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SCHC Compound ACK
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Abstract

The present document describes an extension to the SCHC (Static Context Header Compression and fragmentation) protocol [[RFC8724](#)]. It defines a SCHC Compound ACK message format and procedure, which are intended to reduce the number of response transmissions (i.e., SCHC ACKs) in the ACK-on-Error mode, by accumulating bitmaps of several windows in a single SCHC message (i.e., the SCHC Compound ACK).

Both message format and procedure are generic, so they can be used, for instance, by any of the four LWPAN technologies defined in [[RFC8376](#)], being Sigfox, LoRaWAN, NB-IoT and IEEE 802.15.4w.

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SCHC Compound ACK

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[1.](#) Introduction

The Generic Framework for Static Context Header Compression and Fragmentation (SCHC) specification [[RFC8724](#)] describes two mechanisms: i) a protocol header compression scheme, and ii) a frame fragmentation and loss recovery functionality. Either can be used on top of radio technologies such as the four LWPAN defined in [[RFC8376](#)], being Sigfox, LoRaWAN, NB-IoT and IEEE 802.15.4w. These LPWANs have similar characteristics such as star-oriented topologies, network architecture, connected devices with built-in applications,

etc.

SCHC offers a great level of flexibility to accommodate all these LPWAN technologies. Even though there are a great number of similarities between them, some differences exist with respect to the

transmission characteristics, payload sizes, etc. Hence, there are optimal parameters and modes of operation that can be used when SCHC is used on top of a specific LPWAN technology.

The present document describes an extension to the SCHC protocol for frame fragmentation and loss recovery. It defines a SCHC Compound ACK format and procedure, which is intended to reduce the number of response transmissions (i.e., SCHC ACKs) in the ACK-on-Error mode of SCHC. The SCHC Compound ACK extends the SCHC ACK message format so that it can contain several bitmaps, each bitmap being identified by its corresponding window number.

The SCHC Compound ACK:

- * provides feedback only for windows with fragment losses,
- * has a variable size that depends on the number of windows with fragment losses being reported in the single Compound SCHC ACK,
- * includes the window number (i.e., W) of each bitmap,
- * has the same SCHC ACK format defined in [[RFC8724](#)] when only one window with losses is reported,
- * might not cover all windows with fragment losses of a SCHC Packet,
- * and is distinguishable from the SCHC Receiver-Abort.

[2.](#) Terminology

It is assumed that the reader is familiar with the terms and mechanisms defined in [[RFC8376](#)] and in [[RFC8724](#)].

[3.](#) SCHC Compound ACK

The SCHC Compound ACK is a SCHC ACK message that can contain several

bitmaps, each bitmap being identified by its corresponding window number.

The SCHC Compound ACK groups the window number (W) with its corresponding bitmap. Windows do not need to be contiguous. However, the window numbers and corresponding bitmaps included in the SCHC Compound ACK message MUST be ordered from the lowest-numbered to the highest-numbered window. Hence, if the the bitmap of window number zero is present in the SCHC Compound ACK message, it MUST always be the first one in order and its W number MUST be placed in-between the Rule ID and the C bit. This also avoids confusing any '0s' padding bits following the first bitmap with W number zero.

[3.1.](#) SCHC Compound ACK Message Format

Figure 1 shows the regular SCHC ACK format when all fragments have been correctly received (C=1), as defined in [\[RFC8724\]](#).

```

|-- SCHC ACK Header --|
+-----+-----+-----+-----+
| RuleID | W | C=b'1 | b'0-pad(opt) |
+-----+-----+-----+-----+

```

Figure 1: SCHC Success ACK message format, as defined in [RFC8724](#)

In case SCHC Fragment losses are found in any of the windows of the SCHC Packet, the SCHC Compound ACK MAY be used. The SCHC Compound ACK message format is shown in Figure 2.

```

|--SCHC ACK Header--| W = w1 |...|          W = wi          |
+-----+-----+-----+...+-----+-----+-----+
|RuleID|W=b'w1|C=b'0| Bitmap |...| W=b'wi | Bitmap |b'0-pad(opt)|
+-----+-----+-----+-----+...+-----+-----+-----+

```

Losses are found in windows $W = w1, \dots, wi$; where $w1 < w2 < \dots < wi$

Figure 2: SCHC Compound ACK message format

The SCHC Compound ACK MUST NOT use the Compressed Bitmap format for intermediate windows/bitmaps (i.e., bitmaps that are not the last one), and therefore intermediate bitmaps fields MUST be of size WINDOW_SIZE. Hence, the SCHC Compound ACK MAY use a Compressed

Bitmap format only for the last bitmap. The optional usage of this Compressed Bitmap for the last bitmap MUST be specified by the SCHC technology-specific profile.

