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IGMP and MLD Proxy for EVPN
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Abstract

Ethernet Virtual Private Network (EVPN) solution is becoming pervasive in data center (DC) applications for Network Virtualization Overlay (NVO) and DC interconnect (DCI) services, and in service provider (SP) applications for next generation virtual private LAN services.

This draft describes how to support efficiently endpoints running IGMP for the above services over an EVPN network by incorporating IGMP proxy procedures on EVPN PEs.

http://www.ietf.org/shadow.html

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1 Introduction

Ethernet Virtual Private Network (EVPN) solution [RFC7432] is becoming pervasive in data center (DC) applications for Network Virtualization Overlay (NVO) and DC interconnect (DCI) services, and in service provider (SP) applications for next generation virtual private LAN services.

In DC applications, a point of delivery (POD) can consist of a collection of servers supported by several top of rack (TOR) and Spine switches. This collection of servers and switches are self contained and may have their own control protocol for intra-POD communication and orchestration. However, EVPN is used as standard way of inter-POD communication for both intra-DC and inter-DC. A subnet can span across multiple PODs and DCs. EVPN provides robust multi-tenant solution with extensive multi-homing capabilities to stretch a subnet (VLAN) across multiple PODs and DCs. There can be many hosts/VMs (several hundreds) attached to a subnet that is stretched across several PODs and DCs.

These hosts/VMs express their interests in multicast groups on a given subnet/VLAN by sending IGMP membership reports (Joins) for their interested multicast group(s). Furthermore, an IGMP router periodically sends membership queries to find out if there are hosts on that subnet that are still interested in receiving multicast traffic for that group. The IGMP/MLD Proxy solution described in this draft accomplishes has three objectives:

1) Reduce flooding of IGMP messages: just like the ARP/ND suppression mechanism in EVPN to reduce the flooding of ARP messages over EVPN, it is also desired to have a mechanism to reduce the flooding of IGMP messages (both Queries and Reports) in EVPN.

2) Distributed anycast multicast proxy: it is desirable for the EVPN network to act as a distributed anycast multicast router with respect to IGMP/MLD proxy function for all the hosts attached to that subnet.

3) Selective Multicast: to forward multicast traffic over EVPN network such that it only gets forwarded to the PEs that have interest in the multicast group(s), multicast traffic will not be forwarded to the PEs that have no receivers attached to them for that multicast group. This draft shows how this objective may be achieved when Ingress Replication is used to distribute the multicast traffic among the PEs. Procedures for supporting selective multicast using P2MP tunnels can be found in [bum-procedure-updates]

The first two objectives are achieved by using IGMP/MLD proxy on the

PE and the third objective is achieved by setting up a multicast tunnel (e.g., ingress replication) only among the PEs that have interest in that multicast group(s) based on the trigger from IGMP/MLD proxy processes. The proposed solutions for each of these objectives are discussed in the following sections.

2 Specification of Requirements

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.

3 Terminology

POD: Point of Delivery

ToR: Top of Rack

NV: Network Virtualization

NVO: Network Virtualization Overlay

EVPN: Ethernet Virtual Private Network

IGMP: Internet Group Management Protocol

MLD: Multicast Listener Discovery

EVI: An EVPN instance spanning the Provider Edge (PE) devices participating in that EVPN

MAC-VRF: A Virtual Routing and Forwarding table for Media Access Control (MAC) addresses on a PE

IR: Ingress Replication

Ethernet Segment (ES): When a customer site (device or network) is connected to one or more PEs via a set of Ethernet links, then that set of links is referred to as an 'Ethernet Segment'.

Ethernet Segment Identifier (ESI): A unique non-zero identifier that identifies an Ethernet Segment is called an 'Ethernet Segment Identifier'.

PE: Provider Edge.

BD: Broadcast Domain. As per [RFC7432], an EVI consists of a single or multiple BDs. In case of VLAN-bundle and VLAN-aware bundle service model, an EVI contains multiple BDs. Also, in this document, BD and subnet are equivalent terms.

Ethernet Tag: An Ethernet tag identifies a particular broadcast domain, e.g., a VLAN. An EVPN instance consists of one or more broadcast domains.

Single-Active Redundancy Mode: When only a single PE, among all the PEs attached to an Ethernet segment, is allowed to forward traffic to/from that Ethernet segment for a given VLAN, then the Ethernet segment is defined to be operating in Single-Active redundancy mode.

All-Active Redundancy Mode: When all PEs attached to an Ethernet segment are allowed to forward known unicast traffic to/from that Ethernet segment for a given VLAN, then the Ethernet segment is defined to be operating in All-Active redundancy mode.

This document also assumes familiarity with the terminology of [RFC7432]. Though most of the place this document uses term IGMP membership request (Joins), the text applies equally for MLD membership request too. Similarly, text for IGMPv2 applies to MLDv1 and text for IGMPv3 applies to MLDv2. IGMP / MLD version encoding in BGP update is stated in section 9

4 IGMP/MLD Proxy

The IGMP Proxy mechanism is used to reduce the flooding of IGMP messages over an EVPN network similar to ARP proxy used in reducing the flooding of ARP messages over EVPN. It also provides a triggering mechanism for the PEs to setup their underlay multicast tunnels. The IGMP Proxy mechanism consists of two components: a) Proxy for IGMP Reports and b) Proxy for IGMP Queries.

4.1 Proxy Reporting

When IGMP protocol is used between hosts/VMs and their first hop EVPN router (EVPN PE), Proxy-reporting is used by the EVPN PE to summarize (when possible) reports received from downstream hosts and propagate them in BGP to other PEs that are interested in the information. This is done by terminating the IGMP Reports in the first hop PE, and translating and exchanging the relevant information among EVPN BGP speakers. The information is again translated back to IGMP message at the recipient EVPN speaker. Thus it helps create an IGMP overlay subnet using BGP. In order to facilitate such an overlay, this document also defines a new EVPN route type NLRI, the EVPN Selective

Multicast Ethernet Tag route, along with its procedures to help exchange and register IGMP multicast groups [section 7].

4.1.1 IGMP/MLD Membership Report Advertisement in BGP

When a PE wants to advertise an IGMP membership report (Join) using the BGP EVPN route, it follows the following rules (BGP encoding stated in section 9.1):

1) When the first hop PE receives several IGMP membership reports (Joins), belonging to the same IGMP version, from different attached hosts/VMs for the same (*,G) or (S,G), it only SHOULD send a single BGP message corresponding to the very first IGMP Join (BGP update as soon as possible) for that (*,G) or (S,G). This is because BGP is a stateful protocol and no further transmission of the same report is needed. If the IGMP Join is for (*,G), then multicast group address MUST be sent along with the corresponding version flag (v2 or v3) set. In case of IGMPv3, the exclude flag MUST also needs to be set to indicate that no source IP address to be excluded (include all sources"*").

If the IGMP Join is for (S,G), then besides setting multicast group address along with the version flag v3, the source IP address and the include/exclude flag MUST be set. It should be noted that when advertising the EVPN route for (S,G), the only valid version flag is v3 (v1 and v2 flags MUST be set to zero).

