

Workgroup: BIER

Internet-Draft: draft-ietf-bier-evpn-14

Published: 2 January 2024

Intended Status: Standards Track

Expires: 5 July 2024

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EVPN BUM Using BIER

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", "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.

Status of This Memo

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1. Introduction

[[RFC7432](#)] and [[RFC8365](#)] specify the protocols and procedures for Ethernet VPNs (EVPNs). For broadcast, unknown unicast and multicast (BUM) traffic, provider/underlay tunnels are used to carry the BUM traffic. Several kinds of tunnel technologies can be used as specified in [[RFC7432](#)] and [[RFC8365](#)], and this document specifies the protocols and procedures to use Bit Index Explicit Replication (BIER) [[RFC8279](#)] as provider tunnels for EVPN BUM traffic.

BIER 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 EVPN BUM procedures specified in [[RFC7432](#)] and extended in [[I-D.ietf-bess-evpn-bum-procedure-updates](#)], [[RFC9251](#)], and [[I-D.zhang-bess-mvpn-evpn-cmcast-enhancements](#)] are much aligned with Multicast VPN (MVPN) procedures [[RFC6514](#)] and an EVPN Broadcast Domain corresponds to a VPN in MVPN. As such, this document is also very much aligned with [[RFC8556](#)] that specifies MVPN with BIER. For terseness, some background, terms and concepts are not repeated here. Additionally, some text is borrowed verbatim from [[RFC8556](#)].

1.1. Terminologies

*ES: Ethernet Segment.

*ESI: Ethernet Segment Identifier.

*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 routable in a BIER domain.

*C-S: A multicast source address identifying a multicast source located at an EVPN customer site. "C-" stands for "Customer-".

*C-G: A multicast group address used by an EVPN 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 denoted 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 service providers used to transport C-flows. "P-" stands for "Provider-".

*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.

*PMSI [RFC6513]: Provider 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 - to all PEs in the same VPN.

*S-PMSI: Selective PMSI - to some of the PEs in the same VPN.

*I-PMSI A-D Route: Inclusive PMSI Auto-Discovery route used to advertise the tunnels that instantiate an I-PMSI.

*S-PMSI A-D route: Selective PMSI Auto-Discovery route used to advertise that particular C-flows are bound to (i.e., are traveling through) particular P-tunnels.

*PMSI Tunnel attribute (PTA): A BGP attribute used to identify a particular P-tunnel.

*VXLAN [RFC7348]: Virtual eXtensible Local Area Network.

*NVGRE [RFC7637]: Network Virtualization using Generic Routing Encapsulation.

*GENEVE [RFC8926]: Generic Network Virtualization Encapsulation.

*VNI: VXLAN Network Identifier.

*VSID: Virtual Subnet IDentifier.

*RSVP-P2MP [RFC4875]: Resource ReserVation Protocol for Point-to-Multipoint TE Label Switched Paths.

*mLDP-P2MP [RFC6388]: Label Distribution Protocol Extensions for Point-to-Multipoint and Multipoint-to-Multipoint Label Switched Paths.

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. [RFC8556] specifies the encoding of PTA for the use of BIER with MVPN. Much of that specification is reused for the use of BIER with EVPN and much of the text below is borrowed verbatim from [RFC8556].

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

*"Tunnel Type". The same codepoint 0x0B that IANA has assigned for BIER for MVPN [RFC8556] is used for EVPN as well.

*"Tunnel Identifier". This field contains three subfields for BIER. The text below is exactly as in [\[RFC8556\]](#).

- 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 Network Layer Reachability Information (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 a two-octet field containing the BFR-id, in the sub-domain identified in the first subfield, of the router that is constructing the PTA.
- 3 The third subfield is the BFR-Prefix (see [\[RFC8279\]](#)) 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.

The BFR-prefix need not be the same IP address that is carried in any other field of the x-PMSI A-D route, even if the BFIR is the originating router of the x-PMSI A-D route.

*"MPLS label". For EVPN-MPLS [\[RFC7432\]](#), this field contains an upstream-assigned MPLS label. It is assigned by the BFIR. Constraints on how the originating router selects this label are discussed in [Section 2.3](#). For EVPN-VXLAN/NVGRE/GENEVE [\[RFC8365\]](#) [\[RFC7348\]](#) [\[RFC7637\]](#) [\[RFC8926\]](#), 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 2.2](#).

- "Leaf Info Required per Flow (LIR-pF)" [\[RFC8534\]](#)

- "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, the distribution of these routes is controlled by the provisioning of Route Targets.

2.1. IP-Based Tunnel and BIER PHP

When VXLAN/NVGRE/GENEVE is used for EVPN, by default the outer IP header (and UDP header in the case of VXLAN/GENEVE) is not included in the BIER payload, except when it is known apriori that BIER Penultimate Hop Popping (PHP) [[I-D.ietf-bier-php](#)] is used in the BIER domain and the encapsulation (after the BIER header is popped) between the BIER Penultimate Hop and the egress PE does not have a way to indicate the next header is VXLAN/NVGRE/GENEVE. In that case the full VXLAN/NVGRE/GENEVE encapsulation MUST be used. In the outer IP header, a well-known IP multicast address (to be assigned by IANA) is used as the destination address and the egress PEs MUST be set up to receive and process packets addressed to the address. The address is used for all Broadcast Domains (BDs) and the inner VXLAN/NVGRE/GENEVE header will be used to identify BDs.

