Internet Engineering Task Force (IETF)
Request for Comments: 9572
Updates: 7432
Category: Standards Track
ISSN: 2070-1721

Z. Zhang
W. Lin
Juniper Networks
J. Rabadan
Nokia
K. Patel
Arrcus
A. Sajassi
Cisco Systems

May 2024

Updates to EVPN Broadcast, Unknown Unicast, or Multicast (BUM) Procedures

Abstract

This document specifies updated procedures for handling Broadcast, Unknown Unicast, or Multicast (BUM) traffic in Ethernet VPNs (EVPNs), including selective multicast and segmentation of provider tunnels. This document updates RFC 7432.

Status of This Memo

This is an Internet Standards Track document.

This document is a product of the Internet Engineering Task Force (IETF). It represents the consensus of the IETF community. It has received public review and has been approved for publication by the Internet Engineering Steering Group (IESG). Further information on Internet Standards is available in Section 2 of RFC 7841.

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/rfc9572.

Table of Contents

1. Introduction

[RFC7117] specifies procedures for multicast in the Virtual Private LAN Service (VPLS multicast), using both inclusive tunnels and selective tunnels with or without inter-AS segmentation, similar to the Multicast VPN (MVPN) procedures specified in [RFC6513] and [RFC6514]. [RFC7524] specifies inter-area tunnel segmentation procedures for both VPLS multicast and MVPNs.

[RFC7432] specifies BGP MPLS-based Ethernet VPN (EVPN) procedures, including those handling Broadcast, Unknown Unicast, or Multicast (BUM) traffic. [RFC7432] refers to [RFC7117] for details but leaves a few feature gaps related to selective tunnel and tunnel segmentation (Section 2.1).

This document aims to fill in those gaps by covering the use of selective and segmented tunnels in EVPNs. In the same way that [RFC7432] refers to [RFC7117] for details, this document only specifies differences from relevant procedures provided in [RFC7117] and [RFC7524], rather than repeating the text from those documents. Note that these differences are applicable to EVPNs only and are not updates to [RFC7117] or [RFC7524].

MVPN, VPLS, and EVPN technologies all need to discover other Provider Edges (PEs) in the same L3/L2 VPN and announce the inclusive tunnels. MVPN technology introduced the Inclusive P-Multicast Service Interface (I-PMSI) concept and uses I-PMSI Auto-Discovery (A-D) routes for that purpose. EVPN technology uses Inclusive Multicast Ethernet Tag (IMET) A-D routes, but VPLS technology just adds a PMSI Tunnel Attribute (PTA) to an existing VPLS A-D route for that purpose. For selective tunnels, they all do use the same term: Selective PMSI (S-PMSI) A-D routes.

This document often refers to the I-PMSI concept, which is the same for all three technologies. For consistency and convenience, an EVPN's IMET A-D route and a VPLS's VPLS A-D route carrying a PTA for BUM traffic purposes may each be referred to as an I-PMSI A-D route, depending on the context.

1.1. 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.

1.2. Terminology

It is assumed that the reader is familiar with concepts and terminologies related to MVPN technology [RFC6513] [RFC6514], VPLS multicast [RFC7117], and EVPN technology [RFC7432]. For convenience, the following terms are briefly explained.

AS: Autonomous System

PMSI [RFC6513]: P-Multicast Service Interface. A conceptual interface for a PE to send customer multicast traffic to all or some PEs in the same VPN.

I-PMSI: Inclusive PMSI. Enables traffic to be sent to all PEs in the same VPN.

S-PMSI: Selective PMSI. Enables traffic to be sent to some of the PEs in the same VPN.

I/S-PMSI A-D Route: Auto-Discovery route used to announce the tunnels that instantiate an I/S-PMSI.

Leaf Auto-Discovery (A-D) Route [RFC6513]: For explicit leaf-tracking purposes. Triggered by I/S-PMSI A-D routes and targeted at the triggering route's (re-)advertiser. Its Network Layer Reachability Information (NLRI) embeds the entire NLRI of the triggering PMSI A-D route.

IMET A-D Route [RFC7432]: Inclusive Multicast Ethernet Tag A-D route. The EVPN equivalent of an MVPN Intra-AS I-PMSI A-D route used to announce the tunnels that instantiate an I-PMSI.

SMET A-D Route [RFC9251]: Selective Multicast Ethernet Tag A-D route. The EVPN equivalent of an MVPN Leaf A-D route, but unsolicited and untargeted.

PMSI Tunnel Attribute (PTA): An optional transitive BGP attribute that may be attached to PMSI/Leaf A-D routes to provide information for a PMSI tunnel.

IBGP: Internal BGP (BGP connection between internal peers).

EBGP: External BGP (BGP connection between external peers).

RT: Route Target. Controls route importation and propagation.

2. Tunnel Segmentation

MVPN provider tunnels and EVPN/VPLS BUM provider tunnels, which are referred to as MVPN/EVPN/VPLS provider tunnels in this document for simplicity, can be segmented for technical or administrative reasons, which are summarized in Section 2.1 of this document. [RFC6513] and [RFC6514] cover MVPN inter-AS segmentation, [RFC7117] covers VPLS multicast inter-AS segmentation, and [RFC7524] (seamless MPLS multicast) covers inter-area segmentation for both MVPNs and VPLSs.

