               When to use RFC 6553, 6554 and IPv6-in-IPv6
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Abstract

   This document states different cases where RFC 6553, RFC 6554 and
   IPv6-in-IPv6 encapsulation is required to set the bases to help
   defining the compression of RPL routing information in LLN
   environments.

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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   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 December 29, 2015.

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1. Introduction

   RPL [RFC6550] defines RPL Option to transmit routing information.
   RFC 6553 [RFC6553] defines how to transmit in a Hop-By-Hop Option RPL
   Information,such as information to avoid and detect loops. RFC 6554
   [RFC6554] defines the use of Extension header for Source Routing.

   Several discussions in ROLL/6lo/6tisch Mailing Lists took place
   focusing in the definition how to compress RPL Information in
   constrained environment. ROLL Virtual Interim Meeting (02-2015)
   concluded that there is a need to define how to use RFC 6553, RFC6554
   and tunneling (IP-in-IP) to be able to set the correct environment
   for compression.

2. Terminology and 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 RFC 2119 [RFC2119].

Terminology defined in [RFC7102]

3. Sample/reference topology

In a typical topology we found 6LBR (6LoWPAN Border Router), 6lR
(6LoWPAN Router) and 6LN (6LoWPAN Node) as leaf connected in a DODAG
(Destination Oriented Directed Acyclic Graph). Between these
entities messages such as DIS, DIO and DAO are transmitted. RPL
defines the RPL Control message as an ICMPv6 information message with
a Type of 155. RPL supports two modes of Downward traffic: Storing,
it is fully stateful or Non-Storing it is fully source routed. Any
given RPL Instance is either storing or non-storing.

```
              +--------------+
              | Upper Layers |
              |              |
              +--------------+
              |   RPL        |
              |              |
              +--------------+
              |   ICMPv6     |
              |              |
              +--------------+
              |   IPv6       |
              |              |
              +--------------+
              |   6LoWPAN    |
              |              |
              +--------------+
              |   PHY-MAC    |
              |              |
              +--------------+
```

Figure 1: RPL Stack

```
                              +---------+
                         +---+Internet |
                         |   +---------+
                         |
                      +----+--+
                      |DODAG  |
            +---------+Root    +----------+
            |         |6LBR   |          |
            |         +---+--+           |
            |             |              |
            |             |              |
            |             |              |
       +-----+-+      +--+---+       +--+---+
       |6LR    |      |      |       |      |
    +-----+    |      |      |       |      |
    |     |    |      |      |       |    +------+
    |     |    |      |      |       |    |      |
    |     +-----+-+   +-+----+       +-+----+    |
    |         |           |              |       |
    |         |           |              |       |
    |         |           |              |       |
 +-+---+   +-+---+     +--+--+       +- --+   +---+-+
 |Leaf |   |     |     |     |       |    |   |     |
 |6LN  |   |     |     |     |       |    |   |     |
 +-----+   +-----+     +-----+       +----+   +-----+
```
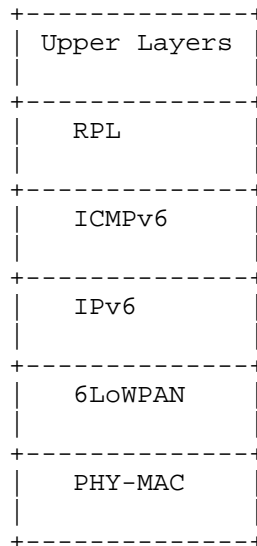
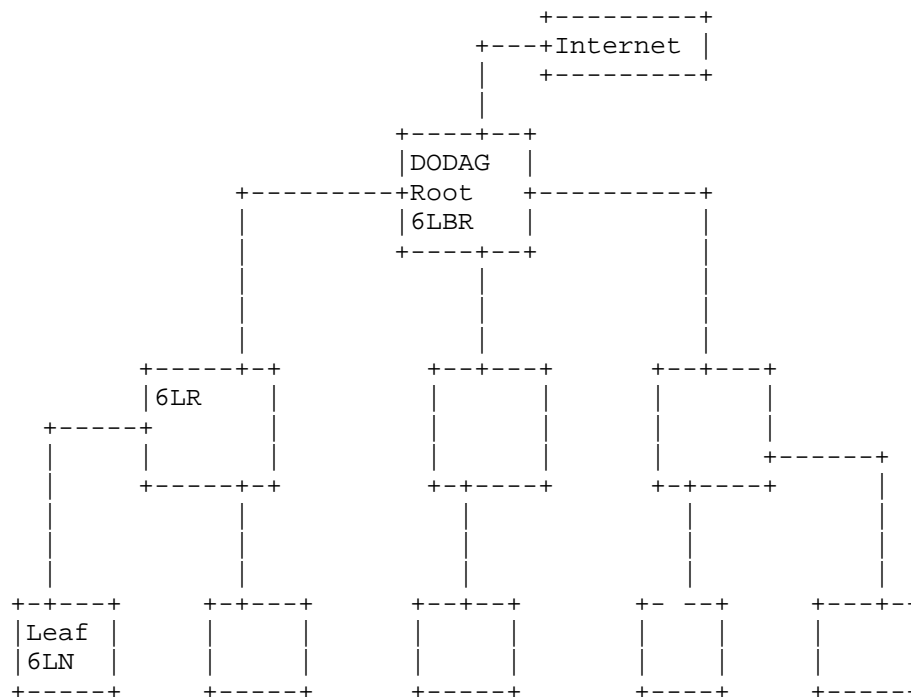   Figure 2: A reference RPL Topology