2.2. Explicit Tracking

When using BIER to transport an EVPN BUM data packet through a BIER domain, an ingress PE functions as a BFIR (see [[RFC8279](#)]). 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.

2.2.1. Using IMET/SMET routes

Both IMET and SMET routes provide explicit tracking functionality.

For an inclusive PMSI, the set of BFERs (egress PEs) includes the originators of all IMET routes for a broadcast domain. For a selective PMSI, the set of BFERs (egress PEs) 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 and without tunnel segmentation, SMET routes are used without the need for S-PMSI A-D routes. Otherwise, the procedures in the following section apply.

2.2.2. 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.

2.2.2.1. 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 Attachment

Circuits (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, in order 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 rules specified in Section 2.2.1 and Section 2.2.2 of [[RFC8556](#)] apply.

2.2.2.2. 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.

The rules specified in Section 2.2.1 of [[RFC8556](#)] apply. Section 2.2.2 of [[RFC8556](#)] does not apply, because like in MVPN, the LIR-pF flag cannot be used with segmentation.

2.2.2.3. Applicability of Additional MVPN Specifications

As with the MVPN case, Section "3. Use of the PMSI Tunnel Attribute in Leaf A-D routes" of [[RFC8556](#)] apply.

Notice that, [[RFC8556](#)] refers to procedures specified in [[RFC6625](#)] and [[RFC8534](#)]. Those two documents were specified for MVPN but apply to IP multicast payload in EVPN as well.

2.3. MPLS Label in PTA

Rules in section 2.1 of [[RFC8556](#)] apply, EXCEPT the following three bullets (they do NOT apply to EVPN) in that section:

- *If the two routes do not have the same Address Family Identifier (AFI) value, then their respective PTAs MUST contain different MPLS label values. This ensures that when an egress PE receives a data packet with the given label, the egress PE can infer from the label whether the payload is an IPv4 packet or an IPv6 packet.
- *If the BFIR is an ingress PE supporting MVPN extranet ([[RFC7900](#)]) functionality, and if the two routes originate from different VRFs on this ingress PE, then the respective PTAs of the two routes MUST contain different MPLS label values.

*If the BFIR is an ingress PE supporting the "Extranet Separation" feature of MVPN extranet (see Section 7.3 of [[RFC7900](#)]), and if one of the routes carries the "Extranet Separation" extended community but the other does not, then the respective PTAs of the two routes MUST contain different MPLS label values.

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/GENEVE, [[RFC8365](#)] specifies local bias procedures, with which 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. This is because the ingress PE already forwarded the packet to those ESes regardless of whether the ingress PE is a Designated Forwarder for those ESes.

With BIER, the local bias procedure still applies for EVPN-VXLAN/NVGRE/GENEVE 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.

4. Data Plane

Like MVPN, the EVPN application plays the role of the "multicast flow overlay" as described in [[RFC8279](#)].

4.1. Encapsulation and Transmission

A BFIR could be either an ingress PE or a P-tunnel segmentation point. The procedures are slightly different as described below.

4.1.1. At a BFIR that is an Ingress PE

To transmit a BUM data packet, an ingress PE first determines the route matched for transmission and routes for tracking leaves according to the following rules.

1. If selective forwarding is not used, or it is not an IP Multicast packet after the Ethernet header, the IMET route originated for the BD by the ingress PE is the route matched

for transmission. Leaf tracking routes are all other received IMET routes for the BD.

2. Otherwise, if selective forwarding is used for all IP Multicast traffic based on SMET routes, the IMET route originated for the BD by the ingress PE is the route matched for transmission. Received SMET routes for the BD whose source and destination address fields match the packet's source and destination IP address are leaf tracking routes.
3. Otherwise, the route matched for transmission is the S-PMSI A-D route originated by the ingress PE for the BD, whose source and destination address fields match the packet's source and destination IP address and has a PTA specifying a valid tunnel type that is not "no tunnel info". Leaf tracking routes are determined as follows:
 - 1) If the match for transmission route carries a PTA that has the LIR flag set but does not have the LIR-pF flag set, the routes matched for tracking are Leaf A-D routes whose "route key" field is identical to the NLRI of the S-PMSI A-D route.
 - 2) If the match for transmission route carries a PTA that has the LIR-pF flag, the leaf tracking routes are Leaf A-D routes 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 [[RFC8534](#)].