With tunnel segmentation, different segments of an end-to-end tunnel may have different encapsulation overheads. However, the largest overhead of the tunnel caused by an encapsulation method on a particular segment is not different from the case of a non-segmented tunnel with that encapsulation method. This is similar to the case of a network with different link types.

There is a difference between MVPN and VPLS multicast inter-AS segmentation (the VPLS approach is briefly described in Section 5.1). For simplicity, EVPNs will use the same procedures as those for MVPNs. All ASBRs can re-advertise their choice of the best route. Each can become the root of its intra-AS segment and inject traffic it receives from its upstream, while each downstream PE/ASBR will only pick one of the upstream ASBRs as its upstream. This is also the behavior even for VPLS in the case of inter-area segmentation.

For inter-area segmentation, [RFC7524] requires the use of the Inter-Area Point-to-Multipoint (P2MP) Segmented Next-Hop Extended Community (S-NH-EC) and the setting of the Leaf Information Required (L) flag in the PTA in certain situations. In the EVPN case, the requirements around the S-NH-EC and the L flag in the PTA differ from [RFC7524] to make the segmentation procedures transparent to ingress and egress PEs.

[RFC7524] assumes that segmentation happens at area borders. However, it could be at "regional" borders, where a region could be a sub-area, or even an entire AS plus its external links (Section 6.1); this would allow for more flexible deployment scenarios (e.g., for single-area provider networks). This document extends the inter-area segmentation concept to inter-region segmentation for EVPNs.

2.1. Reasons for Tunnel Segmentation

Tunnel segmentation may be required and/or desired for administrative and/or technical reasons.

For example, an MVPN/VPLS/EVPN may span multiple providers, and the end-to-end provider tunnels have to be segmented at and stitched by the ASBRs. Different providers may use different tunnel technologies (e.g., provider A uses ingress replication [RFC7988], provider B uses RSVP-TE P2MP [RFC4875], and provider C uses Multipoint LDP (mLDP) [RFC6388]). Even if they use the same tunnel technology (e.g., RSVP-TE P2MP), it may be impractical to set up the tunnels across provider boundaries.

The same situations may apply between the ASes and/or areas of a single provider. For example, the backbone area may use RSVP-TE P2MP tunnels while non-backbone areas may use mLDP tunnels.

Segmentation can also be used to divide an AS/area into smaller regions, so that control plane state and/or forwarding plane state/burden can be limited to that of individual regions. For example, instead of ingress-replicating to 100 PEs in the entire AS, with inter-area segmentation [RFC7524], a PE only needs to replicate to local PEs and Area Border Routers (ABRs). The ABRs will further replicate to their downstream PEs and ABRs. This not only reduces the forwarding plane burden, but also reduces the leaf-tracking burden in the control plane.

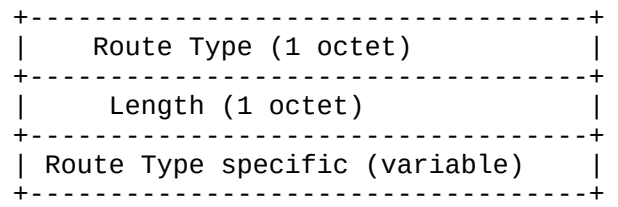
In the case of tunnel aggregation, smaller regions provide the benefit of making it easier to find congruence among the segments of different constituent (service) tunnels and the resulting aggregation (base) tunnel in a region. This leads to better bandwidth efficiency, because the more congruent they are, the fewer leaves of the base tunnel need to discard traffic when a service tunnel’s segment does not need to receive the traffic (yet it is receiving the traffic due to aggregation).

Another advantage of the smaller region is smaller Bit Index Explicit Replication (BIER) subdomains [RFC8279]. With BIER, packets carry a BitString, in which the bits correspond to edge routers that need to receive traffic. Smaller subdomains means that smaller BitStrings can be used without having to send multiple copies of the same

packet.

3. Additional Route Types of EVPN NLRI

[RFC7432] defines the format of EVPN NLRI as follows:



So far, eight route types have been defined in [RFC7432], [RFC9136], and [RFC9251]:

Value	Description
1	Ethernet Auto-discovery
2	MAC/IP Advertisement
3	Inclusive Multicast Ethernet Tag
4	Ethernet Segment
5	IP Prefix
6	Selective Multicast Ethernet Tag Route
7	Multicast Membership Report Synch Route
8	Multicast Leave Synch Route

Table 1: Pre-existing Route Types

This document defines three additional route types:

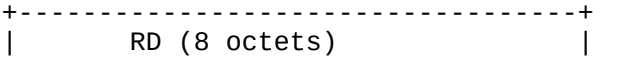
Value	Description
9	Per-Region I-PMSI A-D route
10	S-PMSI A-D route
11	Leaf A-D route

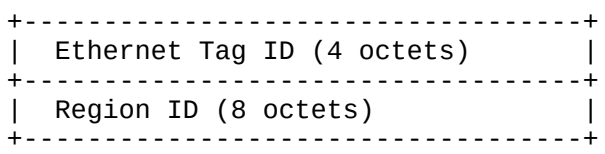
Table 2: New Route Types

The "Route Type specific" field of the Type 9 and Type 10 EVPN NLRIs starts with a Type 1 RD (Route Distinguisher), whose Administrator sub-field MUST match that of the RD in all current EVPN routes that are not Leaf A-D routes (Section 3.3), i.e., non-Leaf A-D routes from the same advertising router for a given EVPN instance (EVI).

