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Transmission of SCHC-compressed packets over IEEE 802.15.4 networks
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Abstract

A framework called Static Context Header Compression and fragmentation (SCHC) has been designed with the primary goal of supporting IPv6 over Low Power Wide Area Network (LPWAN) technologies [RFC8724]. One of the SCHC components is a header compression mechanism. If used properly, SCHC header compression allows a greater compression ratio than that achievable with traditional 6LoWPAN header compression [RFC6282]. For this reason, it may make sense to use SCHC header compression in some 6LoWPAN environments, including IEEE 802.15.4 networks. This document specifies how a SCHC-compressed packet can be carried over IEEE 802.15.4 networks.

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1. Introduction

RFC 6282 is the main specification for IPv6 over Low power Wireless Personal Area Network (6LoWPAN) IPv6 header compression [RFC6282]. This RFC was designed assuming IEEE 802.15.4 as the layer below the 6LoWPAN adaptation layer, and it has also been reused (with proper adaptations) for IPv6 header compression over many other technologies relatively similar to IEEE 802.15.4 in terms of characteristics such as physical layer bit rate, layer 2 maximum payload size, etc. Examples of such technologies comprise BLE, DECT-ULE, ITU G.9959, MS/TP, NFC, and PLC. RFC 6282 provides additional functionality, such as a mechanism for UDP header compression.

In the best cases, RFC 6282 allows to compress a 40-byte IPv6 header down to a 2-byte compressed header (for link-local interactions) or a 3-byte compressed header (when global IPv6 addresses are used). On the other hand, an RFC 6282 compressed UDP header has a typical size of 4 bytes. Therefore, in advantageous conditions, a 48-byte uncompressed IPv6/UDP header may be compressed down to a 6-byte format (when using link-local addresses) or a 7-byte format (for global interactions) by using RFC 6282.

Recently, a framework called Static Context Header Compression (SCHC) has been designed with the primary goal of supporting IPv6 over Low Power Wide Area Network (LPWAN) technologies [RFC8724]. SCHC comprises header compression and fragmentation functionality tailored to the extraordinary constraints of LPWAN technologies, which are more severe than those exhibited by IEEE 802.15.4 or other relatively similar technologies. SCHC header compression allows a greater compression ratio than that of RFC 6282. If used properly, SCHC allows to compress an IPv6/UDP header down to e.g. a single byte. In addition, SCHC can be used to compress Constrained Application Protocol (CoAP) headers as well [RFC7252][RFC8824], which further increases the achievable performance improvement of using SCHC header compression, since there is no 6LoWPAN header compression defined for CoAP. Therefore, it may make sense to use SCHC header compression in some 6LoWPAN environments [I-D.toutain-6lo-6lo-and-schc], including IEEE 802.15.4 networks, considering its greater efficiency.

If SCHC header compression is added to the panoply of header compression mechanisms used in 6LoWPAN environments, then there is a need to signal when a packet header has been compressed by using SCHC. To this end, the present document specifies a 6LoWPAN Dispatch Type for SCHC header compression [RFC4944].

This document specifies how a SCHC-compressed packet can be carried over IEEE 802.15.4 networks. Note that, as per this document, and while SCHC defines fragmentation mechanisms as well, 6LoWPAN/6Lo fragmentation is used when necessary to transport SCHC-compressed packets over IEEE 802.15.4 networks [RFC4944][RFC8930][RFC8931].

TO-DO: indicate here any specific updates of RFC 8724 for use over IEEE 802.15.4.

2. Terminology

2.1. Requirements language

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 BCP14 [RFC2119], [RFC8174], when, and only when, they appear in all capitals, as shown here.

2.2. Background on SCHC

The reader is expected to be familiar with the terms and concepts defined in the specification of SCHC (RFC 8724).

3. Architecture

3.1. Network topologies

IEEE 802.15.4 supports two main network topologies: the star topology, and the peer-to-peer (i.e., mesh) topology.

SCHC has been designed for LPWAN technologies, which are typically based on a star topology where constrained devices (e.g., sensors) communicate with a less constrained, central network gateway [RFC 8376]. However, as stated in [draft-ietf-lpwan-architecture], SCHC is generic and it can also be used in networking environments beyond the ones originally considered for SCHC.

SCHC compression is applicable to both star topology and mesh topology IEEE 802.15.4 networks.

3.2. Protocol stack

The traditional 6LoWPAN-based protocol stack for constrained devices (Figure 1, left) places the 6LoWPAN adaptation layer between IPv6 and an underlying technology such as IEEE 802.15.4. Suitable upper layer protocols include CoAP [RFC7252] and UDP. (Note that, while CoAP has also been specified over TCP, and TCP may play a significant role in IoT environments [RFC9006], 6LoWPAN header compression has not been defined for TCP.)

6LoWPAN can be envisioned as a set of two main sublayers, where the upper one provides header compression, while the lower one offers fragmentation.

This document defines an alternative approach for packet header compression over IEEE 802.15.4, which leads to a modified protocol stack (Figure 1, right).

```
        +------------+          +------------+
        | CoAP, other|          | CoAP, other|
        +------------+          +------------+
        | UDP, other |          | UDP, other |
        +------------+          +------------+
        |    IPv6    |          |    IPv6    |
        +------------+          +------------+
        | 6LoWPAN HC |          |  SCHC HC   |  <-- NEW
        +------------+          +------------+
        |6LoWPAN Frag|          |6LoWPAN Frag|
        +------------+          +------------+
        |  802.15.4  |          |  802.15.4  |
        +------------+          +------------+
```

Figure 1: Traditional 6LoWPAN-based protocol stack over IEEE 802.15.4 (left) and alternative protocol stack using SCHC for header compression (right). HC and Frag stand for Header Compression and Fragmentation, respectively.

