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EVPN BUM Using BIER
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Abstract

This document specifies protocols and procedures for forwarding broadcast, unknown unicast and multicast (BUM) traffic of Ethernet VPNs (EVPN) using Bit Index Explicit Replication (BIER).

Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC2119.

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1. Introduction

[RFC7432] and [I-D.ietf-bess-evpn-overlay] specify the protocols and procedures for Ethernet VPNs (EVPNs). For broadcast, unknown unicast and multicast (BUM) traffic, provider/underlay tunnels (referred to as P-tunnels) are used to carry the BUM traffic. Several kinds of tunnel technologies can be used, as specified in [RFC7432].

Bit Index Explicit Replication (BIER) ([I-D.ietf-bier-architecture]) is an architecture that provides optimal multicast forwarding through a "multicast domain", without requiring intermediate routers to maintain any per-flow state or to engage in an explicit tree-building protocol. The purpose of this document is to specify the protocols and procedures to transport EVPN BUM traffic using BIER.

The EVPN BUM procedures specified in [RFC7432] and extended in [I-D.ietf-bess-evpn-bum-procedure-updates], [I-D.ietf-bess-evpn-igmp-mld-proxy], and [I-D.zzhang-bess-mvpn-evpn-cmcast-enhancements] are much aligned with MVPN procedures. As such, this document is also very much aligned with [I-D.ietf-bier-mvpn]. For terseness, some background, terms and concepts are not repeated here. Additionally, some text is borrowed verbatim from [I-D.ietf-bier-mvpn].

1.1. Terminologies

- BFR: Bit-Forwarding Router.
- BFIR: Bit-Forwarding Ingress Router.
- BFER: Bit-Forwarding Egress Router.
- BFR-Prefix: An IP address that uniquely identifies a BFR and is routeable in a BIER domain.
- C-S: A multicast source address, identifying a multicast source located at a VPN customer site.
- C-G: A multicast group address used by a VPN customer.
- C-flow: A customer multicast flow. Each C-flow is identified by the ordered pair (source address, group address), where each address is in the customer's address space. The identifier of a particular C-flow is usually written as (C-S,C-G). Sets of C-flows can be identified by the use of the "C-*" wildcard (see [RFC6625]), e.g., (C-*,C-G).
- P-tunnel. A multicast tunnel through the network of one or more SPs. P-tunnels are used to transport MVPN multicast data
- IMET Route: Inclusive Multicast Ethernet Tag Auto-Discovery route. Carried in BGP Update messages, these routes are used to advertise the "default" P-tunnel for a particular broadcast domain.
- SMET Route: Selective Multicast Ethernet Tag Auto-Discovery route. Carried in BGP Update messages, these routes are used to advertise the C-flows that the advertising PE is interested in.
- 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 particular C-flows are bound to (i.e., are traveling through) particular P-tunnels.

- PMSI Tunnel attribute (PTA). This BGP attribute carried is used to identify a particular P-tunnel. When C-flows of multiple VPNs are carried in a single P-tunnel, this attribute also carries the information needed to multiplex and demultiplex the C-flows.

2. Use of the PMSI Tunnel Attribute

[RFC7432] specifies that Inclusive Multicast Ethernet Tag (IMET) routes carry a PMSI Tunnel Attribute (PTA) to identify the particular P-tunnel to which one or more BUM flows are being assigned, the same as specified in [RFC6514] for MVPN. [I-D.ietf-bier-mvpn] specifies the encoding of PTA for use of BIER with MVPN. Much of that specification is reused for use of BIER with EVPN and much of the text below is borrowed verbatim from [I-D.ietf-bier-mvpn].

The PMSI Tunnel Attribute (PTA) contains the following fields:

- "Tunnel Type". The same codepoint that [I-D.ietf-bier-mvpn] requests IANA to assign for the new tunnel type "BIER" is used for EVPN as well.

- "Tunnel Identifier". When the "tunnel type" field is "BIER", this field contains two subfields. The text below is exactly as in [I-D.ietf-bier-mvpn].