3.1. Per-Region I-PMSI A-D Route

The per-region I-PMSI A-D route has the following format. Its usage is discussed in Section 6.2.

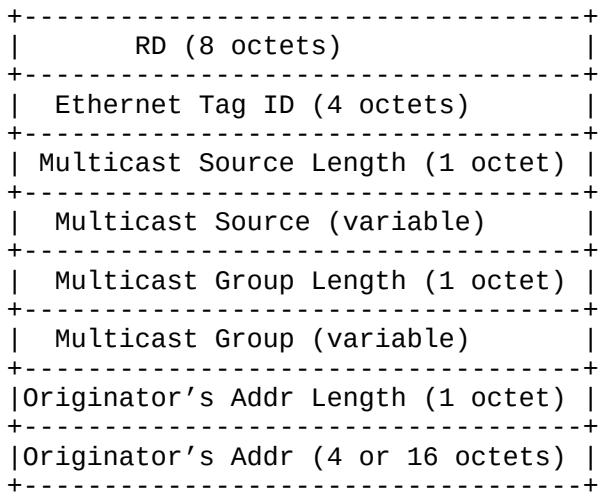




The Region ID identifies the region and is encoded in the same way that an EC is encoded, as detailed in Section 6.2.

3.2. S-PMSI A-D Route

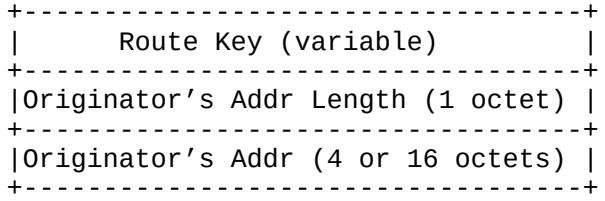
The S-PMSI A-D route has the following format:



Other than the addition of the Ethernet Tag ID and Originator’s Addr Length fields, it is identical to the S-PMSI A-D route as defined in [RFC7117]. The procedures specified in [RFC7117] also apply (including wildcard functionality), except that the granularity level is per Ethernet Tag.

3.3. Leaf A-D Route

The Route Type specific field of a Leaf A-D route consists of the following:



A Leaf A-D route is originated in response to a PMSI route, which could be an IMET A-D route, a per-region I-PMSI A-D route, an S-PMSI A-D route, or some other types of routes that may be defined in the future that trigger Leaf A-D routes. The Route Key is the NLRI of the route for which this Leaf A-D route is generated.

The general procedures for Leaf A-D routes were first specified in [RFC6514] for MVPNs. The principles therein apply to VPLSs and EVPNs as well. [RFC7117] provides details regarding VPLS multicast, and this document points out some specifics for EVPNs, e.g., in Section 5.

4. Selective Multicast

[RFC9251] specifies procedures for EVPN selective forwarding of IP multicast traffic using SMET routes. It assumes that selective

forwarding is always used with ingress replication for all flows (though the same signaling can also be used for an ingress PE to learn the set of egress PEs for selective forwarding with BIER). A Network Virtualization Edge (NVE) proxies the IGMP/MLD state ("MLD" stands for "Multicast Listener Discovery") that it learns on its Attachment Circuits (ACs) to (C-S,C-G) or (C-*,C-G) SMET routes that are advertised to other NVEs, and a receiving NVE converts the SMET routes back to IGMP/MLD messages and sends them out of its ACs. The receiving NVE also uses the SMET routes to identify which NVEs need to receive traffic for a particular (C-S,C-G) or (C-*,C-G) to achieve selective forwarding using ingress replication or BIER.

With the above procedures, selective forwarding is done for all flows, and the SMET routes are advertised for all flows. It is possible that an operator may not want to track all those (C-S, C-G) or (C-*,C-G) states on the NVEs, and the multicast traffic pattern allows inclusive forwarding for most flows while selective forwarding is needed only for a few high-rate flows. For that reason, or for tunnel types other than ingress replication or BIER, S-PMSI/Leaf A-D procedures defined for selective multicast for VPLS in [RFC7117] are used. Other than the fact that different route types and formats are specified with an EVPN SAFI for S-PMSI A-D and Leaf A-D routes (Section 3), all procedures specified in [RFC7117] with respect to selective multicast apply to EVPNs as well, including wildcard procedures. In a nutshell, a source NVE advertises S-PMSI A-D routes to announce the tunnels used for certain flows, and receiving NVEs either join the announced PIM/mLDP tunnel or respond with Leaf A-D routes if the L flag is set in the S-PMSI A-D route’s PTA (so that the source NVE can include them as tunnel leaves).

