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### Encapsulation for BIER in Non-MPLS IPv6 Networks
#### draft-xie-bier-ipv6-encapsulation-00

Abstract

   This document proposes a BIER IPv6 (BIERv6) encapsulation for Non-
   MPLS IPv6 Networks using the IPv6 Destination Option extension
   header.

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] and
   [RFC8174].

Status of This Memo

   This Internet-Draft is submitted in full conformance with the
   provisions of BCP 78 and BCP 79.

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   Task Force (IETF).  Note that other groups may also distribute
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   time.  It is inappropriate to use Internet-Drafts as reference
   material or to cite them other than as "work in progress."

   This Internet-Draft will expire on September 9, 2019.

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## 1.  Introduction

   Bit Index Explicit Replication (BIER) [RFC8279] is an architecture
   that provides optimal multicast forwarding without requiring
   intermediate routers to maintain any per-flow state by using a
   multicast-specific BIER header.

   [RFC8296] defines a common BIER Header format for MPLS and Non-MPLS
   networks.  It has defined two types of encapsulation methods using
   the common BIER Header, (1) BIER encapsulation in MPLS networks,
   here-in after referred as MPLS BIER Header in this document and (2)
   BIER encapsulation in Non-MPLS networks, here-in after referred as
   Non-MPLS BIER Header in this document.  [RFC8296] also assigned

Ethertype=0xAB37 for Non-MPLS BIER Header packets to be directly
carried over the Ethernet links.

This document proposes a BIER IPv6 encapsulation for Non-MPLS IPv6
Networks, defining a method to carry the standard Non-MPLS BIER
header (as defined in [RFC8296]) in the native IPv6 header.  A new
IPv6 Option type - BIER Option is defined to encode the standard Non-
MPLS BIER header and this newly defined BIER Option is carried under
the Destination Options header of the native IPv6 Header [RFC8200].

This document details one of the proposed solutions for transporting
BIER packets in an IPv6 network.  To better understand the overall
BIER IPv6 problem space, use cases and proposed solutions, refer to
[I-D.mcbride-bier-ipv6-problem-statement].

## 2.  Terminology

Readers of this document are assumed to be familiar with the
terminology and concepts of the documents listed as Normative
References.

The following new terms are used throughout this document:

o  BIERv6 - BIER IPv6.

o  BIER Option - An Option type carried in IPv6 Destination Options
   Header which includes the standard Non-MPLS BIER Header.

o  BIERv6 Header - An IPv6 Header with BIER Option.

o  BIERv6 Packet - An IPv6 packet with BIERv6 Header.  Such an IPv6
   packet typically carries the user multicast payload and is
   forwarded by BFRs in the BIERv6 network towards the multicast
   receivers.

o  BIER Multicast Address - A well-known multicast address used as a
   Destination Address in the BIERv6 Header to forward the packets to
   other BFRs in BIERv6 network.

## 3.  BIER IPv6 Encapsulation

### 3.1.  BIER Option in IPv6 Destination Options Header

Destination Options Header and the Options that can be carried under
this extension header is defined in [RFC8200].  This document defines
a new Option type - BIER Option, to encode the Non-MPLS BIER header.
As specified in Section 4.2 [RFC8200], the BIER Option follows type-
length-value (TLV) encoding format and the standard Non-MPLS BIER

header [RFC8296] is encoded in the value portion of the BIER Option
TLV.

This BIER Option MUST be carried only inside the IPv6 Destination
Options header and MUST NOT be carried under the Hop-by-Hop Options
header.

Co-existence of Destination Options Header with BIER option TLV and
other IPv6 extension headers MUST confirm to the general requirements
defined in [RFC8200].  In addition to the requirements defined in
[RFC8200], this document requires that the Destination Options Header
with a BIER Option TLV MUST appear only after the Routing Header if
the Routing Header is present in the IPv6 Header.

