Transmission of IPv6 Packets over Short-Range Optical Wireless Communications (IPv6 over OWC)

draft-ietf-6lo-owc-00 & 01

Younghwan Choi (ETRI),
Cheol-min Kim (KETI), Carles Gomez (UPC)

Status of “IPv6 over OWC”

- draft-choi-6lo-owc-00 (IETF 117, San Francisco, July 2023)
  - The Introduction to the new I.D., IPv6 over OWC

- draft-choi-6lo-owc-01 (IETF 118, Prague, November 2023)
  - Revision addressing technical issues related to IPv6 over OWC

- draft-choi-6lo-owc-02 (IETF 119, Brisbane, March 2024)
  - Revision incorporating comments from IETF118
  - Addition of SCHC in IPv6 over OWC

- **draft-ietf-6lo-owc-00 & 01 (IETF 120, Vancouver, July 2024)**
  - **I.D.,-00 (an initial draft, draft-choi-6lo-owc-02 with typos fixed)**
  - **Addition of SCHC in IPv6 over OWC (new texts and figures in § 4.5.2 & § 6.)**

Initial I.D.,-00 (from draft-choi-6lo-owc-02)

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4.6. Fragmentation and Reassembly Considerations

For PHY1 of OWC, IPv6 over OWC MUST use [RFC4944] Fragmentation and Reassembly (FAR). The MTU of OWC PHY1 is smaller than the MTU of IPv6 Packet (1280 bytes). However, because the MTU of OWC PHY2 and PHY3 are bigger than MTU of IPv6 Packet, IPv6 over OWC MUST NOT use [RFC4944] FAR at the adaptation layer for the payloads as discussed in Section 3.4.

Even though OWC devices have larger MTUs (i.e., PHY2 and PHY3) than 1280 octets, use of a 1280-octet MTU is RECOMMENDED in order to avoid need for Path MTU discovery procedures [RFC7668]. However, for communication between an OWC device and other non-OWC devices on the Internet, probably the MTU is 1280 bytes (for the devices on the Internet) and Path MTU discovery [RFC8201] would be needed.

4.7. Unicast and Multicast Address Mapping

The address resolution procedure for mapping IPv6 non-multicast addresses into OWC Link-Layer Addresses follows the general description in Sections 4.6.1 and 7.2 of [RFC4861], unless otherwise specified.

The 2nd sentence has been removed in the initial I.D.,-00

Updates of I.D.,-01 (from the I.D.,-00)

- Table of Contents (new sub-sections in § 4.5)

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Updates of I.D.,-01 (from the I.D.,-00)

- in § 4.5.2, "SCHC header compression for ipv6-over-owc"

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```
In addition, OWC devices MAY utilize a mechanism for header
compressed by Static Context Header Compression and fragmentation
(SCHC) [RFC8724] if SCHC-compressed header is required.  For
instance, SCHC may be used not only for UDP header compression, but
for IPv6 headers, IPv6/UDP headers, or even IPv6/UDP/CoAP if CoAP is
used (e.g., as in the SCHC HC over 802.15.4)
```

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```
4.5.2.  SCHC header compression

   In addition, OWC devices MAY utilize the header compression mechanism
   offered by Static Context Header Compression and fragmentation (SCHC)
   [I-D.ietf-schc-architecture].  For instance, SCHC may be used to
   compress IPv6 headers, IPv6/UDP headers, IPv6/UDP/CoAP (if CoAP is
   used), etc.  [I-D.ietf-schc-architecture].

   In the star topology, in order to signal that a node supports SCHC
   for header compression, the node uses the 6LoWPAN Capability
   Indication Option (6CIO), with a new 6LoWPAN Capability Bit called
   the "S" bit, defined by the present specification.  The "S" bit is
   the last bit (47th bit) of the "6LoWPAN Capability Bits" subregistry
   (see Figure 5).

      0                   1                   2                   3
      0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |     Type      |   Length = 1  |    Reserved     |X|A|D|L|B|P|E|G|
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
     |                                Reserved                       |S|
     +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

                  Figure 5: New Capability Bit in the 6CIO
```

SCHC for ipv6 over OWC
(Optional)

- **In star topology:**
  - **"S" bit (47th bit) in the 6CIO** supports SCHC for header compression
  - 6CIO w/"S" only sent by **6LoWPAN-ND RS**
  - Then, **6LoWPAN-ND RA** makes use of SCHC

Updates of I.D.,-01 (from the I.D.,-00)

- in § 4.5.2, "SCHC header compression for ipv6-over-owc"

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SCHC for ipv6 over OWC (cont'd)
(Optional)

- **In multi-hop topology:**
  - Whole 6LoWPAN is required to support **SCHC-compressed packets**
  - All nodes MUST support the same **route-over modes** (at least one of SRO, TRO or PRO at a given time)

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New option fields:
S: 1-bit flag. Set to indicate that the node sending the 6CIO option supports SCHC for header compression.

Typically, the 6CIO (with the "S" bit set) will only be sent in 6LoWPAN-ND Router Solicitation (RS) packets. The resulting 6LoWPAN-ND Router Advertisement (RA) can then already make use of SCHC and thus indicate SCHC capability implicitly.

