instantiate the PMSI.

If (and only if) C-G is a C-BIDIR group, the Hierarchical Partitioned method may be used to instantiate the (C-*,C-G) S-PMSI. In this case, when a (C-*,C-G) S-PMSI A-D route is originated, it is originated only by a PE whose best path to the C-RPA for C-G is via a VRF interface, and that PE MUST be the root node of the MP2MP LSP identified in the PTA of the A-D route.

As in [[MVPN](#)] and [[MVPN-BGP](#)], an S-PMSI A-D route does not need to be originated by a particular PE, say PE1, until PE1 has received a "join" indicating that some other PE is interested in receiving customer multicast traffic forwarded from PE1.

The Hierarchical Partitioned method MUST NOT be used to instantiate a (C-S,C-G) or a (C-S,C-*) S-PMSI.

If the "partitioned sets of PEs" method of supporting C-BIDIR is used, as discussed in section 11.2 of [[MVPN](#)] and [section 3.6 of \[RFC6517\]](#), C-BIDIR flows MUST NOT be carried on a P-tunnel specified in the PTA of a (C-S,C-G) or a (C-S,C-*) S-PMSI.

If any VRF of a given MVPN uses this method TO instantiate an S-PMSI with a bidirectional P-tunnel, all VRFs of that MVPN must use this method.

[3.2.2.1. Advertisement of PE Distinguisher Labels](#)

A PE Distinguisher Label is an upstream-assigned MPLS label [[RFC5331](#)] that can be used, in the context of a MP2MP LSP, to denote a particular PE that either has joined or may in the future join that LSP.

In order to use upstream-assigned MPLS labels in the context of an "outer" MP2MP LSP, there must be a convention that identifies a particular router as the router that is responsible for allocating the labels and for advertising the labels to the PEs that may join the MP2MP LSP. This document REQUIRES that the PE Distinguisher Labels used in the context of a given MP2MP LSP be allocated and advertised by the router that is the root node of the LSP.

This convention accords with the rules of [section 7 of \[RFC5331\]](#). Note that according to [section 7 of \[RFC5331\]](#), upstream-assigned

labels are unique in the context of the IP address of the root node; if two MP2MP LSPs have the same root node IP address, the upstream-assigned labels used within the two LSPs come from the same label space.

A PE Distinguisher Labels attribute SHOULD NOT be attached to an I-PMSI or S-PMSI A-D route unless that route also contains a PTA that specifies an MP2MP LSP. (While PE Distinguisher Labels could in theory also be used if the PTA specifies a BIDIR-PIM P-tunnel, such use is outside the scope of this document.)

The PE Distinguisher Labels attribute specifies a set of <MPLS label, IP address> bindings. Each IP address is the IP address of a PE router that is expected to receive the route that contains the attribute. Within a given PE Distinguisher Labels attribute, each IP address MUST appear only once, and each MPLS label MUST appear only once.

When a PE Distinguisher Labels attribute is included in a given I-PMSI or S-PMSI A-D route, it MUST assign a label to the IP address of each of the following sets of PEs:

- The root node of the MP2MP LSP identified in the PTA of the route,
- Any PE that may need to transmit non-C-BIDIR traffic on the MP2MP LSP identified in the PTA of the route. This requirement can be met by assigning a label to every PE that has originated an Intra-AS I-PMSI A-D route. However, if it is known apriori that all the non-C-BIDIR sources are in sites attached to only a subset of the PEs, PE Distinguisher labels can be specified for that subset alone.

3.2.2.2. When an S-PMSI is a 'Match for Transmission'

Given the need for a PE, say PE1, to transmit multicast data packets of a particular C-flow, [[MVPN-WILDCARDS](#)] [Section 3.1](#) gives a four-step algorithm for determining the S-PMSI A-D route, if any, that "matches" that C-flow for transmission.

If the C-flow is not a BIDIR-PIM C-flow, these rules apply unchanged. Once PE1 finds the matching S-PMSI (if any), PE1 may transmit a packet of that C-flow on the P-tunnel advertised in that route. The packet MUST carry the PE Distinguisher Label assigned by the root node of that P-tunnel to the IP address of PE1.