An optimization to the procedures provided in [RFC7117] may be applied. Even if a source NVE sets the L flag to request Leaf A-D routes, an egress NVE MAY omit the Leaf A-D route if it has already advertised a corresponding SMET route, and the source NVE MUST use that in lieu of the Leaf A-D route.

The optional optimizations specified for MVPNs in [RFC8534] are also applicable to EVPNs when the procedures for S-PMSI/Leaf A-D routes are used for EVPN selective multicast forwarding.

5. Inter-AS Segmentation

5.1. Differences from Section 7.2.2 of RFC 7117 when Applied to EVPNs

The first paragraph of Section 7.2.2.2 of [RFC7117] says:

> ... The best route procedures ensure that if multiple ASBRs, in an AS, receive the same Inter-AS A-D route from their EBGP neighbors, only one of these ASBRs propagates this route in Internal BGP (IBGP). This ASBR becomes the root of the intra-AS segment of the inter-AS tree and ensures that this is the only ASBR that accepts traffic into this AS from the inter-AS tree.

The above VPLS behavior requires complicated VPLS-specific procedures for the ASBRs to reach agreement. For EVPNs, a different approach is used; the above text from [RFC7117] is not applicable to EVPNs.

With the different approach for EVPNs/MVPNs, each ASBR will re-advertise its received Inter-AS A-D route to its IBGP peers and becomes the root of an intra-AS segment of the inter-AS tree. The intra-AS segment rooted at one ASBR is disjoint from another intra-AS segment rooted at another ASBR. This is the same as the procedures for S-PMSI routes in [RFC7117] itself.

The following bullet in Section 7.2.2.2 of [RFC7117] does not apply to EVPNs.

| * If the ASBR uses ingress replication to instantiate the intra-
| AS segment of the inter-AS tunnel, the re-advertised route MUST
| NOT carry the PMSI Tunnel attribute.

The following bullet in Section 7.2.2.2 of [RFC7117]:

| * If the ASBR uses a P-multicast tree to instantiate the intra-AS
| segment of the inter-AS tunnel, the PMSI Tunnel attribute MUST
| contain the identity of the tree that is used to instantiate
| the segment (note that the ASBR could create the identity of
| the tree prior to the actual instantiation of the segment).
| If, in order to instantiate the segment, the ASBR needs to know
| the leaves of the tree, then the ASBR obtains this information
| from the A-D routes received from other PEs/ASBRs in the ASBR's
| own AS.

is changed to the following when applied to EVPNs:

| * The PTA MUST specify the tunnel for the segment. If and only
| if, in order to establish the tunnel, the ASBR needs to know
| the leaves of the tree, then the ASBR MUST set the L flag to 1
| in the PTA to trigger Leaf A-D routes from egress PEs and
| downstream ASBRs. It MUST be (auto-)configured with an import
| RT, which controls acceptance of Leaf A-D routes by the ASBR.

Accordingly, the following paragraph in Section 7.2.2.4 of [RFC7117]:

| If the received Inter-AS A-D route carries the PMSI Tunnel
| attribute with the Tunnel Identifier set to RSVP-TE P2MP LSP, then
| the ASBR that originated the route MUST establish an RSVP-TE P2MP
| LSP with the local PE/ASBR as a leaf. This LSP MAY have been
| established before the local PE/ASBR receives the route, or it MAY
| be established after the local PE receives the route.

is changed to the following when applied to EVPNs:

| If the received Inter-AS A-D route has the L flag set in its PTA,
| then a receiving PE MUST originate a corresponding Leaf A-D route.
| A receiving ASBR MUST originate a corresponding Leaf A-D route if
| and only if one of the following conditions is met: (1) it
| received and imported one or more corresponding Leaf A-D routes
| from its downstream IBGP or EBGP peers or (2) it has non-null
| downstream forwarding state for the PIM/mLDP tunnel that
| instantiates its downstream intra-AS segment. The targeted ASBR
| for the Leaf A-D route, which (re-)advertised the Inter-AS A-D
| route, MUST establish a tunnel to the leaves discovered by the
| Leaf A-D routes.

5.2. I-PMSI Leaf Tracking

An ingress PE does not set the L flag in its IMET A-D route's PTA, even with Ingress Replication tunnels or RSVP-TE P2MP tunnels. It does not rely on the Leaf A-D routes to discover leaves in its AS, and Section 11.2 of [RFC7432] explicitly states that the L flag must be set to 0.

An implementation of [RFC7432] might have used the Originating Router's IP Address field of the IMET A-D routes to determine the leaves or might have used the Next Hop field instead. Within the same AS, both will lead to the same result.

With segmentation, an ingress PE MUST determine the leaves in its AS from the BGP next hops in all its received IMET A-D routes, so it does not have to set the L flag to request Leaf A-D routes. PEs within the same AS will all have different next hops in their IMET

A-D routes (and hence will all be considered as leaves), and PEs from other ASes will have the next hop in their IMET A-D routes set to addresses of ASBRs in this local AS; hence, only those ASBRs will be considered as leaves (as proxies for those PEs in other ASes). Note that in the case of ingress replication, when an ASBR re-advertises IMET A-D routes to IBGP peers, it MUST advertise the same label for all those routes for the same Ethernet Tag ID and the same EVI. Otherwise, duplicated copies will be sent by the ingress PE and received by egress PEs in other regions. For the same reason, when an ingress PE builds its flooding list, if multiple routes have the same (nexthop, label) tuple, they MUST only be added as a single branch in the flooding list.

