

6lo  
Internet-Draft  
Intended status: Standards Track  
Expires: January 25, 2018

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July 24, 2017

A 6loRH for BitStrings  
draft-thubert-6lo-bier-dispatch-03

## Abstract

This specification extends the 6LoWPAN Routing Header to signal BitStrings such as utilized in Bit Index Explicit Replication and its Traffic Engineering variant.

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## [1.](#) Introduction

The type of information that needs to be present in a packet inside the LLN but not outside of the LLN varies with the routing operation, but there is overall a need for an extensible compression technique that would simplify the IP-in-IP encapsulation, when needed, and optimally compress existing routing artifacts found in LLNs.

The 6LoWPAN Routing Header (6LoRH) [[RFC8025](#)] [[RFC8138](#)] is such a technique, that extends the 6lo adaptation layer framework [[RFC4944](#)], [[RFC6282](#)] so as to carry routing information for Route-over use cases. The original specification includes the formats necessary for RPL such as the Source Route Header (SRH) and is intended to be extended for additional routing artifacts.

The Bit Index Explicit Replication (BIER), as introduced in the BIER Architecture [[I-D.ietf-bier-architecture](#)], can be used as an alternate artifact to route multicast as well as unicast traffic. The Traffic Engineering for Bit Index Explicit Replication [[I-D.eckert-bier-te-arch](#)] (BIER-TE) adds support for traffic engineering by explicit hop-by-hop forwarding and loose hop forwarding of packets along a unicast route.

This specification provides additional formats for the 6LoRH compression to carry BitStrings such as used for Bit Index Explicit Replication and its Traffic Engineering variant (BIER and BIER-TE, respectively).

## [2.](#) Terminology

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 [\[RFC2119\]](#).

The Terminology used in this document is consistent with and incorporates that described in Terms Used in Routing for Low-Power and Lossy Networks (LLNs). [\[RFC7102\]](#).

Other terms in use in LLNs are found in Terminology for Constrained-Node Networks [\[RFC7228\]](#).

The term "byte" is used in its now customary sense as a synonym for "octet".

"RPL", "RPL Packet Information" (RPI) and "RPL Instance" are defined in the RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks [\[RFC6550\]](#) specification.

The terms Bit-Forwarding Egress Routers (BFR), BFR-id and BitString are defined in [\[I-D.ietf-bier-architecture\]](#). A BitString indicates a continuous sequence of bits indexed by an offset in the sequence. The leftmost bit is bit 0 and corresponds to the value 0x80 of the leftmost octet in the BitString.

## [3.](#) Applicability

BIER and other bit-indexed methods that would leverage BitStrings will generally require additional information in the packet to complement the BitString. For instance, BIER has the concept of a BFR-id and an Entropy value in the BIER header. Since those additional fields depend on the bit-indexed method, they are expected to be transported separately from the BitString. This specification concentrates on the BitString alone.

Within the context of "the Deterministic Networking (DetNet) Architecture" [[I-D.ietf-detnet-architecture](#) ]), the "BIER-TE-based OAM, Replication and Elimination" [[I-D.thubert-bier-replication-elimination](#)] document details how BIER-TE can be leveraged to activate the Deterministic Networking Replication and Elimination functions in a manner that is abstract to the data plane forwarding information. An adjacency, which is represented by a bit in the BIER header, can be mapped in the data plane to an Ethernet hop, a Label Switched Path, or it may correspond to a loose or a strict IPv6 Source Routed Path.

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In the context of LLNs, the 6TiSCH Architecture [[I-D.ietf-6tisch-architecture](#)] introduces the concept of a Track that is a directional traffic-engineered path between a source and a destination. A Track is indicated in a packet by a Source or Destination IPv6 Address and a RPL Local Instance. The RPL Instance is carried in an IPv6 packet as part of the RPL Packet Information (RPI), and a bit in the RPI indicates whether the Instance is Local to the Source or the Destination Address. The RPI can be compressed as a RPI 6LoRH header (RPI-6LoRH) as described in [[RFC8138](#)].

The 6TiSCH requirements for DetNet [[I-D.thubert-6tisch-4detnet](#)] indicate that a 6TiSCH Track may leverage replication and elimination as defined in DetNet. This specification enables this behavior as follows: if a BIER-6LoRH is positioned right after a RPI-6LoRH, then the BitString in the BIER-6LoRH applies to the context of the Track indicated by the source or destination address of the packet and the local Instance ID associated to the source or destination of the packet.

#### [4.](#) The BIER-6LoRH encoding

The BIER 6LoRH (BIER-6LoRH) is a Critical 6LoWPAN Routing Header that provides a variable-size container for a BitString such as, a but not limited to, a BIER BitString.

The capability to parse the BIER BitString is necessary to forward the packet so the Type cannot be ignored.



In the case of a Bloom Filter, a number of Hash functions must be run to obtain a multi-bit signature of an encoded element. This specification uses the 5-bits Control field to signal an Identifier of the set of Hash functions being used to generate a certain BitString, so as to enable the migration from a set of Hash functions to the next.

#### 4.3. Types of BIER-6LoRH header

The Type of a BIER-6LoRH header indicates the size of words used to build the BitString and whether the BitString is operated as an uncompressed bit-by-bit mapping, or as a Bloom filter.