The BIER Option is encoded in type-length-value (TLV) format as
follows:

```
 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
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
| Next Header  |  Hdr Ext Len  |  Option Type  | Option Length |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
~            Non-MPLS BIER Header (defined in RFC8296)          ~
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Next Header  8-bit selector.  Identifies the type of header
   immediately following the Destination Options header.

Hdr Ext Len  8-bit unsigned integer.  Length of the Destination
   Options header in 8-octet units, not including the first 8 octets.

Option Type  To be allocated by IANA.  See section 6.

Option Length  8-bit unsigned integer.  Length of the option, in
   octets, excluding the Option Type and Option Length fields.

Non-MPLS BIER Header  The Non-MPLS BIER Header defined in RFC8296.
   Fields in the Non-MPLS BIER Header MUST be encoded as below.


     BIFT-id: The BIFT-id is a domain-wide unique value in Non-MPLS
     IPv6 encapsulation.  See Section 2.2 of RFC 8296.

     TC: SHOULD be set to binary value 000 upon transmission and MUST
     be ignored upon.  See Section 2.2 of RFC 8296.

S bit: SHOULD be set to 1 upon transmission, and MUST be ignored upon reception.  See [Section 2.2 of RFC 8296](#).

TTL: MUST be set to 0 upon transmission, and MUST be ignored upon reception.  The function of TTL is replaced by the Hop Limit field in IPv6 header.

Nibble: SHOULD be set to 0000 upon transmission, and MUST be ignored upon reception.  See [Section 2.2 of RFC 8296](#).

Ver: MUST be set to 0 upon transmission, and MUST be discarded when it is not 0 upon reception.  See [Section 2.2 of RFC 8296](#).

BSL: See [Section 2.1.2 of RFC 8296](#).

Entropy: See [Section 2.1.2 of RFC 8296](#).

OAM: See [Section 2.1.2 of RFC 8296](#).

Rsv: See [Section 2.1.2 of RFC 8296](#).

DSCP: SHOULD be set to binary value 000000 upon transmission and MUST be ignored upon reception.  In IPv6 BIER encapsulation, uses highest 6-bit of Traffic Class field of IPv6 header to hold a Differentiated Services Codepoint [RFC2474].

Proto: SHOULD be set to 0 upon transmission and MUST be ignored upon reception.  In IPv6 BIER encapsulation, the functionality of this 6-bit Proto field is replaced by the Next Header field in Destination Options header, which is the last IPv6 extension header, to indicate the BIER payload, which is also IPv6 payload.

   For BIER Proto 1, indicating a Downstream-assigned MPLS payload, use Next Header value 139.

   For BIER Proto 2, indicating an Upstream-assigned MPLS payload, there is no Next Header code currently.  An upstream-assigned MPLS label within the context of special BFIR router, which in turn is represented by the BFIR-id and the Sub-domain indirectly indicated by the BIFT-id in a BIER-MPLS or BIER-ETH packet, can be replaced by an IPv6 source address in a BIER IPv6 encapsulation packet in a direct manner.  In this case, use Next Header value 4 for IPv4 payload, or value 41 for IPv6 payload.

For BIER Proto 3, indicating an Ethernet payload, use Next
Header value 97.

For BIER Proto 4, indicating an IPv4 payload, use Next Header
value 4.