5.3. Backward Compatibility

The above procedures assume that all PEs are upgraded to support the segmentation procedures:

* An ingress PE uses the Next Hop and not the Originating Router's IP Address to determine leaves for the I-PMSI tunnel.

* An egress PE sends Leaf A-D routes in response to I-PMSI routes, if the PTA has the L flag set by the re-advertising ASBR.

* In the case of ingress replication, when an ingress PE builds its flooding list, multiple I-PMSI routes may have the same (nexthop, label) tuple, and only a single branch for those routes will be added in the flooding list.

If a deployment has legacy PEs that do not support the above, then a legacy ingress PE would include all PEs (including those in remote ASes) as leaves of the inclusive tunnel and try to send traffic to them directly (no segmentation), which is either undesirable or impossible; a legacy egress PE would not send Leaf A-D routes so the ASBRs would not know to send external traffic to them.

If this backward-compatibility problem needs to be addressed, the following procedure MUST be used (see Section 6.2 for per-PE/AS/region I-PMSI A-D routes):

* An upgraded PE indicates in its per-PE I-PMSI A-D route that it supports the new procedures. This is done by setting a flag bit in the EVPN Multicast Flags Extended Community.

* All per-PE I-PMSI A-D routes are restricted to the local AS and not propagated to external peers.

* The ASBRs in an AS originate per-region I-PMSI A-D routes and advertise them to their external peers to specify tunnels used to carry traffic from the local AS to other ASes. Depending on the types of tunnels being used, the L flag in the PTA may be set, in which case the downstream ASBRs and upgraded PEs will send Leaf A-D routes to pull traffic from their upstream ASBRs. In a particular downstream AS, one of the ASBRs is elected, based on the per-region I-PMSI A-D routes for a particular source AS, to send traffic from that source AS to legacy PEs in the downstream AS. The traffic arrives at the elected ASBR on the tunnel announced in the best per-region I-PMSI A-D route for the source AS, as selected by the ASBR from all the routes that it received over EBGP or IBGP sessions. The election procedure is described in Section 5.3.1.

* In an ingress/upstream AS, if and only if an ASBR has active downstream receivers (PEs and ASBRs), which are learned either explicitly via Leaf A-D routes or implicitly via PIM Join or mLDP label mapping, the ASBR originates a per-PE I-PMSI A-D route

(i.e., a regular IMET route) into the local AS and stitches incoming per-PE I-PMSI tunnels into its per-region I-PMSI tunnel. Via this process, it gets traffic from local PEs and sends the traffic to other ASes via the tunnel announced in its per-region I-PMSI A-D route.

Note that even if there are no backward-compatibility issues, the use of per-region I-PMSI A-D routes provides the benefit of keeping all per-PE I-PMSI A-D routes in their local ASes, greatly reducing the flooding of the routes and their corresponding Leaf A-D routes (when needed) and reducing the number of inter-AS tunnels.

5.3.1. Designated ASBR Election

When an ASBR re-advertises a per-region I-PMSI A-D route into an AS in which a designated ASBR needs to be used to forward traffic to the legacy PEs in the AS, it MUST include a Designated Forwarder (DF) Election EC. The EC and its use are specified in [RFC8584]. The AC-DF bit in the DF Election EC MUST be cleared. If it is known that no legacy PEs exist in the AS, the ASBR MUST NOT include the EC and MUST remove the DF Election EC if one is carried in the per-region I-PMSI A-D routes that it receives. Note that this is done for each set of per-region I-PMSI A-D routes with the same NLRI.

Based on the procedures specified in [RFC8584], an election algorithm is determined according to the DF Election ECs carried in the set of per-region I-PMSI routes of the same NLRI re-advertised into the AS. The algorithm is then applied to a candidate list, which is the set of ASBRs that re-advertised the per-region I-PMSI routes of the same NLRI carrying the DF Election EC.

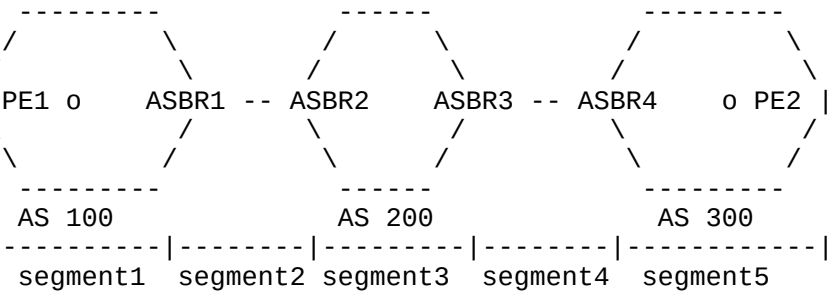
6. Inter-Region Segmentation

6.1. Area/AS vs. Region

[RFC7524] addresses MVPN/VPLS inter-area segmentation and does not explicitly cover EVPNs. However, if "area" is replaced by "region" and "ABR" is replaced by "RBR" (Regional Border Router), then everything still works and can be applied to EVPNs as well.