2) When the first hop PE receives an IGMPv3 Join for (S,G) on a given BD, it SHOULD advertise the corresponding EVPN Selective Multicast Ethernet Tag (SMET) route regardless of whether the source (S) is attached to itself or not in order to facilitate the source move in the future.

3) When the first hop PE receives an IGMP version-X Join first for (*,G) and then later it receives an IGMP version-Y Join for the same (*,G), then it MUST re-advertise the same EVPN SMET route with flag for version-Y set in addition to any previously-set version flag(s). In other words, the first hop PE MUST not withdraw the EVPN route before sending the new route because the flag field is not part of BGP route key processing.

4) When the first hop PE receives an IGMP version-X Join first for (*,G) and then later it receives an IGMPv3 Join for the same multicast group address but for a specific source address S, then the PE MUST advertise a new EVPN SMET route with v3 flag set (and v1 and v2 reset). The include/exclude flag also need to be set accordingly. Since source IP address is used as part of BGP route key processing,

it is considered as a new BGP route advertisement.

5) When a PE receives an EVPN SMET route with more than one version flag set, it will generate the corresponding IGMP report for (*,G) for each version specified in the flags field. With multiple version flags set, there MUST not be source IP address in the receive EVPN route. If there is, then an error SHOULD be logged . If the v3 flag is set (in addition to v2), then the include/exclude flag MUST indicate "exclude". If not, then an error SHOULD be logged. The PE MUST generate an IGMP membership report (Join) for that (*,G) and each IGMP version in the version flag.

6) When a PE receives a list of EVPN SMET NLRIs in its BGP update message, each with a different source IP address and the same multicast group address, and the version flag is set to v3, then the PE generates an IGMPv3 membership report with a record corresponding to the list of source IP addresses and the group address along with the proper indication of inclusion/exclusion.

7) Upon receiving EVPN SMET route(s) and before generating the corresponding IGMP Join(s), the PE checks to see whether it has any CE multicast router for that BD on any of its ES's . The PE provides such a check by listening for PIM Hello messages on that AC (i.e, <ES,BD>). If the PE does have the router's ACs, then the generated IGMP Join(s) are sent to those ACs. If it doesn't have any of the router's AC, then no IGMP Join(s) needs to be generated. This is because sending IGMP Joins to other hosts can result in unintentionally preventing a host from joining a specific multicast group using IGMPv2 - i.e., if the PE does not receive a join from the host it will not forward multicast data to it. Per [RFC4541], when an IGMPv2 host receives a membership report for a group address that it intends to join, the host will suppress its own membership report for the same group, and if the PE does not receive an IGMP Join from host it will not forward multicast data to it. In other words, an IGMPv2 Join MUST NOT be sent on an AC that does not lead to a CE multicast router. This message suppression is a requirement for IGMPv2 hosts. This is not a problem for hosts running IGMPv3 because there is no suppression of IGMP Membership reports.

4.1.2 IGMP/MLD Leave Group Advertisement in BGP

When a PE wants to withdraw an EVPN SMET route corresponding to an IGMPv2 Leave Group (Leave) or IGMPv3 "Leave" equivalent message, it follows the following rules:

1) When a PE receives an IGMPv2 Leave Group or its "Leave" equivalent

message for IGMPv3 from its attached host, it checks to see if this host is the last host that is interested in this multicast group by sending a query for the multicast group. If the host was indeed the last one (i.e. no responses are received for the query), then the PE MUST re-advertises EVPN SMET Multicast route with the corresponding version flag reset. If this is the last version flag to be reset, then instead of re-advertising the EVPN route with all version flags reset, the PE MUST withdraws the EVPN route for that (*,G).

2) When a PE receives an EVPN SMET route for a given (*,G), it compares the received version flags from the route with its per-PE stored version flags. If the PE finds that a version flag associated with the (*,G) for the remote PE is reset, then the PE MUST generate IGMP Leave for that (*,G) toward its local interface (if any) attached to the multicast router for that multicast group. It should be noted that the received EVPN route SHOULD at least have one version flag set. If all version flags are reset, it is an error because the PE should have received an EVPN route withdraw for the last version flag. Error MUST be considered as BGP error and SHOULD be handled as per [RFC7606].

3) When a PE receives an EVPN SMET route withdraw, it removes the remote PE from its OIF list for that multicast group and if there are no more OIF entries for that multicast group (either locally or remotely), then the PE MUST stop responding to queries from the locally attached router (if any). If there is a source for that multicast group, the PE stops sending multicast traffic for that source.

4.2 Proxy Querier

As mentioned in the previous sections, each PE MUST have proxy querier functionality for the following reasons:

1) To enable the collection of EVPN PEs providing L2VPN service to act as distributed multicast router with Anycast IP address for all attached hosts/VMs in that subnet.

2) To enable suppression of IGMP membership reports and queries over MPLS/IP core.

5 Operation

Consider the EVPN network of Figure-1, where there is an EVPN instance configured across the PEs shown in this figure (namely PE1, PE2, and PE3). Let's consider that this EVPN instance consists of a single bridge domain (single subnet) with all the hosts, sources, and

the multicast router connected to this subnet. PE1 only has hosts connected to it. PE2 has a mix of hosts and a multicast source. PE3 has a mix of hosts, a multicast source, and a multicast router. Furthermore, let's consider that for (S1,G1), R1 is used as the multicast router. The following subsections describe the IGMP proxy operation in different PEs with regard to whether the locally attached devices for that subnet are:

- only hosts/VMs
- mix of hosts/VMs and multicast source
- mix of hosts/VMs, multicast source, and multicast router

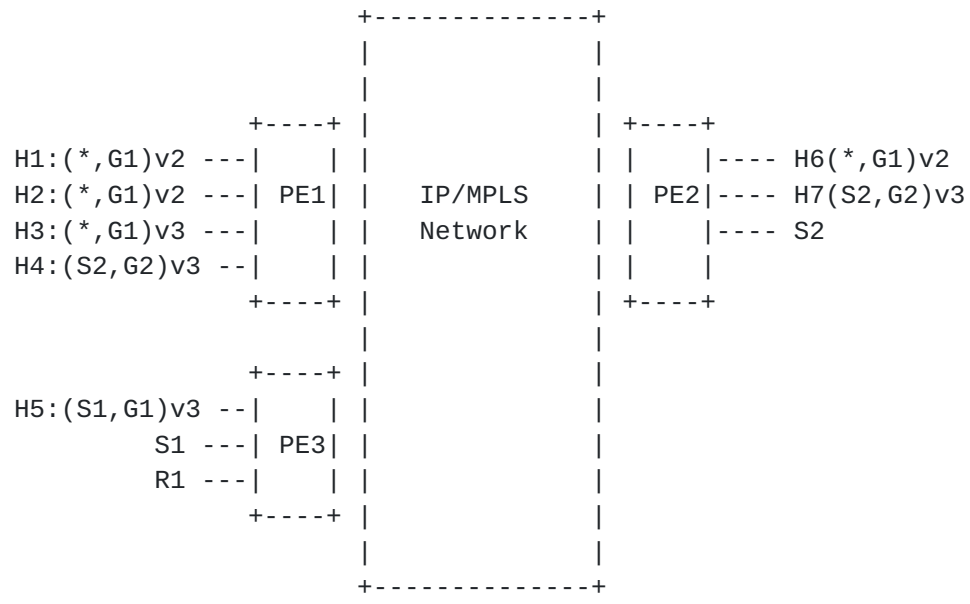


Figure 1: EVPN network

5.1 PE with only attached hosts/VMs for a given subnet

When PE1 receives an IGMPv2 Join Report from H1, it does not forward this join to any of its other ports (for this subnet) because all these local ports are associated with the hosts/VMs. PE1 sends an EVPN Multicast Group route corresponding to this join for (*,G1) and setting v2 flag. This EVPN route is received by PE2 and PE3 that are the members of the same BD (i.e., same EVI in case of VLAN-based service or <EVI,VLAN> in case of VLAN-aware bundle service). PE3 reconstructs the IGMPv2 Join Report from this EVPN BGP route and only sends it to the port(s) with multicast routers attached to it (for