  1 The first subfield is a single octet, containing the sub-domain-id of the sub-domain to which the BFIR will assign the packets that it transmits on the PMSI identified by the NLRI of the IMET, S-PMSI A-D, or per-region I-PMSI A-D route that contains this PTA. How that sub-domain is chosen is outside the scope of this document.

  2 The second subfield is the BFR-Prefix (see [I-D.ietf-bier-architecture]) of the originator of the route that is carrying this PTA. This will either be a /32 IPv4 address or a /128 IPv6 address. Whether the address is IPv4 or IPv6 can be inferred from the total length of the PMSI Tunnel attribute.

- "MPLS label". For EVPN-MPLS [RFC7432], this field contains an upstream-assigned MPLS label. It is assigned by the BFIR. Constraints on the way in which the originating router selects this label are discussed in Section 2.2. For EVPN-VXLAN/NVGRE [I-D.ietf-bess-evpn-overlay], this field is a 24-bit VNI/VSID of global significance.

- "Flags". When the tunnel type is BIER, two of the flags in the PTA Flags field are meaningful. Details about the use of these flags can be found in Section 2.1.

  - "Leaf Info Required per Flow (LIR-pF)" [I-D.ietf-bess-mvpn-expl-track]

  - "Leaf Info Required Bit (LIR)"

Note that if a PTA specifying "BIER" is attached to an IMET, S-PMSI A-D, or per-region I-PMSI A-D route, the route MUST NOT be distributed beyond the boundaries of a BIER domain. That is, any routers that receive the route must be in the same BIER domain as the originator of the route. If the originator is in more than one BIER domain, the route must be distributed only within the BIER domain in which the BFR-Prefix in the PTA uniquely identifies the originator. As with all MVPN routes, distribution of these routes is controlled by the provisioning of Route Targets.

2.1. Explicit Tracking

When using BIER to transport an EVPN BUM data packet through a BIER domain, an ingress PE functions as a BFIR (see [I-D.ietf-bier-architecture]). The BFIR must determine the set of BFERs to which the packet needs to be delivered. This can be done in either of two ways in the following two sections.

2.1.1. Using IMET/SMET routes

Both IMET and SMET (Selective Multicast Ethernet Tag [I-D.ietf-bess-evpn-igmp-mld-proxy]) routes provide explicit tracking functionality.

For an inclusive PMSI, the set of BFERs to deliver traffic to includes the originators of all IMET routes for a broadcast domain. For a selective PMSI, the set of BFERs to deliver traffic to includes the originators of corresponding SMET routes.

The SMET routes do not carry a PTA. When an ingress PE sends traffic on a selective tunnel using BIER, it uses the upstream assigned label that is advertised in its IMET route.

Only when selectively forwarding is for all flows without tunnel segmentation, SMET routes are used without S-PMSI A-D routes. Otherwise, the procedures in the following section apply.

2.1.2. Using S-PMSI/Leaf A-D Routes

There are two cases where S-PMSI/Leaf A-D routes are used as discussed in the following two sections.

2.1.2.1. Selective Forwarding Only for Some Flows

With the SMET procedure, a PE advertises an SMET route for each (C-S,C-G) or (C-*,C-G) state that it learns on its ACs, and each SMET route is tracked by every PE in the same broadcast domain. It may be desired that SMET routes are not used to reduce the burden of explicit tracking.

In this case, most multicast traffic will follow the I-PMSI (advertised via IMET route) and only some flows follow S-PMSIs. To achieve that, S-PMSI/Leaf A-D routes can be used, as specified in [I-D.ietf-bess-evpn-bum-procedure-updates]. The LIR bit may be set in the S-PMSI A-D routes, and the PEs that need to receive corresponding traffic will respond with a Leaf A-D route. The ingress PE identifies the set of BFERs to deliver traffic to according to the set of corresponding Leaf A-D routes received.

The S-PMSI A-D route carries the same PTA as in the IMET route, except that similar to MVPN, the LIR-pF flag may be set for an ingress PE to request individual (C-S,C-G) or (C-*,C-G) Leaf A-D routes.