For BIER Proto 5, indicating a BIER-OAM payload, use Next
Header value 58.  How the BIER-PING is supported with BIER
IPv6 encapsulation is outside the scope of this document.

For BIER Proto 6, indicating an IPv6 payload, use Next Header
value 41.

BFIR-id: See Section 2.1.2 of RFC 8296.

BitString: See Section 2.1.2 of RFC 8296.

## 3.2.  Multicast and Unicast Destination Address

BIER is generally a hop-by-hop and one-to-many architecture, and thus
the IPv6 Destination Address (DA) being a Multicast Address is a
proper approach for both the two paradigms in BIERv6 encapsulation.

This document proposes to use multicast address FF0X::AB37 (to be
allocated and reserved by IANA - See Section 6.2) as the IPv6
destination address for the BIERv6 packets to be forwarded in the
BIER domain.

All the interfaces of the BFRs supporting the BIERv6 encapsulation
defined in this document MUST subscribe and listen to BIER multicast
address FF0X::AB37 belong to scopes [1, 2, 3, 4, 5, E] defined in
[RFC7346].  However it is RECOMMENDED to use Realm-Local scope (scope
value 3), that is FF03:AB37 as a destination address while forwarding
the BIERv6 packet, as this scope zone is exactly the BIERv6 Domain.
The use of other scopes is outside the scope of this document.

Use of a Unicast Address as a IPv6 Destination Address is permissible
and useful in certain cases.

1.  Tunneling a BIERv6 packet over a non-BIER capable router.

2.  Fast rerouting a BIERv6 packet using a unicast by-pass tunnel.

3.  Forwarding a BIERv6 packet to one of the BFR neighbor connected
    on a shared-media LAN.

The unicast address used in BIERv6 packet targeting a BFR SHOULD be
the IPv6 BFR-Prefix advertised from this BFR.  When a BFR advertises

the BIER information with BIERv6 encapsulation capability, the IPv6
BFR-prefix of this BFR MUST be allowed using in BIERv6 packet.  All
the IPv6 BFR-Prefixes used in different sub-domains MUST all be
allowed using in BIERv6 packet.  BIERv6 packet with unicast address
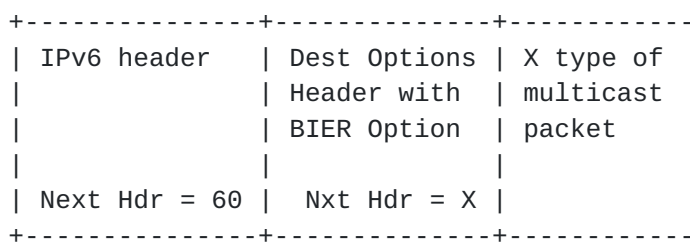other than the IPv6 BFR-Prefixes as destination address SHOULD be
dropped.

Compared to Multicast Destination Address, use of Unicast Destination
Address suffers from the additional cost of modification of
Destination Address at each hop of replication.  Implementations MUST
support use of Multicast Destination Address for BIERv6 packets and
is RECOMMENDED to be the default behavior to forward BIERv6 packets
to a directly connected BFR neighbor.

## 3.3.  BIERv6 Packet Format

As a multicast packet enters the BIER domain in a Non-MPLS IPv6
network, the multicast packet will be encapsulated with BIERv6
Header.

Typically a BIERv6 header would contain the Destination Options
Header as the only Extensions Header besides IPv6 Header.  However,
it is allowed and possible for other extension headers to appear
along with the Destination Options Header as long as the requirements
listed in section 3.1 of this document is met.  Scenarios where-in
the BFIR may encode other extension headers along with the
Destination Options header is outside the scope of this document.

Format of the multicast packet with BIERv6 encapsulation carrying
only the Destination Options header is depicted in the below figure.