If the C-flow is a BIDIR-PIM C-flow, the rules are given below.

Assume PE1 determines that the upstream PE for C-G's C-RPA is PE2.

- If there is an installed S-PMSI A-D route, or an S-PMSI A-D route originated by PE1 itself, whose NLRI contains (C-*,C-G) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route.
- Otherwise, if there is an installed S-PMSI A-D route, or an S-PMSI A-D route currently originated by PE1 itself, whose NLRI contains (C-*,C-BIDIR) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route.
- Otherwise, if there is an installed S-PMSI A-D route (or an S-PMSI A-D route currently originated by PE1 itself) whose NLRI contains (C-*,C-*) and whose PTA identifies a bidirectional P-tunnel, then the C-flow matches that route.

If there is a matching S-PMSI A-D route, PE1 MUST transmit the C-flow on the P-tunnel identified in its PTA. In constructing the packet's MPLS label stack, it must use the PE Distinguisher Label that was assigned by the P-tunnel's root node to the IP address of PE2.

(Note: the PE Distinguisher Label is the one assigned to the address of PE2, not the one assigned to the address of PE1.)

3.2.2.3. When an I-PMSI is a 'Match for Transmission'

If a PE, say PE1, needs to transmit packets of a given C-flow (of a given MVPN) to other PEs, and if, according to the conditions of [section 3.2.2.1](#), that C-flow does not match any S-PMSI A-D route, then the packets of the C-flow need to be transmitted on the MVPN's I-PMSI.

If the C-flow is not a BIDIR-PIM C-flow, the P-tunnel on which the C-flow MUST be transmitted is the one identified in the PTA of the Intra-AS I-PMSI A-D route originated by PE1 for the given MVPN. Each packet of the C-flow MUST carry the PE Distinguisher Label assigned by the root node of that P-tunnel to the IP address of PE1.

If the C-flow is a BIDIR-PIM C-flow, the rules as applied by a particular PE, say PE1, are given below:

- If the C-RPA for C-G is a C-address of PE1, or if PE1's route to the C-RPA is via a VRF interface, then if there is an I-PMSI A-D route, currently originated by PE1, and whose PTA identifies a bidirectional P-tunnel, then the C-flow MUST be transmitted on that P-tunnel. Each packet of the C-flow MUST carry the PE Distinguisher Label assigned by the root node of that P-tunnel to

the IP address of PE1.

- If PE1 determines the upstream PE for C-G's C-RPA to be some other PE, say PE2, then if there is an installed I-PMSI A-D route, originated by PE2, whose PTA identifies a bidirectional P-tunnel, then the C-flow MUST be transmitted on that P-tunnel. Each packet of the C-flow MUST carry the PE Distinguisher Label assigned by the root node of that P-tunnel to the IP address of PE2.

Note that if a VRF is configured to provide C-BIDIR support using the Flat Partitioned Method, but there is no matching S-PMSI A-D route (according to [section 3.2.2.1](#)) and there is no such I-PMSI A-D route meeting the conditions of this section, then a provisioning error has occurred, and the C-flow will not be transmitted.

[3.2.2.4](#). When an S-PMSI is a 'Match for Reception'

Given the need for a PE, say PE1, to receive multicast data packets of a particular C-flow, [[MVPN-WILDCARDS](#)] [Section 3.2](#) specifies procedures for determining the S-PMSI A-D route, if any, that "matches" that C-flow for reception. Those rules require that the matching S-PMSI A-D route has been originated by the upstream PE for the C-flow. These rules are modified in this section, as follows.

Consider a particular C-flow. Suppose either:

- the C-flow is unidirectional, and PE1 determines that its upstream PE is PE2, or
- the C-flow is bidirectional, and PE1 determines that the upstream PE for its C-RPA is PE2.

Then the C-flow may match an installed S-PMSI A-D route that was not originated by PE2, as long as:

1. the PTA of that A-D route identifies an MP2MP LSP, and
2. there is an installed S-PMSI A-D route originated the root node of that LSP, or PE1 itself the root node of the LSP and there is a currently originated S-PMSI A-D route from PE1 whose PTA identifies that LSP, and

3. the latter S-PMSI A-D route (the one identified in 2 just above) contains a PE Distinguisher Labels attribute that assigned an MPLS label to the IP address of PE2.

