6lo working group
Internet-Draft
Intended status: Standards Track
Expires: April 15, 2015

C. Bormann
Universitaet Bremen TZI

October 12, 2014

NHC compression for RPL Packet Information
draft-bormann-6lo-rpl-mesh-02

Abstract

This short draft provides a straw man for the RPL Packet Information (RPI) NHC compression, a method to compress RPL Option [RFC6553] information within 6lowpan-style ("6lo") adaptation layers.

Status of This Memo

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

Internet-Drafts are working documents of the Internet Engineering Task Force (IETF). Note that other groups may also distribute working documents as Internet-Drafts. The list of current Internet-Drafts is at http://datatracker.ietf.org/drafts/current/.

Internet-Drafts are draft documents valid for a maximum of six months and may be updated, replaced, or obsoleted by other documents at any 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 April 15, 2015.

Table of Contents

1. Introduction

[I-D.thubert-6man-flow-label-for-rpl] defines a way to compress information from the [RFC6553] RPL Option, for inclusion in an IPv6 flow label. The present draft shows how to carry the same information in a RPL Packet Information (RPI) NHC compression header, without consuming a lot of the code space for NHC headers.

The RPL Packet Information is added to the 6lo adaptation layer framework ([RFC4944], [RFC6282]) as a small number of additional NHC compression codes.

(More background information in Section 6.)

1.1. Terminology

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 RFC 2119 [RFC2119].

2. The NHC escape mechanism

The NHC space of [RFC6282] is limited to 256 code points. For the case some infrequent bit combinations do not fit into the 256 code points, this specification assigns four code points:

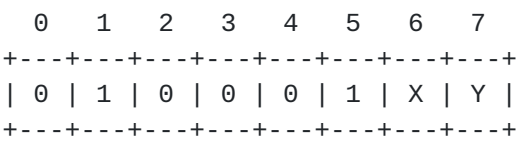


Figure 1: NHC Escape Codes

Each NHC escape code is followed by a further NHC code point. The latter MUST be a code point for which special semantics for a preceding escape code are defined, i.e., an escape code MUST NOT be used in front of an NHC code point that does not define special semantics for this escape code.

An escape code followed by another escape code supplies additional semantics; again, a sequence of such escape codes MUST NOT be used unless the final NHC code following this sequence defines the semantics for the specific sequence.

3. RPI_NHC Encoding

[RFC6550] section 11.2 specifies the RPL Packet Information (RPI) as a set of fields that are to be added to the IP packets for the purpose of Instance Identification, as well as Loop Avoidance and Detection.

[RFC6553] defines an encoding for the RPI as a RPL option located in the IPv6 Hop-by-hop Header.

The present NHC compression mechanism compresses IPv6 Hop-by-hop Headers that contain only that RPL option.

The fields in the RPI include an 'O', an 'R', and an 'F' bit, a 8-bit RPLInstanceID (with some internal structure), and a 16-bit SenderRank.

The SenderRank is the result of the DAGRank operation on the rank of the sender, here the DAGRank operation is defined in section 3.5.1 as:

DAGRank(rank) = floor(rank/MinHopRankIncrease)

If MinHopRankIncrease is set to a multiple of 256, it appears that the least significant 8 bits of the SenderRank will be all zeroes and can be elided, in which case the SenderRank can be compressed into one byte. This idea is used in [RFC6550] by defining DEFAULT_MIN_HOP_RANK_INCREASE as 256. The RPI_NHC provides a compressed form for the RPI and is constructed as follows:

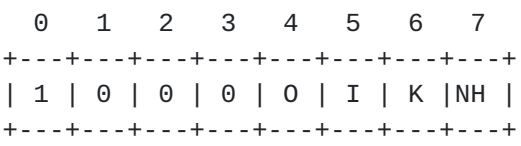


Figure 2: RPI NHC

The RPL_NHC is immediately followed by the RPLInstanceID, unless it is elided, and then the SenderRank, which is either compressed into one byte or fully inlined as the whole 2 bytes. Bits in the RPL_NHC indicate whether the RPLInstanceID is elided and/or the SenderRank is compressed:

O: The O bit is defined in [RFC6550] section 11.2.