If a SCHC sender gets a SCHC Compound ACK with invalid W's, such as duplicate W values or W values not sent yet, it MUST discard the whole SCHC Compound ACK message.

Each different SCHC LPWAN technology profile MUST specify how the SCHC Compound ACK is different from the Receiver-Abort message as per [\[RFC8724\]](#), e.g., the Receiver-Abort message is padded with 1s with an extra byte appended at the end, while the SCHC Compound ACK is 0-padded.

[3.2.](#) SCHC Compound ACK Behaviour

The SCHC ACK-on-Error behaviour is described in [section 8.4.3 of \[RFC8724\]](#). The present document slightly modifies this behaviour, since in the baseline SCHC specification a SCHC ACK reports only one bitmap for the reception of exactly one window of tiles. The present SCHC Compound ACK specification extends the SCHC ACK message format so that it can contain several bitmaps, each bitmap being identified by its corresponding window number.

Also, some flexibility is introduced with respect to [\[RFC8724\]](#), in that the receiver has the capability to respond to the All-0 with a SCHC Compound ACK or not, depending on certain parameters, like network conditions. Note that even though the protocol allows for such flexibility, the actual decision criteria is not specified in this document.

The following sections describe the differences between the baseline SCHC specification and the present SCHC protocol extension specification.

[3.2.1.](#) Sender Behaviour

OLD TEXT ([\[RFC8724\], section 8.4.3.1](#)) - On receiving a SCHC ACK:

- * (...)
- * the fragment sender MUST send SCHC Fragment messages containing all the tiles that are reported missing in the SCHC ACK.
- * if the last of these SCHC Fragment messages is not an All-1 SCHC Fragment, then the fragment sender MUST in addition send after it a SCHC ACK REQ with the W field corresponding to the last window.

NEW TEXT - On receiving a SCHC Compound ACK:

- * (...)
- * the fragment sender MUST resend SCHC Fragment messages containing all the tiles of all the windows that are reported missing in the SCHC Compound ACK.
- * if the last of these SCHC Fragment messages reported missing is not an All-1 SCHC Fragment, then the fragment sender MAY either, send in addition a SCHC ACK REQ with the W field corresponding to the last window, continue the transmission of the remaining fragments to be transmitted, or repeat the All-1 fragment to confirm that all fragments have been correctly received.

[3.2.2.](#) Receiver Behaviour

OLD TEXT ([\[RFC8724\], section 8.4.3.2](#)) - On receiving a SCHC ACK REQ or an All-1 SCHC Fragment:

- * if the receiver knows of any windows with missing tiles for the packet being reassembled, it MUST return a SCHC ACK for the lowest-numbered such window.

NEW TEXT: On receiving an All-0 SCHC Fragment:

- * if the receiver knows of any windows with missing tiles for the packet being reassembled (and if network conditions are known to be conducive), it MAY return a SCHC Compound ACK for the missing fragments, starting from the lowest-numbered window.

NEW TEXT: On receiving a SCHC ACK REQ or an All-1 SCHC Fragment:

- * if the receiver knows of any windows with missing tiles for the packet being reassembled, it MUST return a SCHC Compound ACK for the missing fragments, starting from the lowest-numbered window.

[3.3.](#) SCHC Compound ACK Examples

Figure 3 shows an example transmission of a SCHC Packet in ACK-on-Error mode using the SCHC Compound ACK. In the example, the SCHC Packet is fragmented in 14 tiles, with N=3, WINDOW_SIZE=7, M=2 and two lost SCHC fragments. Only 1 compound SCHC ACK is generated.

Sender	Receiver
-----W=0, FCN=6	----->
-----W=0, FCN=5	----->
-----W=0, FCN=4	----->
-----W=0, FCN=3	----->
-----W=0, FCN=2	--X-->
-----W=0, FCN=1	----->
-----W=0, FCN=0	----->

Bitmap: 1111011

```

(no ACK)
|-----W=1, FCN=6 ----->|
|-----W=1, FCN=5 ----->|
|-----W=1, FCN=4 ----->|
|-----W=1, FCN=3 ----->|
|-----W=1, FCN=2 ----->|
|-----W=1, FCN=1 --X-->|
|-- W=1, FCN=7 + RCS ->| Integrity check: failure
|<--- Compound ACK ----| [C=0, W=0 - Bitmap:1111011,
|-----W=0, FCN=2 ----->| W=1 - Bitmap:1111101]
|-----W=1, FCN=1 ----->| Integrity check: success
|<--- ACK, W=1, C=1 ---| C=1
(End)

```

Figure 3: SCHC Compound ACK message sequence example

```

|-- SCHC ACK Header ---|- W=00 --|----- W=01 -----|
+-----+-----+-----+-----+-----+
| RuleID | W=00  | C=0  | 1111011 | W=01 | 1111101 | b'0-pad (opt) |
+-----+-----+---+-----+-----+-----+-----+

```

Figure 4: SCHC Compound ACK message format example: Losses are found in windows 00 and 01

[3.4.](#) SCHC Compound ACK YANG Data Model

The present document also extends the SCHC YANG data model defined in [[I-D.ietf-lpwan-schc-yang-data-model](#)] by including a new leaf in the Ack-on-Error fragmentation mode to describe both the option to use the SCHC Compound ACK, as well as its bitmap format.