that subnet). In this example, PE3 sends the reconstructed IGMPv2 Join Report for (*,G1) only to R1. Furthermore, even though PE2 receives the EVPN BGP route, it does not send it to any of its ports for that subnet; viz, ports associated with H6 and H7.

When PE1 receives the second IGMPv2 Join from H2 for the same multicast group (*,G1), it only adds that port to its OIF list but it doesn't send any EVPN BGP route because there is no change in information. However, when it receives the IGMPv3 Join from H3 for the same (*,G1). Besides adding the corresponding port to its OIF list, it re-advertises the previously sent EVPN SMET route with the v3 & exclude flag set.

Finally when PE1 receives the IMGMPv3 Join from H4 for (S2,G2), it advertises a new EVPN SMET route corresponding to it.

5.2 PE with a mix of attached hosts/VMs and multicast source

The main difference in this case is that when PE2 receives the IGMPv3 Join from H7 for (S2,G2), it does advertise it in BGP to support source move even though PE2 knows that S2 is attached to its local AC. PE2 adds the port associated with H7 to its OIF list for (S2,G2). The processing for IGMPv2 received from H6 is the same as the IGMPv2 Join described in previous section.

5.3 PE with a mix of attached hosts/VMs, a multicast source and a router

The main difference in this case relative to the previous two sections is that IGMP v2/v3 Join messages received locally needs to be sent to the port associated with router R1. Furthermore, the Joins received via BGP (SMET) need to be passed to the R1 port but filtered for all other ports.

6 All-Active Multi-Homing

Because the LAG flow hashing algorithm used by the CE is unknown at the PE, in an All-Active redundancy mode it must be assumed that the CE can send a given IGMP message to any one of the multi-homed PEs, either DF or non-DF; i.e., different IGMP Join messages can arrive at different PEs in the redundancy group and furthermore their corresponding Leave messages can arrive at PEs that are different from the ones that received the Join messages. Therefore, all PEs attached to a given ES must coordinate IGMP Join and Leave Group (x,G) state, where x may be either '*' or a particular source S, for each BD on that ES. This allows the DF for that [ES,BD] to correctly advertise or withdraw a Selective Multicast Ethernet Tag (SMET) route for that (x,G) group in that BD when needed.

All-Active multihoming PEs for a given ES MUST support IGMP synchronization procedures described in this section if they need to perform IGMP proxy for hosts connected to that ES.

6.1 Local IGMP/MLD Join Synchronization

When a PE, either DF or non-DF, receives on a given multihomed ES operating in All-Active redundancy mode, an IGMP Membership Report for (x,G), it determines the BD to which the IGMP Membership Report belongs. If the PE doesn't already have local IGMP Join (x,G) state for that BD on that ES, it MUST instantiate local IGMP Join (x,G) state and MUST advertise a BGP IGMP Join Synch route for that [ES, BD]. Local IGMP Join (x, G) state refers to IGMP Join (x,G) state that is created as a result of processing an IGMP Membership Report for (x,G).

The IGMP Join Synch route MUST carry the ES-Import RT for the ES on which the IGMP Membership Report was received. Thus it MUST only be sent to the PEs attached to that ES and not any other PEs.

When a PE, either DF or non-DF, receives an IGMP Join Synch route it installs that route and if it doesn't already have IGMP Join (x,G) state for that [ES,BD], it MUST instantiate that IGMP Join (x,G) state - i.e., IGMP Join (x,G) state is the union of the local IGMP Join (x,G) state and the installed IGMP Join Synch route. If the DF did not already advertise (originate) a SMET route for that (x,G) group in that BD, it MUST do so now.

When a PE, either DF or non-DF, deletes its local IGMP Join (x, G) state for that [ES,BD], it MUST withdraw its BGP IGMP Join Synch route for that [ES,BD].

When a PE, either DF or non-DF, receives the withdrawal of an IGMP Join Synch route from another PE it MUST remove that route. When a PE has no local IGMP Join (x,G) state and it has no installed IGMP Join Synch routes, it MUST remove IGMP Join (x,G) state for that [ES, BD]. If the DF no longer has IGMP Join (x,G) state for that BD on any ES for which it is DF, it MUST withdraw its SMET route for that (x,G) group in that BD.

In other words, a PE advertises an SMET route for that (x,G) group in that BD when it has IGMP Join (x,G) state in that BD on at least one ES for which it is DF and it withdraws that SMET route when it does not have IGMP Join (x,G) state in that BD on any ES for which it is DF.

6.2 Local IGMP/MLD Leave Group Synchronization

When a PE, either DF or non-DF, receives, on a given multihomed ES operating in All-Active redundancy mode, an IGMP Leave Group message for (x,G) from the attached CE, it determines the BD to which the IGMPv2 Leave Group belongs. Regardless of whether it has IGMP Join (x,G) state for that [ES,BD], it initiates the (x,G) leave group synchronization procedure, which consists of the following steps:

1) It computes the Maximum Response Time, which is the duration of (x,G) leave group synchronization procedure. This is the product of two locally configured values, Last Member Query Count and Last Member Query Interval (described in Section 3 of [RFC2236]), plus a delta corresponding to the time it takes for a BGP advertisement to propagate between the PEs attached to the multihomed ES (delta is a consistently configured value on all PEs attached to the multihomed ES).

2) It starts the Maximum Response Time timer. Note that the receipt of subsequent IGMP Leave Group messages or BGP Leave Synch routes for (x,G) do not change the value of a currently running Maximum Response Time timer and are ignored by the PE.

3) It initiates the Last Member Query procedure described in Section 3 of [RFC2236]; viz, it sends a number of Group-Specific Query (x,G) messages (Last Member Query Count) at a fixed interval (Last Member Query Interval) to the attached CE.

4) It advertises an IGMP Leave Synch route for that that [ES,BD]. This route notifies the other multihomed PEs attached to the given multihomed ES that it has initiated an (x,G) leave group synchronization procedure; i.e., it carries the ES-Import RT for the ES on which the IGMP Leave Group was received. It also contains the Maximum Response Time and the Leave Group Synchronization Procedure Sequence number. The latter identifies the specific (x,G) leave group synchronization procedure initiated by the advertising PE, which increments the value whenever it initiates a procedure.