```
+---------------+--------------+------------
| IPv6 header   | Dest Options | X type of
|               | Header with  | multicast
|               | BIER Option  | packet
|               |              |
| Next Hdr = 60 |  Nxt Hdr = X |
+---------------+--------------+------------
```

Format of the multicast packet with BIERv6 encapsulation carrying
other extension headers along with Destination Options extension
header is depicted in the below figure.

```
+---------------+-------------+-------------+-----------
|  IPv6 header  | Y Extension | Dest Options | X type of
|               |    Header   | Header with  | multicast
|               |             | BIER Option  | packet
|               |             |              |
| Next Hdr = Y  | Nxt Hdr = 60 | Next Hdr = X |
+---------------+-------------+-------------+-----------
```

Source Address field in the IPv6 header MUST be a routable IPv6
unicast address of the BFIR in any case.

BFIR encodes the Non-MPLS BIER header in the above mentioned
encapsulation format and forwards the BIERv6 packet to the nexthop
BFR following the local BIFT table.

BFRs in the IPv6 network, processes and replicates the packets
towards the BFERs using the local BIFT table.  The bit-string field
in the Non-MPLS BIER header may be changed by the BFRs as they
replicate the packet.  BFRs MUST follow the procedures defined in
section 3.1 as they modify the other fields in the Non-MPLS BIER
header.  The source address in the IPv6 header MUST NOT be modified
by the BFRs.

## 4.  BIERv6 Packet Processing

There is no BIER-specific processing, and all the 8 steps in section
6.5 of RFC8279 apply to BIERv6 packet processing.  However, there are
some IPv6-specific processing procedures due to the base and general
procedures of IPv6.

On the overlay layer, when a multicast packet enters the BIER domain
in a Non-MPLS IPv6 network, the Ingress BFR (BFIR) encapsulates the
multicast packet with a BIERv6 Header, transforming it to a BIERv6
packet.  The BIERv6 header includes an IPv6 header and IPv6
Destination Options Header within a standard Non-MPLS BIER header.
Source Address field in the IPv6 header MUST be set to a routable
IPv6 unicast address of the BFIR.  Destination Address field in the
IPv6 header is set to a BIER multicast address, FF0X::AB37, if the
next-hop BFR is directly connected, or MAY be set to a unicast
address in case of the scenarios discussed in section 3.2.

On the BIER layer, upon receiving an BIERv6 packet, the BFR processes
the IPv6 header first.  This is the general procedure of IPv6.

If the IPv6 Destination address is the BIER multicast address, a
'BIER valid' flag will be obtained by the preceding Multicast DA
lookup.  The BIER option, if exists, will be checked to decide which

neighbor(s) to replicate the BIERv6 packet to.  If the BIER option does not exist, the packet MUST be dropped.

If the IPv6 Destination address is a multicast address other than the BIER multicast address, a 'BIER valid' flag will not be obtained by the preceding Multicast DA lookup.  If the BIER option exist, the packet MUST be dropped.

If the IPv6 Destination address is an IPv6 BFR-Prefix unicast address of this BFR, a 'BIER valid' flag will be obtained by the preceding Unicast DA lookup.  The BIER option, if exists, will be checked to decide which neighbor(s) to replicate the BIERv6 packet to.  If the BIER option does not exist, the normal unicast forwarding applies.

If the IPv6 Destination address is a unicast address other than the IPv6 BFR-Prefix unicast address(es) of this BFR, a 'BIER valid' flag will not be obtained by the preceding Unicast DA lookup.  If the BIER option exist, the packet MUST be dropped.

The Hop Limit field of IPv6 header MUST decrease by 1 when sending packets to a BFR neighbor, while the TTL in the BIER header MUST be unchanged.

The BitString in the BIER header in the Destination Options Header may change when sending packets to a neighbor.  Such change of BitString MUST be aligned with the procedure defined in RFC8279. Because of the requirement to change the content of the option when forwarding BIERv6 packet, the BIER option type should have chg flag 1 per section 4.2 of RFC8200.

The procedures applies normally if a bit corresponding to the self bfr-id is set in the bit-string field of the Non-MPLS BIER header of the BIERv6 packet.  The node is considered to be an Egress BFR (BFER) in this case.  The BFER removes the BIERv6 header, including the IPv6 header and the Destination Options header, and copies the packet to the multicast flow overlay.  The egress VRF of a packet may be determined by a single MFIB lookup on the BFER using both the IPv6 SA and IPv6 DA.

## 5.  Security Considerations

A BIERv6 packet with a special IPv6 Destination Address, either multicast or unicast, would be processed by BIER forwarding procedure only when the 'BIER valid' flag has been obtained ahead of time in the normal MFIB or FIB lookup of the IPv6 header.  Otherwise the packet with an IPv6 BIER Option will be dropped, as if the Option is not recognize by the node.

An IPv6 packet with BIER multicast address FF0X::AB37 as destination
address, but does not carry IPv6 BIER Option will be dropped.

## 6.  IANA Considerations

## 6.1.  BIER Option Type

Allocation is expected from IANA for a BIER Option Type codepoint
from the "Destination Options and Hop-by-Hop Options" sub-registry of
the "Internet Protocol Version 6 (IPv6) Parameters" registry.  The
value 0x70 is suggested.

```
+-----------+-----+-----+-------+------------+------------+
| Hex Value | act | chg | rest  | Description | Reference  |
+-----------+-----+-----+-------+------------+------------+
|    0x70   | 01  |  1  | 10000 | BIER Option | This draft |
+-----------+-----+-----+-------+------------+------------+
```

Figure 1: IPv6 Option Type Suggested

## 6.2.  BIER Multicast Address

Allocation is expected from IANA for a BIER Multicast Address from
the "Variable Scope Multicast Addresses" sub-registry of the "IPv6
Multicast Address Space Registry" registry.  The address 'FF0X::AB37'
is suggested.

```
+-----------------------+--------------------+------------+
|      Address(es)      |    Description     | Reference  |
|                       |                    |            |
+-----------------------+--------------------+------------+
| FF0X:0:0:0:0:0:0:AB37 | ALL_BIER_FORWARDERS | This draft |
+-----------------------+--------------------+------------+
```

Figure 2: Multicast Address Suggested

## 7.  Acknowledgements

The authors would like to thank Stig Venaas for his valuable
comments.

## 8.  References

## 8.1.  Normative References

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