However, a bidirectional C-flow never matches an S-PMSI A-D route whose NLRI contains (C-S,C-G).

If a multicast data packet is received over a matching P-tunnel, but does not carry the value of the PE Distinguisher Label that has been assigned to the upstream PE for its C-flow, then the packet MUST be discarded.

3.2.2.5. When an I-PMSI is a 'Match for Reception'

If a PE needs to receive packets of a given C-flow (of a given MVPN) from another PE, and if, according to the conditions of [section 3.2.3.3](#), that C-flow does not match any S-PMSI A-D route, then the packets of the C-flow need to be received on the MVPN's I-PMSI. When the Hierarchical Partitioned Method is used, each Intra-AS I-PMSI A-D routes of the MVPN will have a PTA, and all such PTAs will specify the same bidirectional P-tunnel. This is the "outer P-tunnel" that carries all packets that are transmitted on the I-PMSI. This determines the top label that packets of that C-flow will be carrying when received. A PE that needs to receive packets of a given C-flow must determine the expected value of the second label for packets of that C-flow. This will be the value of a PE Distinguisher Label, taken from the PE Distinguisher Labels attribute of the Intra-AS I-PMSI A-D route of the root node of that outer tunnel. The expected value of the second label on received packets (corresponding to the "inner tunnel") of a given C-flow is determined according to the following rules.

First, the "distinguished PE" for the C-flow is determined:

- If the C-flow is not a BIDIR-PIM C-flow, the "distinguished PE" for the C-flow is its "upstream PE", as determined by the rules of [\[MVPN\]](#).
- If the C-flow is a BIDIR-PIM C-flow, the "distinguished PE" for the C-flow is its "upstream PE" of the C-flow's C-RPA, as determined by the rules of [\[MVPN\]](#).

The expected value of the second label is the value that the root PE of the outer tunnel has assigned, in the PE Distinguisher Labels attribute of its Intra-AS I-PMSI A-D route, to the IP address of the "distinguished PE".

Packets addresses to C-G that arrive on other than the expected inner and outer P-tunnels (i.e., that arrive with unexpected values of the top two labels) MUST be discarded.

3.2.3. Unpartitioned

When a particular MVPN uses the Unpartitioned Method of instantiating an I-PMSI with a bidirectional P-tunnel, it MUST be the case that at least one VRF of that MVPN originates an Intra-AS I-PMSI A-D route that includes a PTA specifying a bidirectional P-tunnel. The conditions under which an Intra-AS I-PMSI A-D route must be originated from a given VRF are as specified in [[MVPN-BGP](#)]. This document allows all but one of such routes to omit the PTA. However, each such route MAY contain a PTA. If the PTA is present, it MUST specify a bidirectional P-tunnel. As specified in [[MVPN](#)] and [[MVPN-BGP](#)], every PE that imports such an Intra-AS I-PMSI A-D route into one of its VRFs MUST join the P-tunnel, specified in the route's PTA, if the route has a PTA.

Packets received on any of these P-tunnels are treated as having been received over the I-PMSI. The disposition of a received packet MUST NOT depend upon the particular P-tunnel over which it has been received.

When a PE needs to transmit a packet on such an I-PMSI, then if that PE advertised a P-tunnel in the PTA of an Intra-AS I-PMSI A-D route that it originated, the PE SHOULD transmit the on that P-tunnel. However, any PE that transmits a packet on the I-PMSI MAY transmit it on any of the P-tunnels advertised in any of the currently installed Intra-AS I-PMSI A-D routes for its VPN.

This allows a single bidirectional P-tunnel to be used to instantiate the I-PMSI, but also allows the use of multiple bidirectional P-tunnels. There may be a robustness advantage in having multiple P-tunnels available for use, but the number of P-tunnels used does not impact the functionality in any way. If there are, e.g., two P-tunnels available, these procedures allow each P-tunnel to be advertised by a single PE, but they also allow each P-tunnel to be advertised by multiple PEs. Note that the PE advertising a given P-tunnel does not have to be the root node of the tunnel. The root node might not even be a PE router, and might not originate any BGP routes at all.