5) When the Maximum Response Timer expires, the PE that has advertised the IGMP Leave Synch route withdraws it.

6.2.1 Remote Leave Group Synchronization

When a PE, either DF or non-DF, receives an IGMP Leave Synch route it installs that route and it starts a timer for (x,G) on the specified [ES,BD] whose value is set to the Maximum Response Time in the received IGMP Leave Synch route. Note that the receipt of subsequent IGMPv2 Leave Group messages or BGP Leave Synch routes for (x,G) do not change the value of a currently running Maximum Response Time

timer and are ignored by the PE.

6.2.2 Common Leave Group Synchronization

If a PE attached to the multihomed ES receives an IGMP Membership Report for (x,G) before the Maximum Response Time timer expires, it advertises a BGP IGMP Join Synch route for that [ES,BD]. If it doesn't already have local IGMP Join (x, G) state for that [ES, BD], it instantiates local IGMP Join (x,G) state. If the DF is not currently advertising (originating) a SMET route for that (x,G) group in that BD, it does so now.

If a PE attached to the multihomed ES receives an IGMP Join Synch route for (x,G) before the Maximum Response Time timer expires, it installs that route and if it doesn't already have IGMP Join (x,G) state for that BD on that ES, it instantiates that IGMP Join (x,G) state. If the DF has not already advertised (originated) a SMET route for that (x,G) group in that BD, it does so now.

When the Maximum Response Timer expires a PE that has advertised an IGMP Leave Synch route, withdraws it. Any PE attached to the multihomed ES, that started the Maximum Response Time and has no local IGMP Join (x,G) state and no installed IGMP Join Synch routes, it removes IGMP Join (x,G) state for that [ES,BD]. If the DF no longer has IGMP Join (x,G) state for that BD on any ES for which it is DF, it withdraws its SMET route for that (x,G) group in that BD.

6.3 Mass Withdraw of Multicast join Sync route in case of failure

A PE which has received an IGMP Join, would have synced the IGMP Join by the procedure defined in section 6.1. If a PE with local join state goes down or the PE to CE link goes down, it would lead to a mass withdraw of multicast routes. Remote PEs (PEs where these routes were remote IGMP Joins) SHOULD not remove the state immediately; instead General Query SHOULD be generated to refresh the states. There are several ways to Some of the way to detect failure at a peer, e.g. using IGP next hop tracking or ES route withdraw.

7 Single-Active Multi-Homing

Note that to facilitate state synchronization after failover, the PEs attached to a mutihomed ES operating in Single-Active redundancy mode SHOULD also coordinate IGMP Join (x,G) state. In this case all IGMP Join messages are received by the DF and distributed to the non-DF PEs using the procedures described above.

8 Selective Multicast Procedures for IR tunnels

If an ingress PE uses ingress replication, then for a given (x,G) group in a given BD:

1) It sends (x,G) traffic to the set of PEs not supporting IGMP Proxy. This set consists of any PE that has advertised an Inclusive Multicast Tag route for the BD without the "IGMP Proxy Support" flag.

2) It sends (x,G) traffic to the set of PEs supporting IGMP Proxy and having listeners for that (x,G) group in that BD. This set consists of any PE that has advertised an Inclusive Multicast Tag route for the BD with the "IGMP Proxy Support" flag and that has advertised a SMET route for that (x,G) group in that BD.

If an ingress PE's Selective P-Tunnel for a given BD uses P2MP and all of the PEs in the BD support that tunnel type and IGMP proxy, then for a given (x,G) group in a given BD it sends (x,G) traffic using the Selective P-Tunnel for that (x,G) group in that BD. This tunnel includes those PEs that have advertised a SMET route for that (x,G) group on that BD (for Selective P-tunnel) but it may include other PEs as well (for Aggregate Selective P-tunnel).

9 BGP Encoding

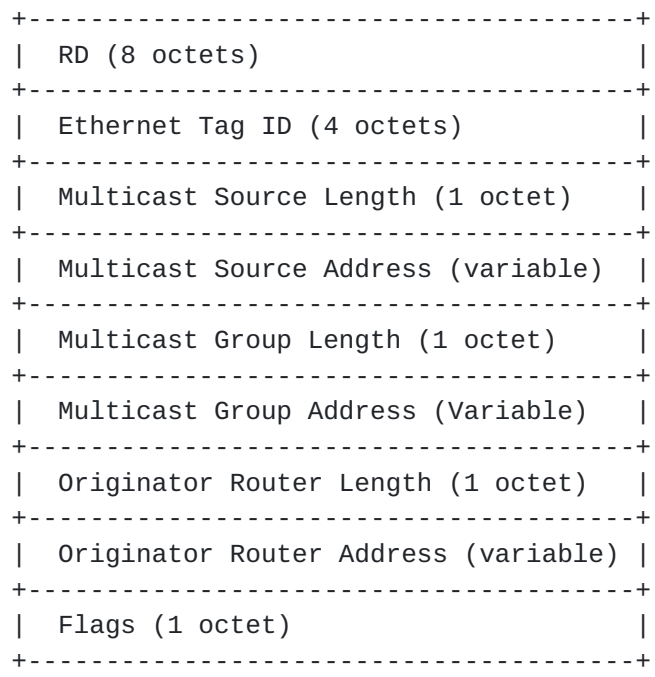
This document defines three new BGP EVPN routes to carry IGMP membership reports. The route type is known as:

+ 6 - Selective Multicast Ethernet Tag Route
+ 7 - Multicast Join Synch Route
+ 8 - Multicast Leave Synch Route

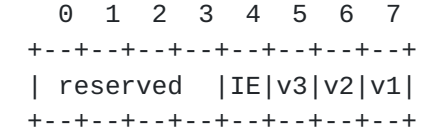
The detailed encoding and procedures for this route type are described in subsequent sections.

9.1 Selective Multicast Ethernet Tag Route

A Selective Multicast Ethernet Tag route type specific EVPN NLRI consists of the following:



For the purpose of BGP route key processing, all the fields are considered to be part of the prefix in the NLRI except for the one-octet flag field. The Flags fields are defined as follows:



The least significant bit, bit 7 indicates support for IGMP version 1.

The second least significant bit, bit 6 indicates support for IGMP version 2.

The third least significant bit, bit 5 indicates support for IGMP version 3.

The forth least significant bit, bit 4 indicates whether the (S,G) information carried within the route-type is of an Include Group type (bit value 0) or an Exclude Group type (bit value 1). The Exclude Group type bit MUST be ignored if bit 5 is not set.

This EVPN route type is used to carry tenant IGMP multicast group information. The flag field assists in distributing IGMP membership interest of a given host/VM for a given multicast route. The version bits help associate IGMP version of receivers participating within

the EVPN domain.

The include/exclude bit helps in creating filters for a given multicast route.

If route is used for IPv6 (MLD) then bit 7 indicates support for MLD version 1. The second least significant bit, bit 6 indicates support for MLD version 2. Since there is no MLD version 3, in case of IPv6 route third least significant bit MUST be 0. In case of IPv6 routes, the fourth least significant bit MUST be ignored if bit 6 is not set.