A region can be a sub-area, or it can be an entire AS, including its external links. Instead of automatically defining a region based on IGP areas, a region would be defined as a BGP peer group. In fact, even with a region definition based on an IGP area, a BGP peer group listing the PEs and ABRs in an area is still needed.

Consider the following example diagram for inter-AS segmentation:

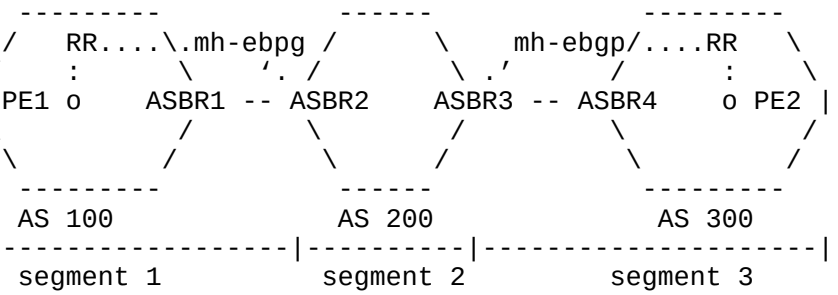


The inter-AS segmentation procedures specified so far ([RFC6513], [RFC6514], [RFC7117], and Section 5 of this document) require all ASBRs to be involved, and ingress replication is used between two ASBRs in different ASes.

In the above diagram, it’s possible that ASBR1/4 does not support segmentation, and the provider tunnels in AS 100/300 can actually

extend across the external link. In this case, the inter-region segmentation procedures can be used instead -- a region is the entire AS100 plus the ASBR1-ASBR2 link or the entire AS300 plus the ASBR3-ASBR4 link. ASBR2/3 would be the RBRs, and ASBR1/4 will just be a transit core router with respect to provider tunnels.

As illustrated in the diagram below, ASBR2/3 will establish a multihop EBGP session, either with a Route Reflector (RR) or directly with PEs in the neighboring AS. I/S-PMSI A-D routes from ingress PEs will not be processed by ASBR1/4. When ASBR2 re-advertises the routes into AS 200, it changes the next hop to its own address and changes its PTA to specify the tunnel type/identification in its own AS. When ASBR3 re-advertises I/S-PMSI A-D routes into the neighboring AS 300, it changes the next hop to its own address and changes its PTA to specify the tunnel type/identification in the neighboring region. Now, the segment is rooted at ASBR3 and extends across the external link to PEs.



6.2. Per-Region Aggregation

Notice that every I/S-PMSI route from each PE will be propagated throughout all the ASes or regions. They may also trigger corresponding Leaf A-D routes, depending on the types of tunnels used in each region. This may result in too many routes and corresponding tunnels. To address this concern, the I-PMSI routes from all PEs in an AS/region can be aggregated into a single I-PMSI route originated from the RBRs, and traffic from all those individual I-PMSI tunnels will be switched into the single I-PMSI tunnel. This is like the MVPN Inter-AS I-PMSI route originated by ASBRs.

The MVPN Inter-AS I-PMSI A-D route can be better called a "per-AS I-PMSI A-D route", to be compared against the (per-PE) Intra-AS I-PMSI A-D routes originated by each PE. In this document, we will call it a "per-region I-PMSI A-D route" in cases where we want to apply aggregation at the regional level. The per-PE I-PMSI routes will not be propagated to other regions. If multiple RBRs are connected to a region, then each will advertise such a route, with the same Region ID and Ethernet Tag ID (Section 3.1). Similar to the per-PE I-PMSI A-D routes, RBRs/PEs in a downstream region will each select the best route from all those re-advertised by the upstream RBRs and hence will only receive traffic injected by one of them.

MVPNs do not aggregate S-PMSI routes from all PEs in an AS like they do for I-PMSI routes, because the number of PEs that will advertise S-PMSI routes for the same (S,G) or (*,G) is small. This is also the case for EVPNs, i.e., there are no per-region S-PMSI routes.

Notice that per-region I-PMSI routes can also be used to address backward-compatibility issues, as discussed in Section 5.3.

The Region ID in the per-region I-PMSI route’s NLRI is encoded like an EC. For example, the Region ID can encode an AS number or area ID in the following EC format:

* For a two-octet AS number, a Transitive Two-Octet AS-specific EC

of sub-type 0x09 (Source AS), with the Global Administrator sub-field set to the AS number and the Local Administrator sub-field set to 0.

* For a four-octet AS number, a Transitive Four-Octet AS-specific EC of sub-type 0x09 (Source AS), with the Global Administrator sub-field set to the AS number and the Local Administrator sub-field set to 0.

* For an area ID, a Transitive IPv4-Address-specific EC of any sub-type, with the Global Administrator sub-field set to the area ID and the Local Administrator sub-field set to 0.

The use of other EC encodings MAY be allowed as long as they uniquely identify the region and the RBRs for the same region use the same Region ID.

