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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:

o Prefix length MUST be 32 for an IPv4 prefix or 128 for an IPv6
   prefix.

o When the Prefix Attributes Flags sub-TLV [RFC7794] is present, the
   N flag MUST be set and the R flag MUST NOT be set.

o 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
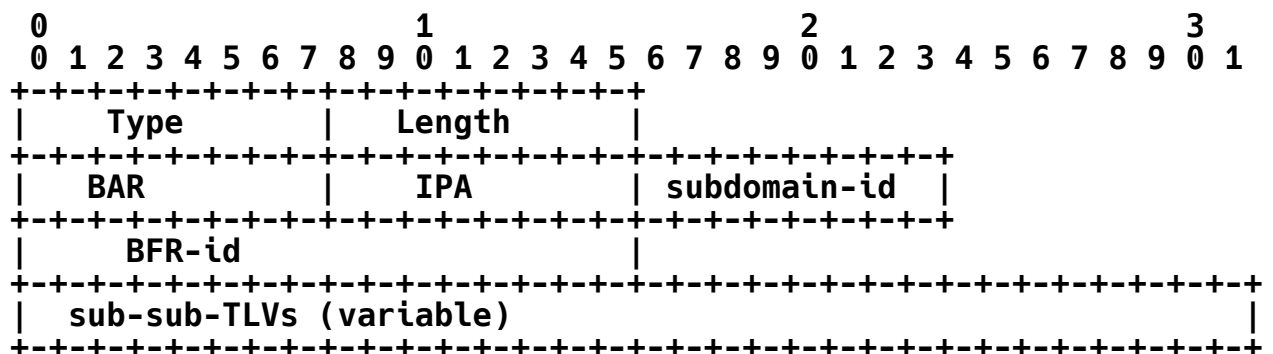time.

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.

```
        0                   1                   2                   3
        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       |     Type      |    Length     |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       |     BAR       |      IPA      |  subdomain-id |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       |     BFR-id                    |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
       |  sub-sub-TLVs (variable)                                     |
       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

   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).
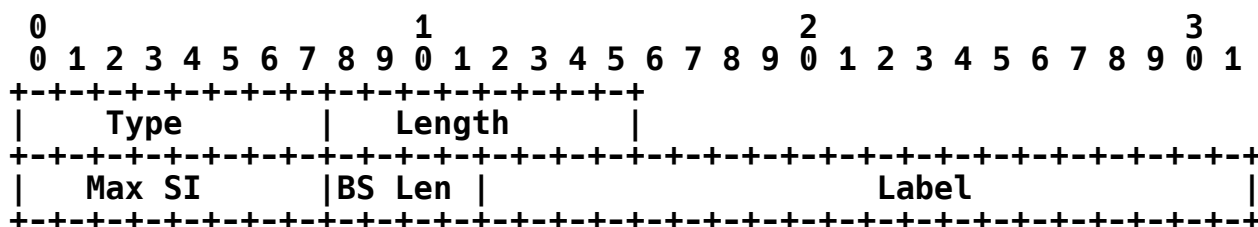
6.2. BIER MPLS Encapsulation Sub-sub-TLV

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].

```
     0                   1                   2                   3
     0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |     Type      |    Length     |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
    |    Max SI     |BS Len |                 Label                 |
    +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

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].

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