   In different scenarios the use of RFC 6553, RFC 6554 and tunneling
   can take place:

   -Flow from leaf to root

   -Flow from leaf to Internet

   -Flow from leaf to leaf

   -Flow from Internet to leaf

   -Flow from leaf to root

4. Example flow from leaf to root

   A leaf node generates DAO and DIS messages and in general does not
   accept them. Additionally, this kind of nodes accepts DIO messages,
   but in general do not generate them. (In inconsistency A leaf node
   generates DIO with infinite rank, to fix it).

4.1. Non-storing

   In non-storing in this case the leaf node uses Hop-By-Hop option (RFC
   6553) to indicate the routing information to send messages to the
   DODAG root, this message is going to be analyzed in each node until
   arrive the DODAG root.

   RFC 6554 was created to strictly send information between RPL routers
   in the same RPL routing domain. How it would be in 6554?

   TBD: Tunneling is necessary in case that there is information to send
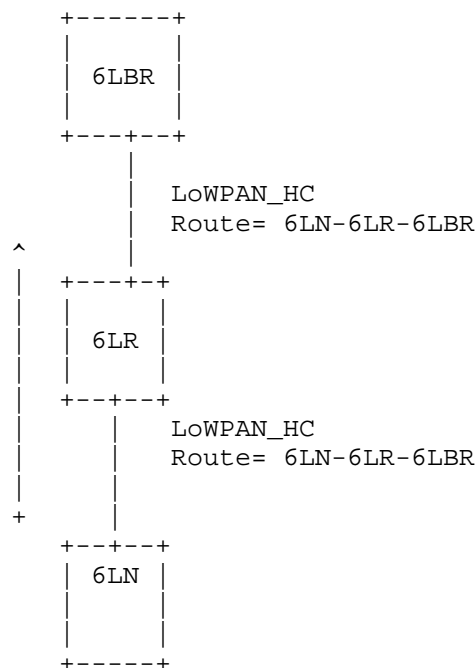   outside RPL Domain and other cases?

```
                        +------+
                        |      |
                        | 6LBR |
                        |      |
                        +---+--+
                            |
                            |   LoWPAN_HC
                            |   Route= 6LN-6LR-6LBR
               ^            |
               |  +---+-+
               |  |     |
               |  | 6LR |
               |  |     |
               |  +--+--+
               |     |   LoWPAN_HC
               |     |   Route= 6LN-6LR-6LBR
               |     |
               +     |
                  +--+--+
                  | 6LN |
                  |     |
                  |     |
                  +-----+
```