6.3. Use of S-NH-EC

[RFC7524] specifies the use of the S-NH-EC because it does not allow ABRs to change the BGP next hop when they re-advertise I/S-PMSI A-D routes to downstream areas. That behavior is only to be consistent with the MVPN Inter-AS I-PMSI A-D routes, whose next hop must not be changed when they're re-advertised by the segmenting ABRs for reasons specific to MVPNs. For EVPNs, it is perfectly fine to change the next hop when RBRs re-advertise the I/S-PMSI A-D routes, instead of relying on the S-NH-EC. As a result, this document specifies that RBRs change the BGP next hop when they re-advertise I/S-PMSI A-D routes and do not use the S-NH-EC. This provides the advantage that neither ingress PEs nor egress PEs need to understand/use the S-NH-EC, and a consistent procedure (based on BGP next hops) is used for both inter-AS and inter-region segmentation.

If a downstream PE/RBR needs to originate Leaf A-D routes, it constructs an IP-based Route Target Extended Community by placing the IP address carried in the Next Hop of the received I/S-PMSI A-D route in the Global Administrator field of the extended community, with the Local Administrator field of this extended community set to 0, and also setting the Extended Communities attribute of the Leaf A-D route to that extended community.

Similar to [RFC7524], the upstream RBR MUST (auto-)configure an RT with the Global Administrator field set to the Next Hop in the re-advertised I/S-PMSI A-D route and with the Local Administrator field set to 0. Using this technique, the mechanisms specified in [RFC4684] for constrained BGP route distribution can be used along with this specification to ensure that only the needed PE/ABR will have to process a particular Leaf A-D route.

6.4. Ingress PE's I-PMSI Leaf Tracking

[RFC7524] specifies that when an ingress PE/ASBR (re-)advertises a VPLS I-PMSI A-D route, it sets the L flag to 1 in the route's PTA. Similar to the inter-AS case, this is actually not really needed for EVPNs. To be consistent with the inter-AS case, the ingress PE does not set the L flag in its originated I-PMSI A-D routes, and it determines the leaves based on the BGP next hops in its received I-PMSI A-D routes, as specified in Section 5.2.

The same backward-compatibility issue exists, and the same solution as that for the inter-AS case applies, as specified in Section 5.3.

7. Multihoming Support

To support multihoming with segmentation, Ethernet Segment Identifier (ESI) labels SHOULD be allocated from a "Domain-wide Common Block"

(DCB) [RFC9573] for all tunnel types, including Ingress Replication tunnels [RFC7988]. Via means outside the scope of this document, PEs know that ESI labels are from a DCB, and existing multihoming procedures will then work "as is" (whether a multihomed Ethernet Segment spans segmentation regions or not).

Not using DCB-allocated ESI labels is outside the scope of this document.

8. IANA Considerations

IANA has assigned the following new EVPN route types in the "EVPN Route Types" registry:

Value	Description	Reference
9	Per-Region I-PMSI A-D route	RFC 9572
10	S-PMSI A-D route	RFC 9572
11	Leaf A-D route	RFC 9572

Table 3: New Route Types

IANA has assigned one flag bit from the "Multicast Flags Extended Community" registry created by [RFC9251]:

Bit	Name	Reference	Change Controller
8	Segmentation Support	RFC 9572	IETF

Table 4: New Multicast Flag

9. Security Considerations

The procedures specified in this document for selective forwarding via S-PMSI/Leaf A-D routes are based on the same procedures as those used for MVPNs [RFC6513] [RFC6514] and VPLS multicast [RFC7117]. The procedures for tunnel segmentation as specified in this document are based on similar procedures used for MVPN inter-AS tunnel segmentation [RFC6514] and inter-area tunnel segmentation [RFC7524], as well as procedures for VPLS multicast inter-AS tunnel segmentation [RFC7117]. When applied to EVPNs, they do not introduce new security concerns beyond those discussed in [RFC6513], [RFC6514], [RFC7117], and [RFC7524]. They also do not introduce new security concerns compared to [RFC7432].

10. References

10.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, DOI 10.17487/RFC2119, March 1997, <https://www.rfc-editor.org/info/rfc2119>.

[RFC6513] Rosen, E., Ed. and R. Aggarwal, Ed., "Multicast in MPLS/BGP IP VPNs", RFC 6513, DOI 10.17487/RFC6513, February 2012, <https://www.rfc-editor.org/info/rfc6513>.

[RFC6514] Aggarwal, R., Rosen, E., Morin, T., and Y. Rekhter, "BGP Encodings and Procedures for Multicast in MPLS/BGP IP

VPNs", RFC 6514, DOI 10.17487/RFC6514, February 2012, <https://www.rfc-editor.org/info/rfc6514>.

[RFC7117] Aggarwal, R., Ed., Kamite, Y., Fang, L., Rekhter, Y., and C. Kodeboniya, "Multicast in Virtual Private LAN Service (VPLS)", RFC 7117, DOI 10.17487/RFC7117, February 2014, <https://www.rfc-editor.org/info/rfc7117>.

[RFC7432] Sajassi, A., Ed., Aggarwal, R., Bitar, N., Isaac, A., Uttaro, J., Drake, J., and W. Henderickx, "BGP MPLS-Based Ethernet VPN", RFC 7432, DOI 10.17487/RFC7432, February 2015, <https://www.rfc-editor.org/info/rfc7432>.