In the Unpartitioned Method, packets received on the I-PMSI cannot be associated with a distinguished PE, so duplicate detection using the techniques of [[MVPN](#)] [section 9.1.1](#) is not possible; the techniques of [[MVPN](#)] 9.1.2 or 9.1.3 would have to be used instead. Support for

C-BIDIR using the "Partitioned set of PEs" technique ([MVPN] [section 11.2](#) and [\[RFC6517\] section 3.6](#)) is not possible when the Unpartitioned Method is used. If it is desired to use that technique to support C-BIDIR, but also to use the Unpartitioned Method of instantiate the I-PMSI, then all the C-BIDIR traffic would have to be carried on an S-PMSI, where the S-PMSI is instantiated using one of the Partitioned Methods.

When a PE, say PE1, needs to transmit multicast data packets of a particular C-flow to other PEs, and PE1 does not have an S-PMSI that is a "match for transmission for that C-flow (see [section 3.2.3.1](#)), PE1 transmits the packets on one of the P-tunnel(s) that instantiates the I-PMSI. When a PE, say PE1, needs to receive multicast data packets of a particular C-flow from another PE, and PE1 does not have an S-PMSI that is a "match for reception for that C-flow (see [section 3.2.3.2](#)), PE1 expect to receive the packets on any of the P-tunnel(s) that instantiates the I-PMSI.

When a particular MVPN uses the Unpartitioned Method to instantiate a (C-*,C-*) S-PMSI using a bidirectional P-tunnel, the same conditions apply as when an I-PMSI is instantiated via the Unpartitioned Method. The only difference is that a PE need not join a P-tunnel that instantiates the S-PMSI unless that PE needs to receive multicast packets on the S-PMSI.

When a particular MVPN uses bidirectional P-tunnels to instantiate other S-PMSIs, different S-PMSI A-D routes that do not contain (C-*,C-*), originated by the same or by different PEs, MAY have PTAs that identify the same bidirectional tunnel, and they MAY have PTAs that do not identify the same bidirectional tunnel. See sections 3.2.3.1 and 3.2.3.3.

While the Unpartitioned Method MAY be used to instantiate an S-PMSI to which one or more C-BIDIR flows are bound, it must be noted that the "Partitioned Set of PEs" method discussed in [\[MVPN\] section 11.2](#) and [\[RFC6517\] section 3.6](#) cannot be supported using the Unpartitioned Method. C-BIDIR support would have to be provided by the procedures of [\[MVPN\] section 11.1](#).

[3.2.3.1](#). When an S-PMSI is a 'Match for Transmission'

Given the need for a PE to transmit multicast data packets of a particular customer C-flow, [\[MVPN-WILDCARDS\] Section 3.1](#) gives a four-step algorithm for determining the S-PMSI A-D route, if any, that "matches" that C-flow for transmission. When referring to that section, please recall that BIDIR-PIM groups are also "Any Source Multicast" (ASM) groups.

When bidirectional P-tunnels are used in the Unpartitioned Method, the same algorithm applies, with one modification, when the PTA of an S-PMSI A-D route identifies a bidirectional P-tunnel. One additional step is added to the algorithm. This new step occurs before the fourth step of the algorithm, and is as follows:

- Otherwise, if there is an S-PMSI A-D route currently originated by PE1, whose NLRI contains (C-*,C-BIDIR), and if C-G is a BIDIR group, the (C-S,C-G) C-flow matches that route.

3.2.3.2. When an S-PMSI is a 'Match for Reception'

Given the need for a PE to receive multicast data packets of a particular customer C-flow, [[MVPN-WILDCARDS](#)] [Section 3.2](#) specifies the procedures for determining the S-PMSI A-D route, if any, that advertised the P-tunnel on which the PE should expect to receive that C-flow.

When bidirectional P-tunnels are used in the Unpartitioned Method, the same procedures apply, with one modification.

