An IPv6 based BIER Encapsulation and Encoding  
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Abstract

This document specifies the packet format and procedures for transporting IPv6 payloads to multiple IPv6 destinations using the Bit Index Explicit Replication (BIER). The BIER BitString is stored within the low-order bits of the IPv6 destination address while the high-order bits are used for unicast forwarding before entering the destination BIER domain, identifying whether a packet is a BIER packet, the destination Sub-Domain, the Set Identifier and the BitString length.

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1. Introduction

The Bit Index Explicit Replication (BIER - [I-D.ietf-bier-architecture]) forwarding technique enables IP multicast transport across a BIER domain. Its architecture is based on three different layers, a multicast flow overlay, a BIER Layer, and a routing underlay. This document specifies the packet format and procedures enabling IPv6 payload transport to multiple destinations, hence defining the transport part of a BIER layer.

BIER BitString is encoded in the low-order bits of the IPv6 destination address of each packet. The high-order bits of the IPv6 destination address are used by intermediate routers for unicast forwarding, deciding whether a packet is a BIER packet, and if so, to identify the BIER Sub-Domain, Set Identifier and BitString length.

Transported payloads can be of various types such as IPv6 or IPv4, unicast or multicast (e.g. using generic packet tunnelling [RFC2473]), or transported data (e.g. using UDP). Any data that can be used as payload to an IPv6 packet can be encapsulated, but special care must be taken when forwarding some types of payloads. For example, the UDP checksum may become invalid as the BIER BitString is modified.

This technique is an alternative to the MPLS encapsulation [I-D.ietf-bier-mpls-encapsulation]. It may be appropriate when deploying an MPLS network is not an option, e.g., in some data centers, or in home networks [RFC7368]. It also offers some
interesting properties with regard to host compatibility (see Section 6).

2. Terminology

In this document, the key words "MAY", "MUST", "MUST NOT", "RECOMMENDED", and "SHOULD", are to be interpreted as described in [RFC2119].

3. IPv6 BIER Packet Format

Payload to be sent to multiple destinations is encapsulated within an IPv6 packet with no additional extension or encapsulation header. Information required by BIER to operate is stored in the destination IP address of the IPv6 header. The BIER BitString is encoded in the low-order bits of the IPv6 destination address of the packet while the high-order bits are used by intermediate BIER routers to identify that the forwarded packet is an IPv6 BIER packet, its BIER sub-domain, its associated BIER Set Identifier, and the BitString length.

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+---------------------------------------------------------+
|         p bits             |         128-p bits         |
|---------------------------------------------------------|
|     BIER IPv6 Prefix       |       BitString bits       |
+---------------------------------------------------------+
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Figure 1: IPv6 BIER destination address format

BIER IPv6 Prefix: This is a prefix used for BIER forwarding within the domain. BIER routers will consider all packets sent to this prefix as an IPv6 BIER packets. Each BIER IPv6 Prefix is associated with a Sub-Domain, a Set Identifier, and a BitString length.

BitString bits: These bits are used to encode the BIER BitString. It encodes the set of BFERs the packet should be sent to. Those bits are modified as the packet is replicated by intermediate BIER routers.

The mapping between a BIER IPv6 Prefix and the BIER parameters may be implemented using either algorithmic mapping (e.g., by including the Sub-Domain and the Set Identifier in the low-order bits of the prefix), by using a binding table (e.g., by associated each prefix with configuration parameters), or using a combination of the two. Although an algorithmic mapping might be advantageous in certain scenarios, only the binding table model can interoperate with any other operating mode. Therefore, implementations SHOULD support the binding table model (in order to interoperate with any other operating modes), and MAY provide other operating modes too.
4. Multicast Flow Overlay Operations

When a multicast packet enters the BIER domain, the BFIR first consults the multicast flow overlay and obtains the Sub-Domain Identifier and the set of BFERs the packet must be sent to. This set is used in order to compute the set of bit indexes representing the set of destination BFERs. All indexes that have the same Set Identifier are grouped in order to create a set of BitStrings associated with their respective SI. For each SI, the multicast packet is encapsulated within an IPv6 BIER packet, as specified in Section 3.

The same process is used when a given IPv6 payload is sent to a set of destinations. But instead of encapsulating the packet, the payload is attached to the BIER IPv6 header and the IPv6 protocol number is set to the type of the payload.

5. Bier Layer Forwarding Operations

Each BIER IPv6 Prefix is inserted in the IPv6 FIB. When a packet is received, a longest prefix match is performed on the destination IPv6 address. If the result of the lookup returns a BIER entry, the BIER Sub-Domain, Set Identifier and BitString length are retrieved. The packet is then processed according to the BIER forwarding algorithm. For each replicated packet, the BitString, included in the IPv6 destination address is modified and the packet is sent on the outgoing interface.

It is worth noting that this algorithm may interact with unicast forwarding. For example, BIER IPv6 Prefixes corresponding to a sub-domain in which a BIER router is not included in MAY be implemented as a unicast forwarding FIB entry.

6. Applicability Statement

The technique described in this document enables transport of IPv6 payloads towards multiple destinations using BIER. The information required by BIER is stored in the destination IPv6 address. In particular, the length of the BIER BitString is limited by the prefix length assigned to BIER forwarding. For example, lengths from 16 to 72 could be used while lengths of 128 or greater are impractical. Therefore, this proposal does not comply with the current version of the BIER architecture document [I-D.ietf-bier-architecture] which mandates fixed, power of 2, values from 64 to 4096, with a minimal supported value of 256. It appears to the authors that such values depend on the underlying technology that is used. In particular, mandated values seem to fit MPLS [I-D.ietf-bier-mpls-encapsulation] requirements, but may be impractical in other scenarios.
Past the BitString length limitation, this proposal offers different advantages:

BIER IPv6 packets are not different from IPv6 unicast packets. If the BIER IPv6 Prefix is a globally unique IPv6 prefix, reachable from outside the BIER domain, it is possible to send a packet from outside the BIER domain to multiple destinations within the BIER domain.

It may be used for transporting IP multicast packets, but also for sending IP payloads directly to multiple destinations.

It does not rely on a new IPv6 extension header, which simplifies deployment and is likely to improve performances.

It is possible to configure a host with an address which corresponds to a BIER address with a single bit set. From the host perspective, such address is not different from a unicast IPv6 address. Which means a BIER-unaware host may receive BIER packets transparently. As an example, if multicast traffic is being transported over BIER using standard IP-in-IPv6 encapsulation, an end-host could behave as tunnel end-point for this traffic without requiring any BIER specific configuration.

Finally, it is worth mentioning that this proposal relies on routers modifying the IPv6 destination address from IPv6 packets. Just like other BIER encapsulations, this technique will likely require the development of specific monitoring tools and techniques.

7. Security Considerations

This technique allows IPv6 BIER packets to be sent across the internet toward multiple destination located in a given BIER domain. If this is considered a threat, a firewall at the entrance of the BIER domain in order to avoid BIER packets from being injected and replicated within the network.

8. IANA Considerations

This specification does not require any action from IANA.

9. References

9.1. Normative References

9.2. Informative References


Appendix A. Acknowledgements

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