In a multihop topology, SCHC header compression can only be used as long as the whole 6LoWPAN network is administratively required to support SCHC-compressed packet transmission over a multihop network. In that case, all network nodes MUST support at least one of the route-over modes defined in [I-D.ietf-6lo-schc-15dot4], i.e., Straightforward Route-Over (SRO), Tunneled, RPL-based Route-Over (TRO) or Pointer-based Route-Over (PRO), and all network nodes MUST use the same route-over mode at a given time.

In order to transmit a SCHC-compressed IPv6 packet over OWC, the frame format to be used depends on the network topology (i.e., star vs multihop) and, for multihop topologies, on the route-over mode used. The frame format SHALL be the corresponding one defined in Sections 4.1 to 4.3 of [I-D.ietf-6lo-schc-15dot4], where "IEEE 802.15.4 frame payload" needs to be replaced by "IEEE 802.15.7 frame payload" in the case of IPv6 over OWC.

Updates of I.D.,-01 (from the I.D.,-00)

- in § 6, “IANA Considerations” & in § 8, “References”

From IANA review, it will be changed to “registry” in the next version.

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6. IANA Considerations

This document has no IANA actions.

IANA Considerations for SCHC of “ipv6 over OWC”

8. References

New References for SCHC of “ipv6 over OWC”

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6. IANA Considerations

IANA is requested to make the following addition to the "6LoWPAN Capability Bits" subregistry, as follows:

Bit	Description	Reference
47	SCHC Support (S bit)	RFC This

Figure 9: New 6LoWPAN Capability Bit (S bit)

8. References

[I-D.ietf-6lo-schc-15dot4]
Gomez, C. and A. Minaburo, "Transmission of SCHC-compressed packets over IEEE 802.15.4 networks", Work in Progress, Internet-Draft, draft-ietf-6lo-schc-15dot4-06, 4 July 2024, <https://datatracker.ietf.org/api/v1/doc/document/draft-ietf-6lo-schc-15dot4/>.

[I-D.ietf-schc-architecture]
Pelov, A., Thubert, P., and A. Minaburo, "Static Context Header Compression (SCHC) Architecture", Work in Progress, Internet-Draft, draft-ietf-schc-architecture-02, 11 April 2024, <https://datatracker.ietf.org/doc/html/draft-ietf-schc-architecture-02>.

Please read the draft
and
welcome any feedback !!

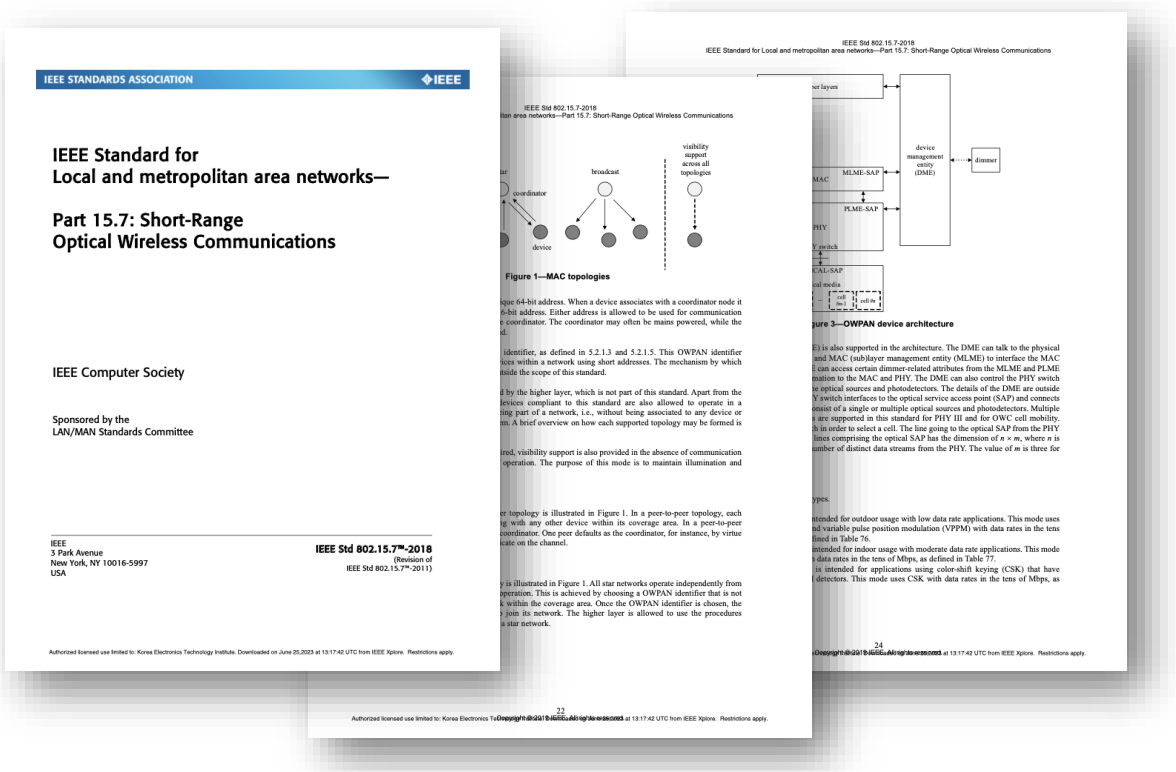
Thank you.