9.1.1 Constructing the Selective Multicast Ethernet Tag route

This section describes the procedures used to construct the Selective Multicast Ethernet Tag (SMET) route.

The Route Distinguisher (RD) SHOULD be a Type 1 RD [RFC4364]. The value field comprises an IP address of the PE (typically, the loopback address) followed by a number unique to the PE.

The Ethernet Tag ID MUST be set as follows:

EVI is VLAN-Based or VLAN Bundle service - set to 0
EVI is VLAN-Aware Bundle service without translation - set to the customer VID for that BD
EVI is VLAN-Aware Bundle service with translation - set to the normalized Ethernet Tag ID - e.g., normalized VID

The Multicast Source Length MUST be set to length of the multicast Source address in bits. If the Multicast Source Address field contains an IPv4 address, then the value of the Multicast Source Length field is 32. If the Multicast Source Address field contains an IPv6 address, then the value of the Multicast Source Length field is 128. In case of a (*, G) Join, the Multicast Source Length is set to 0.

The Multicast Source Address is the source IP address from the IGMP membership report. In case of a (*, G), this field is not used.

The Multicast Group Length MUST be set to length of multicast group address in bits. If the Multicast Group Address field contains an IPv4 address, then the value of the Multicast Group Length field is 32. If the Multicast Group Address field contains an IPv6 address, then the value of the Multicast Group Length field is 128.

The Multicast Group Address is the Group address from the IGMP membership report.

The Originator Router Length is the length of the Originator Router Address in bits.

The Originator Router Address is the IP address of router originating the prefix. It should be noted that using the "Originating Router's IP address" field is needed for local-bias procedures and may be needed for building inter-AS multicast underlay tunnels where the BGP next-hop can get overwritten.

The Flags field indicates the version of IGMP protocol from which the membership report was received. It also indicates whether the multicast group had the INCLUDE or EXCLUDE bit set.

IGMP is used to receive group membership information from hosts/VMs by TORs. Upon receiving the hosts/VMs expression of interest of a particular group membership, this information is then forwarded using Ethernet Multicast Source Group Route NLRI. The NLRI also keeps track of receiver's IGMP protocol version and any source filtering for a given group membership. All EVPN SMET routes are announced with per-EVI Route Target extended communities.

9.1.2 Default Selective Multicast Route

If there is multicast router connected behind the EVPN domain, the PE MAY originate a default SMET (*,*) to get all multicast traffic in domain.

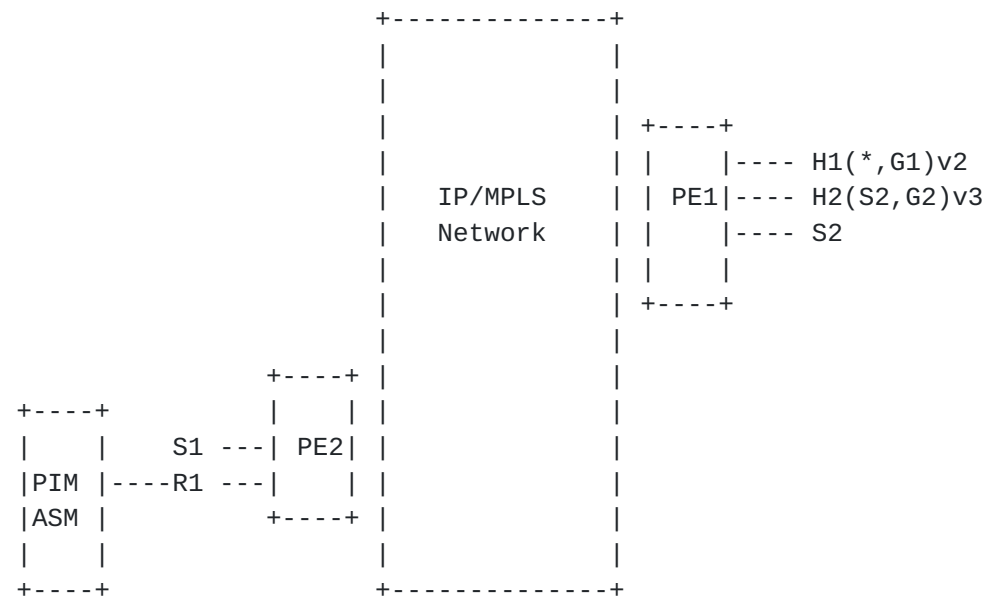
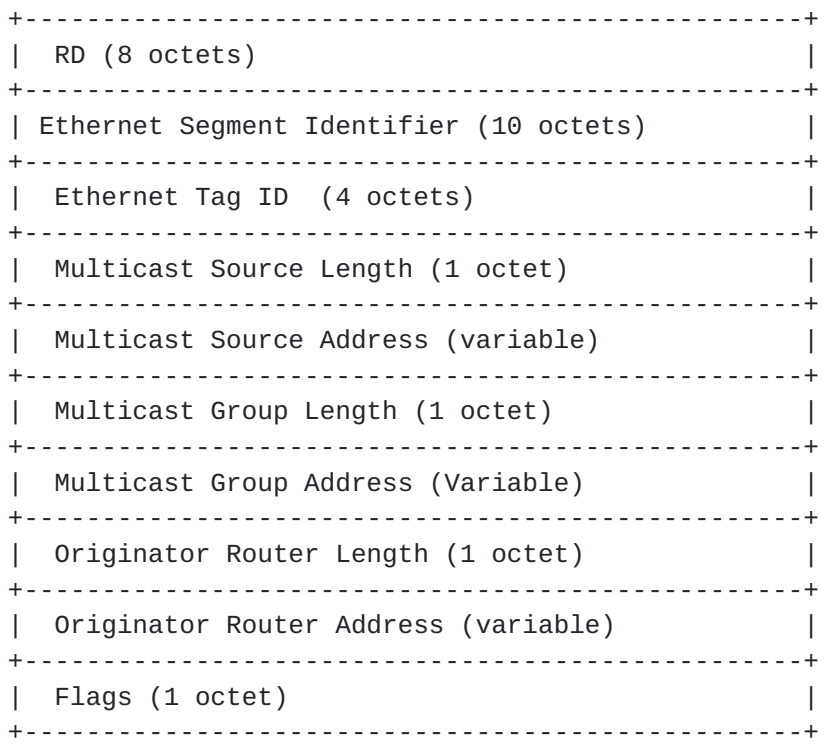


Figure 2: Multicast Router behind EVPN domain

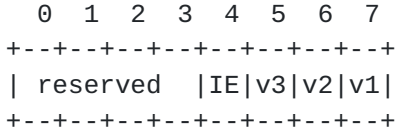
Consider the EVPN network of Figure-2, where there is an EVPN instance configured across the PEs. Lets consider PE2 is connected to multicast router R1 and there is a network running PIM ASM behind R1. If there are receivers behind the PIM ASM network, the PIM Join would be forwarded to the PIM RP (Rendezvous Point). If receivers behind PIM ASM network are interested in a multicast flow originated by multicast source S2 (behind PE1), it is necessary for PE2 to receive multicast traffic. In this case PE2 MUST originate a (*,*) SMET route to receive all of the multicast traffic in the EVPN domain.

