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Bit Index Explicit Replication (BIER) Support via IS-IS

Abstract

This document defines IS-IS extensions to support multicast forwarding using the Bit Index Explicit Replication (BIER) architecture.

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/rfc8401.

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1. Introduction

Bit Index Explicit Replication (BIER) [RFC8279] defines an architecture where all intended multicast receivers are encoded as a bitmask in the multicast packet header within different encapsulations such as described in [RFC8296]. A router that receives such a packet will forward the packet based on the bit position in the packet header towards the receiver(s) following a precomputed tree for each of the bits in the packet. Each receiver is represented by a unique bit in the bitmask.

This document presents necessary extensions to the currently deployed IS-IS for IP [RFC1195] to support distribution of information necessary for operation of BIER domains and subdomains. This document defines a new TLV to be advertised by every router participating in BIER signaling.

This document defines support for MPLS encapsulation as specified in [RFC8296]. Support for other encapsulation types and the use of multiple encapsulation types are outside the scope of this document.

2. Terminology

Some of the terminology specified in [RFC8279] is replicated here and extended by necessary definitions:

BIER: Bit Index Explicit Replication. The overall architecture of forwarding multicast using a bit position.

BIER-OL: BIER Overlay Signaling. The method for the BFIR to learn about BFERs.

BFR: Bit Forwarding Router. A router that participates in Bit Index Multipoint Forwarding. A BFR is identified by a unique BFR-prefix in a BIER domain.

BFIR: Bit Forwarding Ingress Router. The ingress border router that inserts the BitString into the packet. Each BFIR must have a valid BFR-id assigned.

BFER: Bit Forwarding Egress Router. A router that participates in Bit Index Forwarding as a leaf. Each BFER must be a BFR. Each BFER must have a valid BFR-id assigned.

BFT: Bit Forwarding Tree used to reach all BFERs in a domain.

BIER subdomain: A further distinction within a BIER domain identified by its unique subdomain identifier. A BIER subdomain can support multiple BitString Lengths.

BFR-id: An optional, unique identifier for a BFR within a BIER subdomain.

Invalid BFR-id: Unassigned BFR-id. The special value 0 is reserved for this purpose.

BAR: BIER Algorithm. Used to calculate underlay next hops.

IPA: IGP Algorithm. May be used to modify, enhance, or replace the calculation of underlay paths as defined by the BAR value.

SPF: Shortest Path First routing calculation based on the IGP link metric.

2.1. 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.

3. IANA Considerations

This document adds the following entry to the "Sub-TLVs for TLVs 135, 235, 236, and 237" registry.

Value: 32

Name: BIER Info

This document also introduces a new registry for sub-sub-TLVs for the BIER Info sub-TLV. The registration policy is Expert Review as defined in [RFC8126]. The "Sub-sub-TLVs for BIER Info Sub-TLV" has been created within the "IS-IS TLV Codepoints" registry. The defined value is as follows:

Type	Name
1	BIER MPLS Encapsulation

IANA has created the "BIER Algorithms" registry within the "Bit Index Explicit Replication (BIER)" registry. The registration policies [RFC8126] for this registry are:

"Standards Action" for values 0-127

"Specification Required" for values 128-239

"Experimental Use" for values 240-254

The initial values in the "BIER Algorithms" registry are:

0: No BIER-specific algorithm is used

255: Reserved

4. Concepts

4.1. BIER Domains and Subdomains

An IS-IS-signaled BIER domain is aligned with the scope of distribution of BFR-prefixes that identify the BFRs within IS-IS. In such a case, IS-IS acts as the supporting BIER underlay.

Within such a domain, the extensions defined in this document advertise BIER information for one or more BIER subdomains. Each subdomain is uniquely identified by a subdomain-id (SD). Each subdomain is associated with a single IS-IS topology (MT) [RFC5120], which may be any of the topologies supported by IS-IS. Local configuration controls which <MT,SD> pairs are supported by a router. The mapping of subdomains to topologies MUST be consistent within the IS-IS flooding domain used to advertise BIER information.

Each BIER subdomain has as its unique attributes the encapsulation used and the type of tree it uses to forward BIER frames (currently always SPF). Additionally, per supported BitString length in the subdomain, each router will advertise the necessary label ranges to support it.

4.2. Advertising BIER Information

BIER information advertisements are associated with a new sub-TLV in the extended reachability TLVs. BIER information is always associated with a host prefix, which MUST be a node address for the advertising node. If this is not the case, the advertisement MUST be ignored. Therefore, the following restrictions apply:

- Prefix length MUST be 32 for an IPv4 prefix or 128 for an IPv6 prefix.
- When the Prefix Attributes Flags sub-TLV [RFC7794] is present, the N flag MUST be set and the R flag MUST NOT be set.
- BIER sub-TLVs MUST be included when a prefix reachability advertisement is leaked between levels.