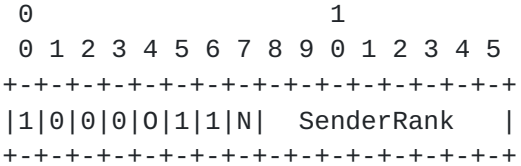
NH: 1-bit field. The Next Header (NH) bit is defined in [RFC6282] section 4.2, and it is set to indicate that the next header is encoded using LOWPAN_NHC.

I: 1-bit field. If it is set, the Instance ID is elided and the RPLInstanceID is the Global RPLInstanceID 0. If it is not set, the byte immediately following the RPL_NHC contains the RPLInstanceID as specified in [RFC6550] section 5.1.

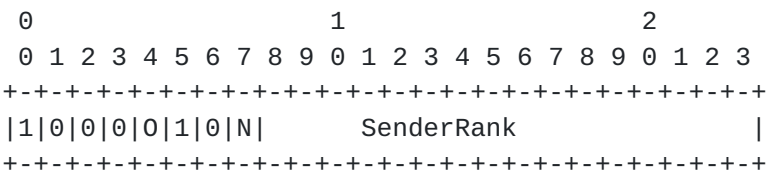
K: 1-bit field. If it is set, the SenderRank is be compressed into one byte, and the lowest significant byte is elided. If it is not set, the SenderRank, is fully inlined as 2 bytes.

R, and F bits: The R and F bits are defined in [RFC6550] section 11.2. If R=0 and F=0, the NHC code is used as defined above. If either is non-zero, a single escape code with X=R and Y=F is prepended in front of the NHC code. (An escape code with X=0 and Y=0 MUST NOT be used with RPI_NHC. A sequence of two or more escape codes MUST NOT be used with RPI_NHC.)

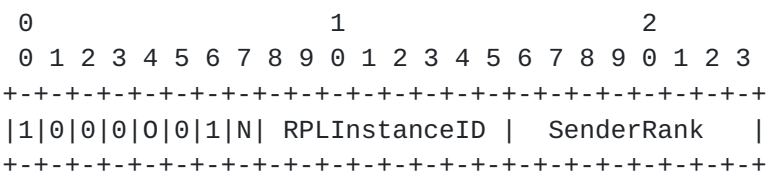
In the following case, the RPLInstanceID is the Global RPLInstanceID 0, and the MinHopRankIncrease is a multiple of 256 so the least significant byte is all zeroes and can be elided:



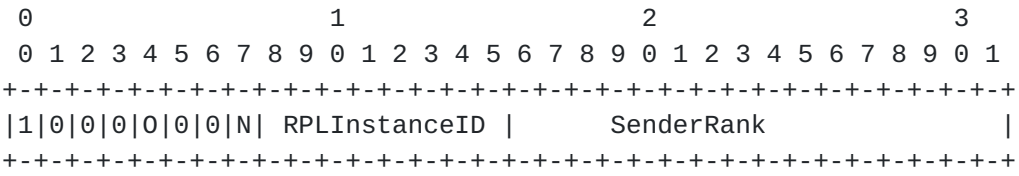
In the following case, the RPLInstanceID is the Global RPLInstanceID 0, but both bytes of the SenderRank are significant so it can not be compressed:



In the following case, the RPLInstanceID is not the Global RPLInstanceID 0, and the MinHopRankIncrease is a multiple of 256:



In the following case, the RPLInstanceID is not the Global RPLInstanceID 0, and both bytes of the SenderRank are significant:



Depending on the RPLInstanceID and the MinHopRankIncrease, the proposed format thus squeezes the RPI into 16 to 40 bits, which compares to 64 bits when using a Hop-by-hop option with the RPL option as specified in [RFC6553].