Ref.#1: Short-Range Optical Wireless Communications (OWC) ?

- **OWC** uses **intensity modulation of optical sources**, such as **Light Emitting Diodes (LEDs)**.
- **OWC** combines lighting and **bidirectional data communications**.
- **OWC** can be finding applications in various domains including area **lighting, signboards, streetlights, vehicles, traffic signals, displays, LED panels, and digital signage, smart phones ...**
- **OWC** devices can be powered by **limited energy sources (e.g., battery or energy harvesting)** for energy-efficient services.

Ref.#2: OWC v.s. IEEE 802.15.7

- OWC is defined by **IEEE 802.15.7 standard** providing 6 characteristics, such as



Visible Light Communication (VLC),

Short-Range Bidirectional Communication,

Line-of-Sight (LOS) &

Non-Line-of-Sight (NLOS) Support,

High and Low Data Rates,

Energy Efficiency,

and Secure Communication.

Ref.#3: Test-bed for “IPv6 over OWC”

Ref.#4: Test Results of “IPv6 over OWC”

- Ping responses

```
PING 2001:db8:aaaa::1cfd:08ff:fe73:8567(2001:db8:aaaa:0:1cfd:8ff:fe73:8567) 100 data bytes
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=1 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=2 ttl=63 time=1.68 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=3 ttl=63 time=1.68 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=4 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=5 ttl=63 time=1.67 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=6 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=7 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=8 ttl=63 time=1.67 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=9 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=10 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=11 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=12 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=13 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=14 ttl=63 time=1.63 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=15 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=16 ttl=63 time=1.62 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=17 ttl=63 time=1.67 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=18 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=19 ttl=63 time=1.62 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=20 ttl=63 time=1.62 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=21 ttl=63 time=1.68 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=22 ttl=63 time=1.62 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=23 ttl=63 time=1.64 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=24 ttl=63 time=1.65 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=25 ttl=63 time=1.67 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=26 ttl=63 time=1.62 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=27 ttl=63 time=1.66 ms
108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=28 ttl=63 time=1.64 ms
```

- Wireshark captured

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000000	::e0:4cff:fe5a:dd06	::1cfd:8ff:fe73:8567	UDP	134	51991 → 1234 Len=100
2	0.000000505	::e0:4cff:fe5a:dd06	::1cfd:8ff:fe73:8567	UDP	134	51991 → 1234 Len=100
3	0.000000599	::e0:4cff:fe5a:dd06	::1cfd:8ff:fe73:8567	UDP	134	51991 → 1234 Len=100

```
> Frame 1: 134 bytes on wire (1072 bits), 134 bytes captured (1072 bits) on interface enx988389fde577, id 0
> Ethernet II, Src: RealtekS_5a:dd:06 (00:e0:4c:5a:dd:06), Dst: SamsungE_fd:e5:77 (98:83:89:fd:e5:77)
v 6LoWPAN, Src: ::e0:4cff:fe5a:dd06, Dest: ::1cfd:8ff:fe73:8567
  v IPHC Header
      011. .... = Pattern: IP header compression (0x03)
      ...0 1... .... .... = Traffic class and flow label: ECN and flow label inline (0x1)
      .... .1.. .... .... = Next header: Compressed
      .... ..10 .... .... = Hop limit: 64 (0x2)
      .... .... 0... .... = Context identifier extension: False
      .... .... .1.. .... = Source address compression: Stateful
      .... .... ..11 .... = Source address mode: Compressed (0x0003)
      .... .... .... 0... = Multicast address compression: False
      .... .... .... .1.. = Destination address compression: Stateful
      .... .... .... ..01 = Destination address mode: 64-bits inline (0x0001)
    00.. .... = ECN: 0
    ..00 .... = Padding: 0x00
    .... 1100  1011 0001  1001 0000 = Flow label: 0x0cb190
    [Source: ::e0:4cff:fe5a:dd06]
    Destination: ::1cfd:8ff:fe73:8567
  v UDP header compression
      1111 0... = Pattern: UDP compression header (0x1e)
      .... .0.. = Checksum: Inline
      .... ..00 = Ports: Inline (0)
    Source port: 51991
    Destination port: 1234
    UDP checksum: 0xc4fa
> Internet Protocol Version 6, Src: ::e0:4cff:fe5a:dd06, Dst: ::1cfd:8ff:fe73:8567
> User Datagram Protocol, Src Port: 51991, Dst Port: 1234
> Data (100 bytes)
```

Ref.#5: IEEE WCL about “IPv6 over OWC”

Cheol-min Kim, Sang-Kyu Lim, Jin-Doo Jeong, Younghwan Choi, Seok-Joo Koh, "**6LoWPAN Over Optical Wireless Communications for IPv6 Transport in Internet of Things Networks**” **IEEE Wireless Communications Letters**, Vol. 11, Issue 6, June 2022.