2.1.2.2. Tunnel Segmentation

Another case where S-PMSI/Leaf A-D routes are necessary is tunnel segmentation, which is also specified in [I-D.ietf-bess-evpn-bum-procedure-updates], and further clarified in [I-D.zzhang-bess-mvpn-evpn-cmcast-enhancements] for segmentation with SMET routes. This is only applicable to EVPN-MPLS.

Similar to MVPN, the LIR-pF flag cannot be used with segmentation, and the S-PMSI A-D routes' PTA MUST carry an upstream assigned label to allow tunnel segmentation points to do label switching. The S-PMSI A-D routes could be proactively (re-)advertised by the ingress PEs or segmentation points, or could be triggered by the unsolicited Leaf A-D routes received from downstream.

2.2. MPLS Label in PTA

Similar to the MVPN case in [I-D.ietf-bier-mvpn], the label allocation for the upstream assigned label in the PTA MUST follow the following rules (text borrowed verbatim from [I-D.ietf-bier-mvpn]).

Suppose an ingress PE originates two x-PMSI A-D routes, where we use the term "x-PMSI" to mean "I-PMSI or S-PMSI or IMET". Suppose both routes carry a PTA, and the PTA of each route specifies"BIER".

- If the two routes do not carry the same set of Route Targets (RTs), then their respective PTAs MUST contain different MPLS label values.

- If segmented P-tunnels are being used, then the respective PTAs of the two routes MUST contain different MPLS label values, as long as the NLRIs are not identical. In this case, the MPLS label can be used by the BFER to identify the particular C-flow to which a data packet belongs, and this greatly simplifies the process of forwarding a received packet to its next P-tunnel segment. This is explained further below.

When segmented P-tunnels are being used, an ABR or ASBR may receive, from a BIER domain, an x-PMSI A-D route whose PTA specifies "BIER". This means that BIER is being used for one segment of a segmented P-tunnel. The ABR/ASBR may in turn need to originate an x-PMSI A-D route whose PTA identifies the next segment of the P-tunnel. The next segment may also be "BIER". Suppose an ABR/ASBR receives x-PMSI A-D routes R1 and R2, and as a result originates x-PMSI A-D routes R3 and R4 respectively, where the PTAs of each of the four routes specify BIER. Then the PTAs of R3 and R4 MUST NOT specify the same MPLS label.

The ABR/ASBR MUST then program its dataplane such that a packet arriving with the upstream-assigned label specified in route R1 is transmitted with the upstream-assigned label specified in route R3, and a packet arriving with the upstream-assigned label specified in route R2 is transmitted with the label specified in route R4. Of course, the data plane must also be programmed to encapsulate the transmitted packets with an appropriate BIER header, whose BitString is determined by the multicast flow overlay.

3. Multihoming Split Horizon

For EVPN-MPLS, [RFC7432] specifies the use of ESI labels to identify the ES from which a BUM packet originates. A PE receiving that packet from the core side will not forward it to the same ES. The procedure works for both Ingress Replication (IR) and RSVP-TE/mLDP P2MP tunnels, using downstream- and upstream-assigned ESI labels respectively. For EVPN-VXLAN/NVGRE, [I-D.ietf-bess-evpn-overlay] specifies local-bias procedures, where a PE receiving a BUM packet from the core side knows from encapsulation the ingress PE so it does not forward the packet to any multihoming ESes that the ingress PE is

on, because the ingress PE already forwarded the packet to those ESes, regardless of whether the ingress PE is a DF for those ESes.

With BIER, the local-bias procedure still applies for EVPN-VXLAN/NVGRE as the BFIR-id in the BIER header identifies the ingress PE. For EVPN-MPLS, ESI label procedures also still apply though two upstream assigned labels will be used (one for identifying the broadcast domain and one for identifying the ES) - the same as in the case of using a single P2MP tunnel for multiple broadcast domains. The BFIR-id in the BIER header identifies the ingress PE that assigned those two labels.

Details for split-horizon in case of segmentation will be provided in future revisions.

4. Data Plane

Similar to MVPN, the EVPN application plays the role of the "multicast flow overlay" as described in [I-D.ietf-bier-architecture].