4. Operation

A 6lo compressor that is about to create either an RFC 6282 IPHC header [RFC6282] or a Frag1 header [RFC4944] and finds a Hop-by-Hop Options header [RFC2460] with an RPL Option [RFC6553] in it, performs the following checks:

1. Does the compression scheme apply? I.e.:

   A. is no sub-tlv present in the RPL Option?

   B. is the RPL Option the only option in the Hop-by-Hop Options header?

2. Does the additional compression for I=1 apply? I.e.: is RPLInstanceID == 0?

3. Does the additional compression for K=1 apply? I.e.: is SenderRank < 256?

4. Is both R=0 and F=0, or do we need an escape code?

If check 1 succeeds, the compressor removes the Hop-by-Hop Options header (replacing the zero-valued next header field in the IPv6 header with the value of the next header field of the Hop-by-Hop Options header), and, depending on the outcome of check 2 and 3, generates an RPI_NHC Header with I and K set from the payload information in the RPL Option. If one or both of R and F are non-zero (check 4), it precedes the first byte in the RPI_NHC header with an escape code with X=R and Y=F. It then continues generating the RFC 6282 IPHC or RFC 4944 Frag1 header, filling in the continuation of the RPL Information header as defined in Section 3.

A 6lo decompressor that encounters a RPL Information header reverses this process, creating a Hop-by-Hop Options header with a single RPL Option carrying the information in the RPL Information header.

5. Discussion

(This section to be removed by the RFC editor.)

Compared to [I-D.thubert-6man-flow-label-for-rpl], the 6lo-based approach used here has the following advantages:

- more efficient (in size) encoding possible
- avoids any entanglement with flow label from RFC 6437
- avoids any issues with undetected changes to flow label field, which might be:
  - because the IPv6 header is not covered by a checksum
  - because nodes that happen to become on-path use the flow label for something else
- nodes outside 6lo that do not need the compression do not have to deal with an alternate representations of the RFC 6553 information

Compared to [I-D.toutain-6lo-local-extensions], RPL Information Header proposal is entirely focused on RFC 6553 So it may be possible to complete this focused draft much faster than a general approach. Also, the result is likely to be more efficient.

Compared to [I-D.thubert-6lo-rpl-nhc], much more of the NHC space is left usable, e.g., leaving bits available to possibly eventually cover [RFC6554].

Finally, this draft can be ignored by implementations not implementing RPL.

6. Background

Some more historical background about compression and RPL:\

(This section to be removed by the RFC editor.)

The ROLL WG has a routing protocol, RPL [RFC6550], that requires some data to be shipped around together with IP packets. [RFC6553] and [RFC6554] define ways to do this that are consistent with the IP architecture: The RPL Option defined in [RFC6553] is a hop-by-hop option that provides RPL rank and instance-id, as well as a few flags; the Routing Header defined in [RFC6554] provides the source routing needed for downward-routed packets in RPL's dominant non-storing mode.

Unfortunately, the overhead (signal-to-fluff ratio) for both representations is relatively high, and in a constrained environment, that matters.

An obvious next step would have been looking at ways to do header compression. Compressing RPL was extensively discussed, but mostly with a view to compressing the (control plane) ROLL messages carried in ICMPv6, not so much about the RPL information carried with the (data plane) IP packets themselves. GHC [I-D.ietf-6lo-ghc] is trying to be a reasonably useful, but also reasonably general way to compress the control plane messages.

For the data packets, the flow label (and its now predominant non-use) provides an attractive place in the IPv6 packets to ship around the [RFC6553] information, but not the potentially more substantial [RFC6554] information. In 6lo networks, normally [RFC6282] compresses away empty flow labels, but it is cheap to put them in, so a flow label really only costs 3 bytes (instead of the 8 bytes a RPL Option [RFC6553] costs). The most useful information from [RFC6553] can be stuffed into 19 bits, as demonstrated by [I-D.thubert-6man-flow-label-for-rpl].

[RFC6282] has extension points (GHC uses one of them), but not really useful ones for the ROLL data plane. So it appears it never occurred to us that the best way to handle these 19 bits is to actually sidestep [RFC6282], and use the existing extension points of [RFC4944]. Until Laurent Toutain showed one way of doing this [I-D.toutain-6lo-local-extensions]. The previous version of the present draft just went from there and used Laurent's idea for compressing the [RFC6553] option, in a way that is as efficient as

(or, in most cases, actually more efficient than) using the flow label opportunity.