Type	Encoding	Control field	BitString Size
15	bit-by-bit	Group ID	8 bits
16	bit-by-bit	Group ID	16 bits
17	bit-by-bit	Group ID	32 bits
18	bit-by-bit	Group ID	64 bits
19	bit-by-bit	Group ID	128 bits
20	Bloom filter	Hash function Set ID	8 bits
21	Bloom filter	Hash function Set ID	16 bits
22	Bloom filter	Hash function Set ID	32 bits
23	Bloom filter	Hash function Set ID	64 bits
24	Bloom filter	Hash function Set ID	128 bits

Figure 2: The BIER-6LoRH Types

In order to address a potentially large number of devices, the BitString may grow very large. Yet, the maximum frame size for a given MAC layer may limit the number of bits that can be dedicated to routing. With this specification, a number of BIER-6LoRH headers of a same type (bit-by-bit or Bloom filter) may be placed contiguously in the packet. This results in a larger BitString that is the concatenation of the BitStrings in the individual headers in the order they are appearing in the packet.

## 5. Implementation Status

A research-stage implementation was developed at Cisco's Paris Innovation Lab (PIRL) by Zacharie Brodard. It was implemented on OpenWSN open-source firmware and tested on the OpenMote-CC2538 hardware. It implements the header types 15, 16, 17, 18 and 19 (bit-by-bit encoding without group ID) in order to allow a BIER-TE protocol over IEE802.15.4e.

Links:

github: <https://github.com/zach-b/openwsn-fw/tree/BIER>

OpenWSN firmware: <https://openwsn.atlassian.net/wiki/pages/viewpage.action?pageId=688187>

OpenMote hardware: <http://www.openmote.com/>

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## 6. Security Considerations

The security considerations of [\[RFC8138\]](#) apply.

## 7. IANA Considerations

This document extends the IANA registry created by [\[RFC8138\]](#) for the 6LoWPAN Routing Header Type, and adds the following values:

[8.](#) Acknowledgments

[9.](#) References

[9.1.](#) Normative References

- [RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", [BCP 14](#), [RFC 2119](#), DOI 10.17487/RFC2119, March 1997, <<http://www.rfc-editor.org/info/rfc2119>>.
- [RFC4944] Montenegro, G., Kushalnagar, N., Hui, J., and D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", [RFC 4944](#), DOI 10.17487/RFC4944, September 2007, <<http://www.rfc-editor.org/info/rfc4944>>.
- [RFC6550] Winter, T., Ed., Thubert, P., Ed., Brandt, A., Hui, J., Kelsey, R., Levis, P., Pister, K., Struik, R., Vasseur, JP., and R. Alexander, "RPL: IPv6 Routing Protocol for Low-Power and Lossy Networks", [RFC 6550](#), DOI 10.17487/RFC6550, March 2012, <<http://www.rfc-editor.org/info/rfc6550>>.
- [RFC8025] Thubert, P., Ed. and R. Cragie, "IPv6 over Low-Power Wireless Personal Area Network (6LoWPAN) Paging Dispatch", [RFC 8025](#), DOI 10.17487/RFC8025, November 2016, <<http://www.rfc-editor.org/info/rfc8025>>.
- [RFC8138] Thubert, P., Ed., Bormann, C., Toutain, L., and R. Cragie, "IPv6 over Low-Power Wireless Personal Area Network (6LoWPAN) Routing Header", [RFC 8138](#), DOI 10.17487/RFC8138, April 2017, <<http://www.rfc-editor.org/info/rfc8138>>.

[9.2.](#) Informative References



- [I-D.bergmann-bier-ccast]  
Bergmann, O., Bormann, C., Gerdes, S., and H. Chen, "Constrained-Cast: Source-Routed Multicast for RPL", [draft-bergmann-bier-ccast-02](#) (work in progress), October 2016.
- [I-D.eckert-bier-te-arch]  
Eckert, T., Cauchie, G., Braun, W., and M. Menth, "Traffic Engineering for Bit Index Explicit Replication BIER-TE", [draft-eckert-bier-te-arch-05](#) (work in progress), June 2017.
- [I-D.ietf-6tisch-architecture]  
Thubert, P., "An Architecture for IPv6 over the TSCH mode of IEEE 802.15.4", [draft-ietf-6tisch-architecture-11](#) (work in progress), January 2017.
- [I-D.ietf-bier-architecture]  
Wijnands, I., Rosen, E., Dolganow, A., Przygienda, T., and S. Aldrin, "Multicast using Bit Index Explicit Replication", [draft-ietf-bier-architecture-07](#) (work in progress), June 2017.
- [I-D.ietf-detnet-architecture]  
Finn, N., Thubert, P., Varga, B., and J. Farkas, "Deterministic Networking Architecture", [draft-ietf-detnet-architecture-02](#) (work in progress), June 2017.
- [I-D.thubert-6tisch-4detnet]  
Thubert, P., "6TiSCH requirements for DetNet", [draft-thubert-6tisch-4detnet-01](#) (work in progress), June 2015.
- [I-D.thubert-bier-replication-elimination]  
Thubert, P., Brodard, Z., and H. Jiang, "BIER-TE-based OAM, Replication and Elimination", [draft-thubert-bier-replication-elimination-00](#) (work in progress), September 2016.
- [RFC6282] Hui, J., Ed. and P. Thubert, "Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks", [RFC 6282](#), DOI 10.17487/RFC6282, September 2011, <<http://www.rfc-editor.org/info/rfc6282>>.
- [RFC7102] Vasseur, JP., "Terms Used in Routing for Low-Power and Lossy Networks", [RFC 7102](#), DOI 10.17487/RFC7102, January 2014, <<http://www.rfc-editor.org/info/rfc7102>>.

[RFC7228] Bormann, C., Ersue, M., and A. Keranen, "Terminology for Constrained-Node Networks", [RFC 7228](#), DOI 10.17487/RFC7228, May 2014, <<http://www.rfc-editor.org/info/rfc7228>>.

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