              Figure 3: From leaf to Root - Non-Storing Mode

4.2. Storing

   IP6 6553{X,Y] ?ipip payload. In storing mode is suitable the use of
   RFC 6553 to send RPL Information through HBH field checking the
   routing table to find out where to send the message. It may include
   IP-in-IP encapsulation to transmit information not related with the
   RPL domain.

```
                  +------+
                  |      |
                  | 6LBR |
                  |      |
                  +---+--+
                      |
                      |   LoWPAN_HC
                      |   0x63|HBH Data
           ^          |
           |   +---+-+
           |   |   |   |
           |   | 6LR |  6LR check in routing table
           |   |   |   |
           |   +--+--+
           |       |    LoWPAN_HC
           |       |    0x63|HBH Data
           |       |
           +       |
               +--+--+
               | 6LN |
               |     |
               |     |
               +-----+
```
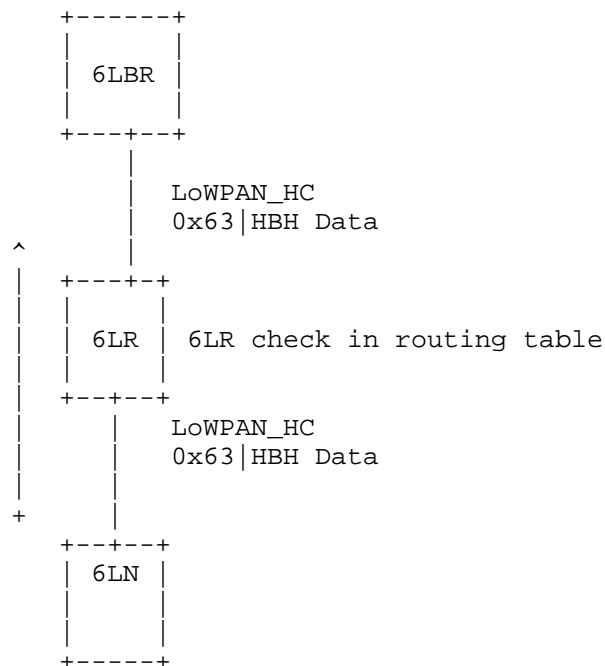
Figure 4: From leaf to Root - Storing Mode

5. Example flow from leaf to Internet

5.1. Non-storing

   In this case the IP-in-IP encapsulation should take place to send
   information not related to the RPL domain inside of the RPL domain.

   RPL information from RFC 6553 should not go out to Internet. The
   router sould take this information out before send the packet to
   Internet. The HBH Option is going to be analyzed in each node to the
   root.

   Related to RFC 6554 the Source Header route is added and removed by
   DODAG root. However, RFC 6554 was created to strictly send
   information between RPL routers in the same RPL routing domain. How
   it would be in 6554?

5.2. Storing

   In storing the information of RFC 6553 should take away by DODAG root
   before go to Internet.

6. Example flow from leaf to leaf

   can leafs insert appropriate headers, without ipip? In [RFC6550] RPL
   allows a simple one-hop P2P optimization for both storing and non-
   storing networks. A node may send a P2P packet destined to a one-hop
   neighbor direclty to that node. Section 9 in [RFC6550].

6.1. Traditional storing

   The route go through an ancestor that knows the route to the
   destination, using HBH [RFC6553] to carry RPL Information.

6.2. Traditional non-storing

   The route go through the DODAG root, using source routing [RFC6554].

6.3. P2P non-storing

   (p2p storing? TBD)

7. Example flow from Internet to leaf

   A DODAG root do not add routing extension to incoming packets, it
   instead uses tunneling.

7.1. Storing

   DODAG root adds the HBH header [RFC6553] and send the packet downward
   to the destination.

7.2. Non-storing

   DODAG root is going to add the source route header [RFC6554]

8. Example flow from root to leaf

8.1. Storing

   DODAG root adds the HBH header [RFC6553] and send the packet downward
   to the destination.

8.2. Non-storing

DODAG root is going to add the source route header [RFC6554]

9. IANA Considerations

   There are no IANA considerations related to this document.

10. Security Considerations

   TBD.

11. Acknowledgements

12. References

12.1. Normative References

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

   [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.

   [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.

   [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.

12.2. Informative References

   [RFC7102]   Vasseur, JP., "Terms Used in Routing for Low-Power and
               Lossy Networks", RFC 7102, January 2014.

Authors' Addresses

Maria Ines Robles
Ericsson
Hirsalantie 11
Jorvas 02420
Finland

Email: maria.ines.robles@ericsson.com

Michael C. Richardson
Sandelman Software Works
470 Dawson Avenue
Ottawa, ON K1Z 5V7
CA

Email: mcr+ietf@sandelman.ca
URI: http://www.sandelman.ca/