9.2 Multicast Join Synch Route

This EVPN route type is used to coordinate IGMP Join (x,G) state for a given BD between the PEs attached to a given ES operating in All-Active (or Single-Active) redundancy mode and it consists of following:



For the purpose of BGP route key processing, all the fields are considered to be part of the prefix in the NLRI except for the one-octet Flags field, whose fields are defined as follows:



The least significant bit, bit 7 indicates support for IGMP version 1. The second least significant bit, bit 6 indicates support for IGMP version 2. The third least significant bit, bit 5 indicates support for IGMP version 3. The fourth least significant bit, bit 4 indicates whether the (S, G) information carried within the route-type is of Include Group type (bit value 0) or an Exclude Group type (bit value 1). The Exclude Group type bit MUST be ignored if bit 5 is not set.

The Flags field assists in distributing IGMP membership interest of a given host/VM for a given multicast route. The version bits help associate IGMP version of receivers participating within the EVPN domain. The include/exclude bit helps in creating filters for a

given multicast route.

If route is being prepared for IPv6 (MLD) then bit 7 indicates support for MLD version 1. The second least significant bit, bit 6 indicates support for MLD version 2. Since there is no MLD version 3, in case of IPv6 route third least significant bit MUST be 0. In case of IPv6 route, the fourth least significant bit MUST be ignored if bit 6 is not set.

9.2.1 Constructing the Multicast Join Synch Route

This section describes the procedures used to construct the IGMP Join Synch route. Support for this route type is optional. If a PE does not support this route, then it MUST NOT indicate that it supports 'IGMP proxy' in the Multicast Flag extended community for the EVIs corresponding to its multi-homed Ethernet Segments (ESs).

An IGMP Join Synch route MUST carry exactly one ES-Import Route Target extended community, the one that corresponds to the ES on which the IGMP Join was received. It MUST also carry exactly one EVI-RT EC, the one that corresponds to the EVI on which the IGMP Join was received. See Section 9.5 for details on how to encode and construct the EVI-RT EC.

The Route Distinguisher (RD) SHOULD be a Type 1 RD [RFC4364]. The value field comprises an IP address of the PE (typically, the loopback address) followed by a number unique to the PE.

The Ethernet Segment Identifier (ESI) MUST be set to the 10-octet value defined for the ES.

The Ethernet Tag ID MUST be set as follows:

EVI is VLAN-Based or VLAN Bundle service - set to 0
EVI is VLAN-Aware Bundle service without translation - set to the customer VID for the BD
EVI is VLAN-Aware Bundle service with translation - set to the normalized Ethernet Tag ID - e.g., normalized VID

The Multicast Source length MUST be set to length of Multicast Source address in bits. If the Multicast Source field contains an IPv4 address, then the value of the Multicast Source Length field is 32. If the Multicast Source field contains an IPv6 address, then the value of the Multicast Source Length field is 128. In case of a (*, G) Join, the Multicast Source Length is set to 0.

The Multicast Source is the Source IP address of the IGMP membership report. In case of a (*, G) Join, this field does not exist.

The Multicast Group length MUST be set to length of multicast group address in bits. If the Multicast Group field contains an IPv4 address, then the value of the Multicast Group Length field is 32. If the Multicast Group field contains an IPv6 address, then the value of the Multicast Group Length field is 128.

The Multicast Group is the Group address of the IGMP membership report.

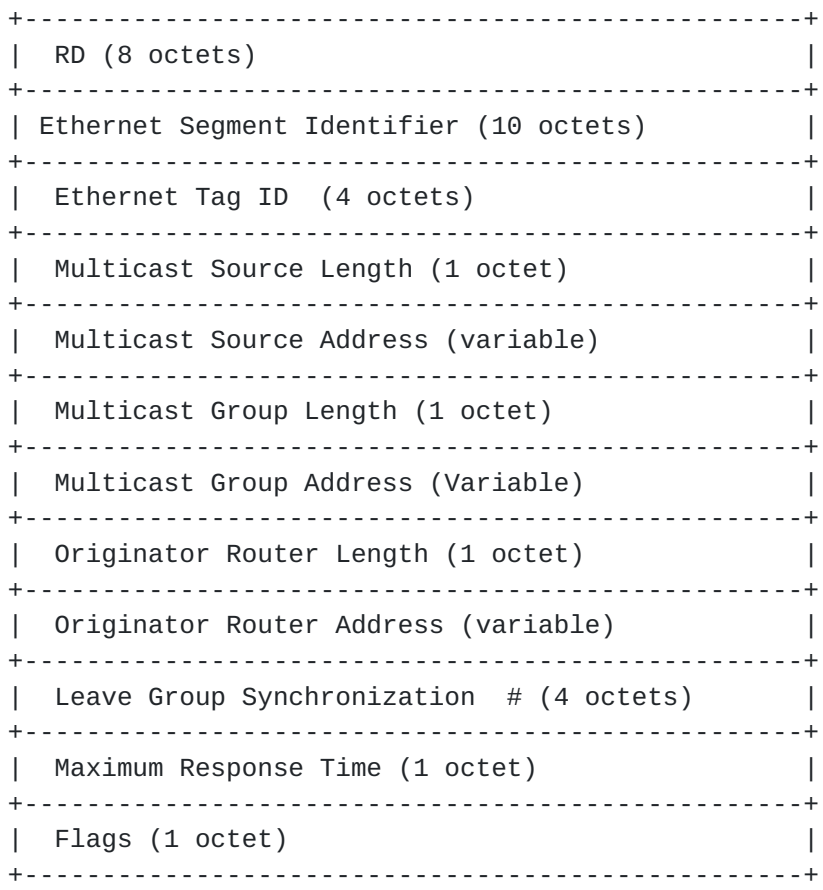
The Originator Router Length is the length of the Originator Router address in bits.

The Originator Router Address is the IP address of Router Originating the prefix.

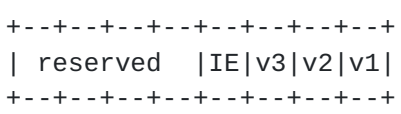
The Flags field indicates the version of IGMP protocol from which the membership report was received. It also indicates whether the multicast group had INCLUDE or EXCLUDE bit set.

9.3 Multicast Leave Synch Route

This EVPN route type is used to coordinate IGMP Leave Group (x,G) state for a given BD between the PEs attached to a given ES operating in All-Active (or Single-Active) redundancy mode and it consists of following:



For the purpose of BGP route key processing, all the fields are considered to be part of the prefix in the NLRI except for the Maximum Response Time and the one-octet Flags field, whose fields are defined as follows:



The least significant bit, bit 7 indicates support for IGMP version 1. The second least significant bit, bit 6 indicates support for IGMP version 2. The third least significant bit, bit 5 indicates support for IGMP version 3. The fourth least significant bit, bit 4 indicates whether the (S, G) information carried within the route-type is of Include Group type (bit value 0) or an Exclude Group type (bit value 1). The Exclude Group type bit MUST be ignored if bit 5 is not set.