[3.4.1.](#) SCHC YANG Data Model Extension

```

module ietf-schc-compound-ack {
  yang-version 1.1;
  namespace "urn:ietf:params:xml:ns:yang:ietf-schc-compound-ack";
  prefix schc-compound-ack;

  import ietf-schc {
    prefix schc;
  }

  organization
    "IETF IPv6 over Low Power Wide-Area Networks (lpwan) working group";
  contact
    "WG Web:   <https://datatracker.ietf.org/wg/lpwan/about/>
    WG List:  <mailto:lp-wan@ietf.org>
    Editor:   Laurent Toutain
              <mailto:laurent.toutain@imt-atlantique.fr>
    Editor:   Juan Carlos Zuniga
              <mailto:j.c.zuniga@ieee.org>";
  description
    "
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    authors of the code. All rights reserved.
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    Relating to IETF Documents
    (https://trustee.ietf.org/license-info).
    This version of this YANG module is part of RFC XXXX
    (https://www.rfc-editor.org/info/rfcXXXX); see the RFC itself
    for full legal notices.
    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 BCP 14 (RFC 2119) (RFC 8174) when, and only when,
    they appear in all capitals, as shown here.

    *****

    This module extends the ietf-schc module to include the
    Compound ACK behavior for ACK-on-Error as defined in RFC YYYY.
    It introduces a new leaf for ACK-on-Error defining the format
    of the SCHC Compound ACK, adding the possibility to send
    several bitmaps in a single SCHC ACK message."

  revision 2022-02-08 {
    description

```

```
    "Initial version for RFC YYYY ";
  reference
    "RFC YYYY: SCHC Compound ACK";
}

identity bitmap-format-base-type {
  description
    "Define how the bitmap is formed in ACK messages.";
}

identity bitmap-RFC8724 {
  base bitmap-format-base-type;
  description
    "Bitmap by default as defined in RFC8724.";
}

identity bitmap-compound-ack {
  base bitmap-format-base-type;
  description
    "Compound ACK.";
}

typedef bitmap-format-type {
  type identityref {
    base bitmap-format-base-type;
  }
  description
    "type used in rules";
}

augment "/schc:schc/schc:rule/schc:nature/schc:fragmentation/schc:mode/schc:ack" {
  leaf bitmap-format {
    when "derived-from(..../schc:fragmentation-mode, 'schc:fragmentation-mode')";
    type schc-compound-ack:bitmap-format-type;
    default "schc-compound-ack:bitmap-RFC8724";
    description
      "How the bitmaps are included in the SCHC ACK message.";
  }

  leaf last-bitmap-compression {
    when "derived-from(..../schc:fragmentation-mode, 'schc:fragmentation-mode')";
    type boolean;
    default true;
    description
      "when true ultimate bitmap in the SCHC ACK message c";
  }
}
```

```
        "added to SCHC rules";
    }

}
<CODE ENDS>
```

Figure 5: SCHC YANG Data Model - Compound ACK extension

[3.4.2.](#) SCHC YANG Tree Extension

```
augment /schc:schc/schc:rule/schc:nature/schc:fragmentation/schc:mode/schc:ack {
  +--rw bitmap-format?    schc-compound-ack:bitmap-format-type
}
```

Figure 6: SCHC YANG Tree - Compound ACK extension

[4.](#) SCHC Compound ACK Parameters

This section lists the parameters related to the SCHC Compound ACK usage that need to be defined in the Profile, in addition to the ones listed in Annex D of [\[RFC8724\]](#).

- * Usage or not of the SCHC Compound ACK message.
- * Usage or not of the compressed bitmap format in the last window of the SCHC Compound ACK message.
- * Differentiation between SCHC Receiver-Abort and SCHC Compound ACK message, e.g., Receiver-Abort message padded with 1s with an extra byte appended at the end, while the SCHC Compound ACK is 0-padded.

[5.](#) Security considerations

The current document specifies a message format extension for SCHC. Hence, the same Security Considerations defined in [\[RFC8724\]](#) apply.

[6.](#) Acknowledgements

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