4.1. Encapsulation and Transmission

To transmit a BUM data packet, an ingress PE first pushes the ESI label per [RFC7432] if the following conditions are all met:

- The packet is received on a multihomed ES.
- It's EVPN-MPLS.
- ESI label procedure is used for split-horizon.

It then finds the S-PMSI A-D route, or the SMET/IMET route that matches that packet. Any S-PMSI A-D route with a PTA specifying "no tunnel information" is ignored. If one ore more SMET routes are matched, the IMET route originated by the ingress PE for the broadcast domain is then located to obtain the PTA.

If the found S-PMSI A-D or the IMET route has a PTA specifying "BIER", and the ingress PE determines that BIER should be used (e.g., per procedures in [I-D.ietf-bess-evpn-igmp-mld-proxy] about interworking with PEs that do not support certain tunnel types), the (upstream-assigned) MPLS label from that PTA is pushed on the packet's label stack in case of EVPN-MPLS. In case of EVPN-VXLAN/NVGRE, a VXLAN/NVGRE header is prepended to the packet with the VNI/VSID set to the value in the PTA's label field and no IP/UDP header is used.

Then the packet is encapsulated in a BIER header and forwarded, according to the procedures of [I-D.ietf-bier-architecture] and [I-D.ietf-bier-mpls-encapsulation]. See especially Section 4, "Imposing and Processing the BIER Encapsulation", of [I-D.ietf-bier-mpls-encapsulation]. The "Proto" field in the BIER header is set to 2 in case of EVPN-MPLS or a value to be assigned in case of EVPN-VXLAN/NVGRE (Section 5).

In order to create the proper BIER header for a given packet, the BFIR must know all the BFERs that need to receive that packet. If SMET routes are matched, it determines all the BFERs from all the matching SMET routes in the broadcast domain.

If an S-PMSI route is matched, it determines all the BFERs by finding all the Leaf A-D routes that correspond to the S-PMSI A-D route that is the packet's match for transmission. There are two different cases to consider:

1 The S-PMSI A-D route that is the match for transmission carries a PTA that has the LIR flag set but does not have the LIR-pF flag set. In this case, the corresponding Leaf A-D routes are those whose "route key" field is identical to the NLRI of the S-PMSI A-D route.

2 The S-PMSI A-D route that is the match for transmission carries a PTA that has the LIR-pF flag. In this case, the corresponding Leaf A-D routes are those whose "route key" field is derived from the NLRI of the S-PMSI A-D route according to the procedures described in Section 5.2 of [EXPLICIT_TRACKING].

4.2. Disposition

The same procedures in section 3.2 of [I-D.ietf-bier-mvpn] are followed for EVPN-MPLS (text could be copied here). For EVPN-VXLAN/NVGRE, the only difference is that the payload is VXLAN/NVGRE and the VNI/VSID field in the VXLAN/NVGRE header is used to determine the corresponding mac VRF or broadcast domain.

4.2.1. At a BFER that is an Egress PE

Once the corresponding mac VRF or broadcast domain is determined from the upstream assigned label or VNI/VSID, EVPN forwarding procedures per [RFC7432] or [I-D.ietf-bess-evpn-overlay] are followed. In case of EVPN-MPLS, if there is an inner label in the label stack following the BIER header, that inner label is considered as the upstream assigned ESI label for split horizon purpose.

4.2.2. At a BFER that is a P-tunnel Segmentation Boundary

This is only applicable to EVPN-MPLS. The same procedures in Section 3.2.2 of [I-D.ietf-bier-mvpn] are followed, subject to multihoming considerations described in Section 3 of this document.

5. IANA Considerations

This document requests two assignments in "BIER Next Protocol Identifiers" registry, with the following two recommended values:

- 7: Payload is VXLAN encapsulated (no IP/UDP header)

- 8: Payload is NVGRE encapsulated (no IP header)

6. Security Considerations

To be updated.

7. Acknowledgements

The authors thank Eric Rosen for his review and suggestions. Additionally, much of the text is borrowed verbatim from [I-D.ietf-bier-mvpn].

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