The Flags field assists in distributing IGMP membership interest of a given host/VM for a given multicast route. The version bits help associate IGMP version of receivers participating within the EVPN domain. The include/exclude bit helps in creating filters for a given multicast route.

If route is being prepared for IPv6 (MLD) then bit 7 indicates support for MLD version 1. The second least significant bit, bit 6 indicates support for MLD version 2. Since there is no MLD version 3, in case of IPv6 route third least significant bit MUST be 0. In case of IPv6 route, the fourth least significant bit MUST be ignored if bit 6 is not set.

9.3.1 Constructing the Multicast Leave Synch Route

This section describes the procedures used to construct the IGMP Leave Synch route. Support for this route type is optional. If a PE does not support this route, then it MUST not indicate that it supports 'IGMP proxy' in Multicast Flag extended community for the EVIs corresponding to its multi-homed Ethernet Segments.

An IGMP Leave Synch route MUST carry exactly one ES-Import Route Target extended community, the one that corresponds to the ES on which the IGMP Leave was received. It MUST also carry exactly one EVI-RT EC, the one that corresponds to the EVI on which the IGMP Leave was received. See Section 9.5 for details on how to form the EVI-RT EC.

The Route Distinguisher (RD) SHOULD be a Type 1 RD [RFC4364]. The value field comprises an IP address of the PE (typically, the loopback address) followed by a number unique to the PE.

The Ethernet Segment Identifier (ESI) MUST be set to the 10-octet value defined for the ES.

The Ethernet Tag ID MUST be set as follows:

EVI is VLAN-Based or VLAN Bundle service - set to 0
EVI is VLAN-Aware Bundle service without translation - set to the customer VID for the BD
EVI is VLAN-Aware Bundle service with translation - set to the normalized Ethernet Tag ID - e.g., normalized VID

The Multicast Source length MUST be set to length of multicast source address in bits. If the Multicast Source field contains an IPv4

address, then the value of the Multicast Source Length field is 32. If the Multicast Source field contains an IPv6 address, then the value of the Multicast Source Length field is 128. In case of a (*, G) Join, the Multicast Source Length is set to 0.

The Multicast Source is the Source IP address of the IGMP membership report. In case of a (*, G) Join, this field does not exist.

The Multicast Group length MUST be set to length of multicast group address in bits. If the Multicast Group field contains an IPv4 address, then the value of the Multicast Group Length field is 32. If the Multicast Group field contains an IPv6 address, then the value of the Multicast Group Length field is 128.

The Multicast Group is the Group address of the IGMP membership report.

The Originator Router Length is the length of the Originator Router address in bits.

The Originator Router Address is the IP address of Router Originating the prefix.

The Flags field indicates the version of IGMP protocol from which the membership report was received. It also indicates whether the multicast group had INCLUDE or EXCLUDE bit set.

9.4 Multicast Flags Extended Community

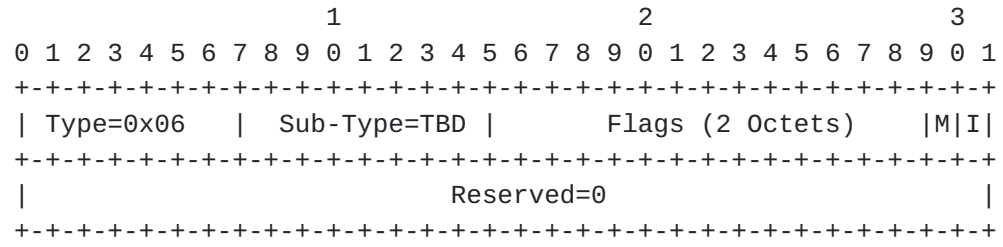
The 'Multicast Flags' extended community is a new EVPN extended community. EVPN extended communities are transitive extended communities with a Type field value of 6. IANA will assign a Sub-Type from the 'EVPN Extended Community Sub-Types' registry.

A PE that supports IGMP proxy on a given BD MUST attach this extended community to the Inclusive Multicast Ethernet Tag (IMET) route it advertises for that BD and it MUST set the IGMP Proxy Support flag to 1. Note that an [RFC7432] compliant PE will not advertise this extended community so its absence indicates that the advertising PE does not support IGMP Proxy.

The advertisement of this extended community enables more efficient multicast tunnel setup from the source PE specially for ingress replication - i.e., if an egress PE supports IGMP proxy but doesn't have any interest in a given (x,G), it advertises its IGMP proxy capability using this extended community but it does not advertise

any SMET route for that (x,G). When the source PE (ingress PE) receives such advertisements from the egress PE, it does not replicate the multicast traffic to that egress PE; however, it does replicate the multicast traffic to the egress PEs that don't advertise such capability even if they don't have any interests in that (x,G).

A Multicast Flags extended community is encoded as an 8-octet value, as follows:



The low-order (lease significant) two bits are defined as the "IGMP Proxy Support and MLD Proxy Support" bit. The absence of this extended community also means that the PE does not support IGMP proxy.
where:

o Type is 0x06 as registered with IANA for EVPN Extended Communities.

o Sub-Type : TBD

o Flags are two Octets value.

- Bit 15 (shown as I) defines IGMP Proxy Support. Value of 1 for bit 15 means that PE supports IGMP Proxy. Value of 0 for bit 15 means that PE does not supports IGMP Proxy.

- Bit 14 (shown as M) defines MLD Proxy Support. Value of 1 for bit 14 means that PE supports MLD Proxy. Value of 0 for bit 14 means that PE does not support MLD proxy.

- Bit 0 to 13 are reserved for future.

o Reserved bits are set to 0. They could be defined in future.

9.5 EVI-RT Extended Community

In EVPN, every EVI is associated with one or more Route Targets (RTs). These Route Targets serve two functions:

- Distribution control: RTs control the distribution of the routes. If a route carries the RT associated with a particular EVI, it will be distributed to all the PEs on which that EVI exists.

- EVI identification: Once a route has been received by a particular PE, the RT is used to identify the EVI to which it applies.

An IGMP Join Synch or IGMP Leave Synch route is associated with a particular combination of ES and EVI. These routes need to be distributed only to PEs that are attached to the associated ES. Therefore these routes carry the ES-Import RT for that ES.

Since an IGMP Join Synch or IGMP Leave Synch route does not need to be distributed to all the PEs on which the associated EVI exists, these routes cannot carry the RT associated with that EVI. Therefore, when such a route arrives at a particular PE, the route's RTs cannot be used to identify the EVI to which the route applies. Some other means of associating the route with an EVI must be used.

This document specifies four new Extended Communities (EC) that can be used to identify the EVI with which a route is associated, but which do not have any effect on the distribution of the route. These new ECs are known as the "Type 0 EVI-RT EC", the "Type 1 EVI-RT EC", the "Type 2 EVI-RT EC", and the "Type 3 EVI-RT EC".

A Type 0 EVI-RT EC is an EVPN EC (type 6) of sub-type 0xA.