The last paragraph of Section 3.2.2 of [[MVPN-WILDCARDS](#)] begins:

"If (C-*,C-G) does not match a (C-*,C-G) S-PMSI A-D route from PE2, but PE1 has an installed (C-*,C-*) S-PMSI A-D route from PE2, then (C-*,C-G) matches the (C-*,C-*) route if one of the following conditions holds:"

This is changed to:

"If (C-*,C-G) does not match a (C-*,C-G) S-PMSI A-D route from PE2, but C-G is a BIDIR group and PE1 has an installed (C-*,C-BIDIR) S-PMSI A-D route, then (C-*,C-G) matches that route. Otherwise, if PE1 has an installed (C-*,C-*) S-PMSI A-D route from PE2, then (C-*,C-G) matches the (C-*,C-*) route if one of the following conditions holds:"

3.2.4. Minimal Feature Set for Compliance

A PE that does not provide C-BIDIR support using the "partitioned set of PEs" method may be deemed compliant to this specification if it supports the Unpartitioned Method, using either MP2MP LSPs or BIDIR-PIM multicast distribute trees as P-tunnels.

A PE that does provide C-BIDIR support using the "partitioned set of PEs" method, MUST, at a minimum, be able to provide C-BIDIR support

using the "Partial Mesh of MP2MP P-tunnels" variant of this method (see section 11.2 of [[MVPN](#)]). An implementation will be deemed compliant to this minimum requirement if it can carry all of a VPN's C-BIDIR traffic on a (C-*,C-BIDIR) S-PMSI that is instantiated by a bidirectional P-tunnel, using the flat partitioned method.

[4. IANA Considerations](#)

This document has no actions for IANA.

[5. Security Considerations](#)

There are no additional security considerations beyond those of [[MVPN](#)] and [[MVPN-BGP](#)], or any that may apply to the particular protocol used to set up the bidirectional tunnels ([[BIDIR-PIM](#)], [[mLDP](#)]).

[6. Acknowledgments](#)

The authors wish to thank Karthik Subramanian, Rajesh Sharma, and Apoorva Karan for their input. We also thank Yakov Rekhter for his valuable critique.

Special thanks go to Jeffrey Zhang for his careful review, probing questions, and useful suggestions.

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8. Normative References

[BIDIR-PIM] "Bidirectional Protocol Independent Multicast", Handley, Kouvelas, Speakman, Vicisano, [RFC 5015](#), October 2007

[L3VPN], "BGP/MPLS IP Virtual Private Networks", Rosen, Rekhter (editors), [RFC 4364](#), February 2006

[mLDP] "Label Distribution Protocol Extensions for Point-to-Multipoint and Multipoint-to-Multipoint Label Switched Paths", Wijnands, Minei, Kompella, Thomas, [RFC 6388](#), November 2011

[MVPN] "Multicast in MPLS/BGP IP VPNs", Rosen, Aggarwal, et. al., [RFC 6513](#), February 2012

[MVPN-BGP] "BGP Encodings and Procedures for Multicast in MPLS/BGP IP VPNs", Aggarwal, Rosen, Morin, Rekhter, [RFC 6514](#), February 2012

[MVPN-WILDCARDS] "Wild Cards in Multicast VPN Auto-Discovery Routes", Rosen, Rekhter, Hendrickx, Qiu, [RFC 6625](#), May 2012

[PIM] "Protocol Independent Multicast - Sparse Mode (PIM-SM): Protocol Specification (Revised)", Fenner, Handley, Holbrook, Kouvelas, [RFC 4601](#), August 2006

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

9. Informative References

[RFC5331] "MPLS Upstream Label Assignment and Context-Specific Label Space", Aggarwal, Rekhter, Rosen, [RFC 5331](#), August 2008

[RFC6517] "Mandatory Features in a Layer 3 Multicast BGP/MPLS VPN Solution", Morin, Niven-Jenkins, Kamite, Zhang, Leymann, Bitar, [RFC 6517](#), February 2012

[MVPN_XNET] "Extranet Multicast in BGP/IP MPLS VPNs", Rekhter, Rosen (editors), [draft-ietf-l3vpn-mvpn-extranet-02.txt](#), August 2013