Note that in both cases, SMET routes may be used in lieu of Leaf A-D routes, as a PE may omit the Leaf A-D route in response to an S-PMSI A-D route with LIR or LIR-pF bit set, if an SMET route with the corresponding Tag, Source, and Group fields is already originated [[I-D.ietf-bess-evpn-bum-procedure-updates](#)]. In particular, in the second case above, even though the SMET route does not have a PTA attached, it is still considered a Leaf A-D route in response to a wildcard S-PMSI A-D route with the LIR-pF bit set.

4. Otherwise, the route matched for transmission and leaf tracking routes are determined as in rule [1](#).

If no route is matched for transmission, the packet is not forwarded onto a P-tunnel. If the tunnel that the ingress determines to use based on the route matched for transmission (and considering interworking with PEs that do not support certain tunnel types per procedures in [[RFC9251](#)]) requires leaf tracking (e.g. Ingress Replication, RSVP-TE P2MP tunnel, or BIER) but there are no leaf

tracking routes, the packet will not be forwarded onto a P-tunnel either.

The following text assumes that BIER is the determined tunnel type. The ingress PE pushes an upstream-assigned 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.

The MPLS label from the PTA of the route matched for transmission is then pushed onto the packet's label stack for EVPN-MPLS. For EVPN-VXLAN/NVGRE/GENEVE, a VXLAN/NVGRE/GENEVE header is prepended to the packet with the VNI/VSID set to the value in the PTA's label field, and then an IP/UDP header is prepended if needed (e.g. for PHP purpose).

Then the packet is encapsulated in a BIER header and forwarded, according to the procedures of [\[RFC8279\]](#) and [\[RFC8296\]](#). See especially Section 4, "Imposing and Processing the BIER Encapsulation", of [\[RFC8296\]](#). The "Proto" field in the BIER header is set to 2 in the case of EVPN-MPLS, or a value to be assigned in the case of EVPN-VXLAN/NVGRE/GENEVE ([Section 5](#)) when an IP header is not used, or 4/6 if an IP header is used for EVPN-VXLAN/NVGRE/GENEVE.

To create the proper BIER header for a given packet, the BFIR must know all the BFERS that need to receive that packet. This is determined from the set of leaf tracking routes.

4.1.2. At a BFIR that is a P-tunnel Segmentation Point

In this case, the encapsulation for the upstream segment of the P-tunnel includes (among other things) a label that identifies the x-PMSI or IMET A-D route that is the match for reception on the upstream segment. The segmentation point re-advertised the route into one or more downstream regions. Each instance of the re-advertised route for a downstream region has a PTA that specifies the tunnel for that region. For any particular downstream region, the route matched for transmission is the re-advertised route and the leaf tracking routes are determined as follows if needed for the tunnel type:

- *If the route matched for transmission is an x-PMSI route, it must have the LIR flag set in its PTA and the leaf tracking routes are all the matching Leaf A-D and SMET routes received in the downstream region.

*If the route matched for transmission is an IMET route, the leaf tracking routes are all the IMET routes for the same BD received in the downstream region.

If the downstream region uses BIER, the packet is forwarded as follows: the upstream segmentation's encapsulation is removed and the above-mentioned label is swapped to the upstream-assigned label in the PTA of the route matched for transmission, and then a BIER header is imposed as in [Section 4.1.1](#).

4.2. Disposition

The same procedures in section 4.2 of [[RFC8556](#)] are followed for EVPN-MPLS, except some EVPN specifics discussed in the following two sub-sections in this document.

For EVPN-VXLAN/NVGRE/GENEVE, the only difference is that the payload is VXLAN/NVGRE/GENEVE (with or without an IP header) and the VNI/VSID field in the VXLAN/NVGRE/GENEVE header is used to determine the corresponding broadcast domain.

4.2.1. At a BFER that is an Egress PE

Once the corresponding broadcast domain is determined from the upstream-assigned label or VNI/VSID, EVPN forwarding procedures per [[RFC7432](#)] or [[RFC8365](#)] are followed. In the case of EVPN-MPLS, if there is an inner label in the label stack following the BIER header, that inner label is considered the upstream-assigned ESI label for split horizon purpose.

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

This is only applicable to EVPN-MPLS. The same procedures in Section 4.2.2 of [[RFC8556](#)] are followed, subject to multihoming procedures specified in [[I-D.ietf-bess-evpn-bum-procedure-updates](#)].

5. IANA Considerations

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

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

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

*9: Payload is GENEVE encapsulated (no IP/UDP header)

This document requests assignments of an IPv4 and an IPv6 multicast address for the case discussed in [Section 2.1](#). Preferably this is assigned from the Local Network Control Block (224.0.0/24) for IPv4

and Link-Local Scope Multicast Addresses for IPv6. The description is "NVO BUM Traffic".

6. Security Considerations

This document is about using BIER as provider tunnels for EVPN. It is very similar to using BIER as MVPN provider tunnel, and does not introduce additional security implications beyond what have been discussed in EVPN base protocol specification [RFC7432] and MVPN using BIER [RFC8556].

7. Acknowledgements

The authors thank Eric Rosen for his review and suggestions. Additionally, much of the text is borrowed verbatim from [RFC8556].

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