SCHC header compression may be applied to the headers of different protocols or sets of protocols. Some examples include: i) IPv6 packet headers, ii) joint IPv6 and UDP packet headers, iii) joint IPv6, UDP and CoAP packet headers, etc.

4. Frame Format

This document defines the frame format to be used when a SCHC-compressed packet is carried over IEEE 802.15.4. Such format is carried as IEEE 802.15.4 frame payload. The format comprises a SCHC Dispatch Type, a SCHC Packet (i.e. a SCHC-compressed packet (RFC 8724), and Padding bits, if any). Figure 2 illustrates the described frame format.

```
   <---------- IEEE 802.15.4 frame payload ---------->

                   <----- SCHC Packet ----->
   +----------------+-------------+---------+ - - - - +
   | SCHC Dispatch  | SCHC Header | Payload | Padding |
   +----------------+-------------+---------+ - - - - +
```

Figure 2: Encapsulated, SCHC-compressed packet. Padding bits are added if needed.

4.1. SCHC Dispatch

Adding SCHC header compression to the panoply of header compression mechanisms used in 6LoWPAN/6Lo environments creates the need to signal when a packet header has been compressed by using SCHC. To this end, the present document specifies the SCHC Dispatch. The SCHC Dispatch indicates that the next field in the frame format is a SCHC-compressed header (SCHC Header in Figure 2, see 4.2)).

This document defines the SCHC Dispatch as a 6LoWPAN Dispatch Type for SCHC header compression [RFC4944]. With the aim to minimize overhead, the present document allocates a 1-byte pattern in Page 0 [RFC8025] for the SCHC Dispatch Type:

SCHC Dispatch Type bit pattern: 01000100 (Page 0) (Note: to be confirmed by IANA))

4.2. SCHC Header

SCHC Header (Figure 2) corresponds to a packet header that has been compressed by using SCHC. As defined in [RFC8724], the SCHC Header comprises a RuleID, and a compression residue. The present specification defines a RuleID size of 8 bits.

4.3. Padding

If SCHC header compression leads to a SCHC Packet size of a non-integer number of bytes, padding bits of value equal to zero MUST be appended to the SCHC Packet as appropriate to align to an octet boundary.

5. SCHC compression for IPv6, UDP, and CoAP headers

SCHC header compression may be applied to the headers of different protocols or sets of protocols. Some examples include: i) IPv6 packet headers, ii) joint IPv6 and UDP packet headers, iii) joint IPv6, UDP and CoAP packet headers, etc.

5.1. SCHC compression for IPv6 and UDP headers

With the exception of IPv6 addresses and UDP ports, IPv6 and UDP header fields MUST be compressed as per Section 10 of RFC 8724.

IPv6 addresses are split into two 64-bit-long fields; one for the prefix and one for the Interface Identifier (IID).

To allow for a single Rule being used for both directions, RFC 8724 identifies IPv6 addresses and UDP ports by their role (Dev or App) and not by their position in the header (source or destination). However, such roles are not applicable in some types of 6LoWPAN environments (e.g., when a sender and its destination are both nodes in a mesh topology network). In such cases, the terms Uplink and Downlink as they have been defined in RFC 8724 are not applicable either.

The present specification identifies IPv6 addresses and UDP ports by their position in the header (source or destination). Accordingly, the present specification defines two new values for the Direction Indicator: Transmit (Tx) and Receive (Rx).

5.1.1. Compression of IPv6 addresses

Compression of IPv6 source and destination prefixes MUST be performed as per Section 10.7.1 of RFC 8724.

If the source or destination IID are based on an L2 address, then the IID can be reconstructed with information coming from the L2 header. In that case, the TV is not set, the MO is set to "ignore" and the CDA is set to compute-IID.

As described in [RFC8065], it may be undesirable to build the source IPv6 IID of a device out of the device address. Another static value is used instead. In that case, the TV contains the static value, the MO operator is set to "equal" and the CDA is set to "not-sent".

If several IIDs are possible, then the TV contains the list of possible IIDs, the MO is set to "match-mapping" and the CDA is set to "mapping-sent".

It may also happen that the IID variability only expresses itself on a few bytes. In that case, the TV is set to the stable part of the IID, the MO is set to "MSB" and the CDA is set to "LSB".

5.1.2. Compression of UDP ports

TO-DO

5.2. SCHC compression for CoAP headers

CoAP header fields MUST be compressed as per Sections 4 to 6 of RFC 8824.

5.3. Header compression examples

TO-DO: provide examples for IPv6-only, IPv6/UDP and IPv6/UDP/CoAP.

6. Fragmentation and reassembly

After applying SCHC header compression to a packet intended for transmission, if the size of the resulting frame format (Section 4) exceeds the IEEE 802.15.4 frame payload space available, such frame format MUST be fragmented, carried and reassembled by means of 6LoWPAN fragmentation and reassembly [RFC4944][RFC8930][RFC8931].

7. IANA Considerations

This document requests the allocation of the Dispatch Type Field bit pattern 01000100 (Page 0) as SCHC Dispatch Type.

8. Security Considerations

This document does not define SCHC header compression functionality beyond the one defined in RFC 8724. Therefore, the security considerations in section 12.1 of RFC 8724 apply.

As a safety measure, a SCHC decompressor implementing the present specification MUST NOT reconstruct a packet larger than 1500 bytes [RFC8724].

9. Acknowledgments

Ana Minaburo and Laurent Toutain suggested for the first time the use of SCHC in environments where 6LoWPAN has traditionally been used. Laurent Toutain, Pascal Thubert, Dominique Barthel, and Guangpeng Li made comments that helped shape this document.

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