5. Procedures

5.1. Multi-Topology and Subdomain

A given subdomain is supported within one and only one topology. All routers in the flooding scope of the BIER sub-TLVs MUST advertise the same subdomain within the same multi-topology. A router receiving an <MT,SD> advertisement that does not match the locally configured pair

MUST report a misconfiguration of the received <MT,SD> pair. All received BIER advertisements associated with the conflicting <MT,SD> pair MUST be ignored. Note that in the presence of such a misconfiguration, this will lead to partitioning of the subdomain.

Example:

The following combination of advertisements are valid: <0,0> <0,1>, and <2,2>.

The following combination of advertisements are invalid: <0,0> <0,1>, and <2,0>. Advertisements associated with <0,0> and <2,0> must be ignored.

5.2. BFR-id Advertisements

If a BFER/BFIR is configured with a BFR-id, then it advertises this value in its BIER advertisements. If no BFR-id is configured, then the value "Invalid BFR-id" is advertised. A valid BFR-id MUST be unique within the flooding scope of the BIER advertisements. All BFERs/BFIRs MUST detect advertisement of duplicate valid BFR-IDs for a given <MT,SD>. When such duplication is detected, all of the routers advertising duplicates MUST be treated as if they did not advertise a valid BFR-id. This implies they cannot act as BFER or BFIR in that <MT,SD>.

5.3. Logging Misconfiguration

Whenever an advertisement is received that violates any of the constraints defined in this document, the receiving router MUST support logging this occurrence. Logging SHOULD be dampened to avoid excessive output.

5.4. Flooding Reduction

It is expected that changes in the BIER domain information that is advertised by IS-IS occur infrequently. If this expectation is not met for an extended period of time (more than a few seconds of burstiness), changes will increase the number of Link State PDU (LSP) updates and negatively impact performance in the network. Implementations SHOULD protect against this possibility by, for example, dampening updates if they occur over an extended period of time.

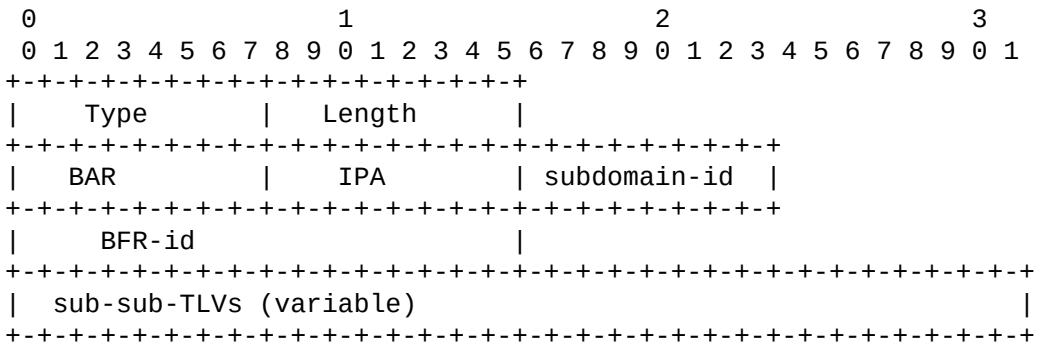
6. Packet Formats

All IS-IS BIER information is carried within the TLVs 235, 237, [RFC5120], 135 [RFC5305], or 236 [RFC5308].

6.1. BIER Info Sub-TLV

This sub-TLV carries the information for the BIER subdomains that the router participates in as a BFR. This sub-TLV MAY appear multiple times in a given prefix-reachability TLV -- once for each subdomain supported in the associated topology.

The sub-TLV advertises a single <MT,SD> combination followed by optional sub-sub-TLVs as described in the following sections.



Type: As indicated in the IANA section.

Length: Variable

BAR: BIER Algorithm. Specifies a BIER-specific algorithm used to calculate underlay paths to reach BFERs. Values are allocated from the "BIER Algorithms" registry. 1 octet.

IPA: IGP Algorithm. Specifies an IGP Algorithm to either modify, enhance, or replace the calculation of underlay paths to reach BFERs as defined by the BAR value. Values are from the IGP Algorithm registry. 1 octet.

subdomain-id: Unique value identifying the BIER subdomain. 1 octet.