A Type 1 EVI-RT EC is an EVPN EC (type 6) of sub-type 0xB.

A Type 2 EVI-RT EC is an EVPN EC (type 6) of sub-type 0xC.

A Type 3 EVI-RT EC is an EVPN EC (type 6) of sub-type TBD.

Each IGMP Join Synch or IGMP Leave Synch route MUST carry exactly one EVI-RT EC. The EVI-RT EC carried by a particular route is constructed as follows. Each such route is the result of having received an IGMP Join or an IGMP Leave message from a particular

BD. The route is said to be associated associated with that BD. For each BD, there is a corresponding RT that is used to ensure that routes "about" that BD are distributed to all PEs attached to that BD. So suppose a given IGMP Join Synch or Leave Synch route is associated with a given BD, say BD1, and suppose that the corresponding RT for BD1 is RT1. Then:

0. If RT1 is a Transitive Two-Octet AS-specific EC, then the EVI-RT EC carried by the route is a Type 0 EVI-RT EC. The value field of the Type 0 EVI-RT EC is identical to the value field of RT1.

1. If RT1 is a Transitive IPv4-Address-specific EC, then the EVI-RT EC carried by the route is a Type 1 EVI-RT EC. The value field of the Type 1 EVI-RT EC is identical to the value field of RT1.

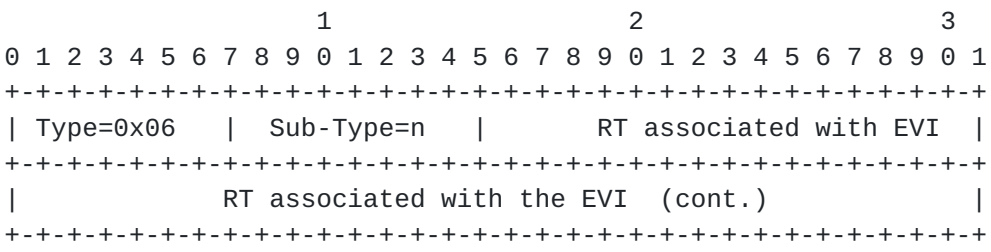
2. If RT1 is a Transitive Four-Octet-specific EC, then the EVI-RT EC carried by the route is a Type 2 EVI-RT EC. The value field of the Type 2 EVI-RT EC is identical to the value field of RT1.

3. If RT1 is a Transitive IPv6-Address-specific EC, then the EVI-RT EC carried by the route is a Type 3 EVI-RT EC. The value field of the Type 3 EVI-RT EC is identical to the value field of RT1.

An IGMP Join Synch or Leave Synch route MUST carry exactly one EVI-RT EC.

Suppose a PE receives a particular IGMP Join Synch or IGMP Leave Synch route, say R1, and suppose that R1 carries an ES-Import RT that is one of the PE's Import RTs. If R1 has no EVI-RT EC, or has more than one EVI-RT EC, the PE MUST apply the "treat-as-withdraw" procedure of [RFC7606].

Note that an EVI-RT EC is not a Route Target Extended Community, is not visible to the RT Constrain mechanism [RFC4684], and is not intended to influence the propagation of routes by BGP.



Where the value of 'n' is 0x0A, 0x0B, 0x0C, or 0x0D corresponding to EVI-RT type 0, 1, 2, or 3 respectively.

9.6 Rewriting of RT ECs and EVI-RT ECs by ASBRs

There are certain situations in which an ES is attached to a set of PEs that are not all in the same AS, or not all operated by the same provider. In some such situations, the RT that corresponds to a particular EVI may be different in each AS. If a route is propagated from AS1 to AS2, an ASBR at the AS1/AS2 border may be provisioned with a policy that removes the RTs that are meaningful in AS1 and replaces them with the corresponding (i.e., RTs corresponding to the same EVIs) RTs that are meaningful in AS2. This is known as RT-rewriting.

Note that if a given route's RTs are rewritten, and the route carries an EVI-RT EC, the EVI-RT EC needs to be rewritten as well.

10 IGMP/MLD Immediate Leave

IGMP MAY be configured with immediate leave option. This allows the device to remove the group entry from the multicast routing table immediately upon receiving a IGMP leave message for (x,G). In case of all active multi-homing while synchronizing the IGMP Leave state to redundancy peers, Maximum Response Time MAY be filled in as Zero. Implementations SHOULD have identical configuration across multi-homed peers. In case IGMP Leave Synch route is received with Maximum Response Time Zero, irrespective of local IGMP configuration it MAY be processed as an immediate leave.

11 IGMP Version 1 Membership Request

This document does not provide any detail about IGMPv1 processing. Multicast working group are in process of deprecating uses of IGMPv1 so it is RECOMMENDED that implementations only use IGMPv2 and above for IPv4 and MLDv1 and above for IPv6.

12 Security Considerations

Same security considerations as [RFC7432], [RFC2236], [RFC3376], [RFC2710], [RFC3810].

13 IANA Considerations

IANA has allocated the following codepoints from the EVPN Extended Community sub-types registry.

0x09	Multicast Flags Extended Community	[this document]
0x0A	EVI-RT Type 0	[this document]
0x0B	EVI-RT Type 1	[this document]
0x0C	EVI-RT Type 2	[this document]

IANA is requested to allocate a new codepoint from the EVPN Extended Community sub-types registry for the following.

0x0D	EVI-RT Type 3	[this document]

IANA has allocated the following EVPN route types from the EVPN Route Type registry.

6 - Selective Multicast Ethernet Tag Route
7 - Multicast Join Synch Route
8 - Multicast Leave Synch Route

IANA is requested to create a registry, "Multicast Flags Extended Community Flags", in the BGP registry.

The Multicast Flags Extended Community contains a 16-bit Flags field. The bits are numbered 0-15, from high-order to low-order.

The registry should be initialized as follows:

Bit	Name	Reference
0 - 13	Unassigned	
14	MLD Proxy Support	This document
15	IGMP Proxy Support	This document

The registration policy should be "First Come First Served".

14 References

14.1 Normative References

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

[RFC4360] S. Sangli et al, ""BGP Extended Communities Attribute", February, 2006.

[RFC7432] Sajassi et al., "BGP MPLS Based Ethernet VPN", February, 2015.

[RFC3376] Cain, B., Deering, S., Kouvelas, I., Fenner, B., and A. Thyagarajan, "Internet Group Management Protocol, Version 3", RFC 3376, October 2002.

[RFC2710] Deering, S., Fenner, W., and B. Haberman, "Multicast Listener Discovery (MLD) for IPv6", RFC 2710, October 1999.

[RFC3810] Vida, R. and L. Costa, "Multicast Listener Discovery Version 2 (MLDv2) for IPv6", RFC 3810, June 2004.

[RFC7606] Chen, E., Ed., Scudder, J., Ed., Mohapatra, P., and K. Patel, "Revised Error Handling for BGP UPDATE Messages", RFC 7606, DOI 10.17487/RFC7606, August 2015.

[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)"

14.2 Informative References

[RFC4541] Christensen, M., Kimball, K., and F. Solensky, "Considerations for IGMP and MLD snooping PEs", 2006.

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