The present draft is a variation of the idea to use NHC header compression for representing the [RFC6553] RPL option [I-D.thubert-6lo-rpl-nhc]. It may be slightly less efficient than the previous version of this draft, but it is much more conservative in consuming NHC code point space than [I-D.thubert-6lo-rpl-nhc].

In summary, this means the present draft intends to replace the flow label bit allocation of [I-D.thubert-6man-flow-label-for-rpl]. It does not cover the "license-to-drop" the flow label that [I-D.thubert-6man-flow-label-for-rpl] implies (and that is denied by [RFC6437]). It also does not cover the compression of [RFC6554] source routing information, but does provide an extension point for adding that later.

7. IANA considerations

This draft requests IANA to assign the following LOWPAN_NHC types in the "IPv6 Low Power Personal Area Network Parameters" registry:

010001XY: Escape X=0/Y=0 to X=1/Y=1 [RFCthis]

1000IOKN: RPL Information [RFCthis]

8. Security considerations

The security considerations of [RFC4944], [RFC6282], and [RFC6553] apply.

9. Acknowledgments

This document is based on the ideas in the specifications [I-D.thubert-6man-flow-label-for-rpl] and [I-D.thubert-6lo-rpl-nhc] and has borrowed a lot of text from the latter. Its use of the RFC 4944 framework was inspired by [I-D.toutain-6lo-local-extensions]. Ralph Droms supplied a number of helpful comments on the -00 draft. The discussion in the 6man and roll working groups also was helpful.

10. References

10.1. Normative References

[RFC2119] Bradner, S., "Key words for use in RFCs to Indicate Requirement Levels", BCP 14, RFC 2119, March 1997.

[RFC2460] Deering, S. and R. Hinden, "Internet Protocol, Version 6 (IPv6) Specification", RFC 2460, December 1998.

[RFC4944] Montenegro, G., Kushalnagar, N., Hui, J., and D. Culler, "Transmission of IPv6 Packets over IEEE 802.15.4 Networks", RFC 4944, September 2007.

[RFC6282] Hui, J. and P. Thubert, "Compression Format for IPv6 Datagrams over IEEE 802.15.4-Based Networks", RFC 6282, September 2011.

[RFC6553] Hui, J. and JP. Vasseur, "The Routing Protocol for Low-Power and Lossy Networks (RPL) Option for Carrying RPL Information in Data-Plane Datagrams", RFC 6553, March 2012.

10.2. Informative References

[I-D.ietf-6lo-ghc]
Bormann, C., "6LoWPAN Generic Compression of Headers and Header-like Payloads (GHC)", draft-ietf-6lo-ghc-05 (work in progress), September 2014.

[I-D.thubert-6lo-rpl-nhc]
Thubert, P., "A compression mechanism for the RPL option", draft-thubert-6lo-rpl-nhc-01 (work in progress), August 2014.

[I-D.thubert-6man-flow-label-for-rpl]
Thubert, P., "The IPv6 Flow Label within a LLN domain", draft-thubert-6man-flow-label-for-rpl-05 (work in progress), August 2014.

[I-D.toutain-6lo-local-extensions]
Toutain, L., "6LoWPAN Local Extensions", draft-toutain-6lo-local-extensions-00 (work in progress), June 2014.

[RFC6437] Amante, S., Carpenter, B., Jiang, S., and J. Rajahalme, "IPv6 Flow Label Specification", RFC 6437, November 2011.

[RFC6550] Winter, T., Thubert, P., 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, March 2012.

[RFC6554] Hui, J., Vasseur, JP., Culler, D., and V. Manral, "An IPv6 Routing Header for Source Routes with the Routing Protocol for Low-Power and Lossy Networks (RPL)", RFC 6554, March 2012.

Author's Address

Carsten Bormann
Universitaet Bremen TZI
Postfach 330440
Bremen D-28359
Germany

Phone: +49-421-218-63921
Email: cabo@tzi.org