BFR-id: A 2-octet field encoding the BFR-id, as documented in [RFC8279]. If no BFR-id has been assigned, the value of this field is set to "Invalid BFR-id", which is defined as illegal in [RFC8279].

The use of non-zero values in either the BAR field or the IPA field is outside the scope of this document. If an implementation does not support the use of non-zero values in these fields but receives a BIER Info sub-TLV containing non-zero values in these fields, it SHOULD treat the advertising router as incapable of supporting BIER (one way of handling incapable routers is documented in Section 6.9 of [RFC8279] and additional methods may be defined in the future).

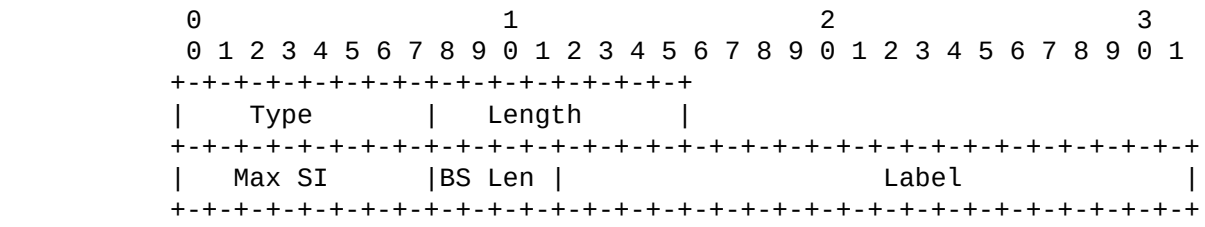
6.2. BIER MPLS Encapsulation Sub-sub-TLV

This sub-sub-TLV carries the information for the BIER MPLS encapsulation including the label range for a specific BitString length for a certain <MT,SD>. It is advertised within the BIER Info sub-TLV (Section 6.1). This sub-sub-TLV MAY appear multiple times within a single BIER Info sub-TLV.

If the same BitString length is repeated in multiple sub-sub-TLVs inside the same BIER Info sub-TLV, the BIER Info sub-TLV MUST be ignored.

Label ranges within all BIER MPLS Encapsulation sub-sub-TLVs across all BIER Info sub-TLVs advertised by the same BFR MUST NOT overlap. If overlap is detected, the advertising router MUST be treated as if it did not advertise any BIER sub-TLVs.

Label values MUST NOT match any of the reserved values defined in [RFC3032].



Type: Value of 1 indicating MPLS encapsulation.

Length: 4

Max SI: Maximum Set Identifier (Section 1 of [RFC8279]) used in the encapsulation for this BIER subdomain for this BitString length, 1 octet. Each SI maps to a single label in the label range. The first label is for SI=0, the second label is for SI=1, etc. If the label associated with the Maximum Set Identifier exceeds the 20-bit range, the sub-sub-TLV MUST be ignored.

Local BitString Length (BS Len): Encoded BitString length as per [RFC8296]. 4 bits.

Label: First label of the range, 20 bits. The labels are as defined in [RFC8296].

7. Security Considerations

Security concerns for IS-IS are addressed in [RFC5304] and [RFC5310].

The Security Considerations section of [RFC8279] discusses the possibility of performing a Denial-of-Service (DoS) attack by setting too many bits in the BitString of a BIER-encapsulated packet. However, this sort of DoS attack cannot be initiated by modifying the IS-IS BIER advertisements specified in this document. A BFIR decides which systems are to receive a BIER-encapsulated packet. In making this decision, it is not influenced by the IS-IS control messages. When creating the encapsulation, the BFIR sets one bit in the encapsulation for each destination system. The information in the IS-IS BIER advertisements is used to construct the forwarding tables that map each bit in the encapsulation into a set of next hops for the host that is identified by that bit, but it is not used by the BFIR to decide which bits to set. Hence, an attack on the IS-IS control plane cannot be used to cause this sort of DoS attack.

While a BIER-encapsulated packet is traversing the network, a BFR that receives a BIER-encapsulated packet with n bits set in its BitString may have to replicate the packet and forward multiple copies. However, a given bit will only be set in one copy of the packet. This means that each transmitted replica of a received packet has fewer bits set (i.e., is targeted to fewer destinations) than the received packet. This is an essential property of the BIER-forwarding process as defined in [RFC8279]. While a failure of this process might cause a DoS attack (as discussed in the Security Considerations of [RFC8279]), such a failure cannot be caused by an attack on the IS-IS control plane.

Further discussion of BIER-specific security considerations can be found in [RFC8279].

8. References

8.1. Normative References

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8.2. Informative References

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