[RFC7524] Rekhter, Y., Rosen, E., Aggarwal, R., Morin, T., Grosclaude, I., Leymann, N., and S. Saad, "Inter-Area Point-to-Multipoint (P2MP) Segmented Label Switched Paths (LSPs)", RFC 7524, DOI 10.17487/RFC7524, May 2015, <https://www.rfc-editor.org/info/rfc7524>.

[RFC8174] Leiba, B., "Ambiguity of Uppercase vs Lowercase in RFC 2119 Key Words", BCP 14, RFC 8174, DOI 10.17487/RFC8174, May 2017, <https://www.rfc-editor.org/info/rfc8174>.

[RFC8534] Dolganow, A., Kotalwar, J., Rosen, E., Ed., and Z. Zhang, "Explicit Tracking with Wildcard Routes in Multicast VPN", RFC 8534, DOI 10.17487/RFC8534, February 2019, <https://www.rfc-editor.org/info/rfc8534>.

[RFC8584] Rabadan, J., Ed., Mohanty, S., Ed., Sajassi, A., Drake, J., Nagaraj, K., and S. Sathappan, "Framework for Ethernet VPN Designated Forwarder Election Extensibility", RFC 8584, DOI 10.17487/RFC8584, April 2019, <https://www.rfc-editor.org/info/rfc8584>.

[RFC9251] Sajassi, A., Thoria, S., Mishra, M., Patel, K., Drake, J., and W. Lin, "Internet Group Management Protocol (IGMP) and Multicast Listener Discovery (MLD) Proxies for Ethernet VPN (EVPN)", RFC 9251, DOI 10.17487/RFC9251, June 2022, <https://www.rfc-editor.org/info/rfc9251>.

[RFC9573] Zhang, Z., Rosen, E., Lin, W., Li, Z., and IJ. Wijnands, "MVPN/EVPN Tunnel Aggregation with Common Labels", RFC 9573, DOI 10.17487/RFC9573, May 2024, <https://www.rfc-editor.org/info/rfc9573>.

10.2. Informative References

[RFC4684] Marques, P., Bonica, R., Fang, L., Martini, L., Raszuk, R., Patel, K., and J. Guichard, "Constrained Route Distribution for Border Gateway Protocol/MultiProtocol Label Switching (BGP/MPLS) Internet Protocol (IP) Virtual Private Networks (VPNs)", RFC 4684, DOI 10.17487/RFC4684, November 2006, <https://www.rfc-editor.org/info/rfc4684>.

[RFC4875] Aggarwal, R., Ed., Papadimitriou, D., Ed., and S. Yasukawa, Ed., "Extensions to Resource Reservation Protocol - Traffic Engineering (RSVP-TE) for Point-to-Multipoint TE Label Switched Paths (LSPs)", RFC 4875, DOI 10.17487/RFC4875, May 2007, <https://www.rfc-editor.org/info/rfc4875>.

[RFC6388] Wijnands, IJ., Ed., Minei, I., Ed., Kompella, K., and B. Thomas, "Label Distribution Protocol Extensions for Point-to-Multipoint and Multipoint-to-Multipoint Label Switched Paths", RFC 6388, DOI 10.17487/RFC6388, November 2011, <https://www.rfc-editor.org/info/rfc6388>.

[RFC7988] Rosen, E., Ed., Subramanian, K., and Z. Zhang, "Ingress Replication Tunnels in Multicast VPN", RFC 7988, DOI 10.17487/RFC7988, October 2016, <https://www.rfc-editor.org/info/rfc7988>.

[RFC8279] Wijnands, IJ., Ed., Rosen, E., Ed., Dolganow, A., Przygienda, T., and S. Aldrin, "Multicast Using Bit Index Explicit Replication (BIER)", RFC 8279, DOI 10.17487/RFC8279, November 2017, <https://www.rfc-editor.org/info/rfc8279>.

[RFC9136] Rabadan, J., Ed., Henderickx, W., Drake, J., Lin, W., and A. Sajassi, "IP Prefix Advertisement in Ethernet VPN (EVPN)", RFC 9136, DOI 10.17487/RFC9136, October 2021, <https://www.rfc-editor.org/info/rfc9136>.

Acknowledgements

The authors thank Eric Rosen, John Drake, and Ron Bonica for their comments and suggestions.

Contributors

The following people also contributed to this document through their earlier work in EVPN selective multicast.

Junlin Zhang
Huawei Technologies
Huawei Bld., No. 156 Beiqing Rd.
Beijing
100095
China
Email: jackey.zhang@huawei.com

Zhenbin Li
Huawei Technologies
Huawei Bld., No. 156 Beiqing Rd.
Beijing
100095
China
Email: lizhenbin@huawei.com

Authors' Addresses

Zhaohui Zhang
Juniper Networks
Email: zzhang@juniper.net

Wen Lin
Juniper Networks
Email: wlin@juniper.net

Jorge Rabadan
Nokia
Email: jorge.rabadan@nokia.com

Keyur Patel
Arrcus
Email: keyur@arrcus.com

Ali Sajassi
Cisco Systems
Email: sajassi@cisco.com