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

draft-choi-6lo-owc-02

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

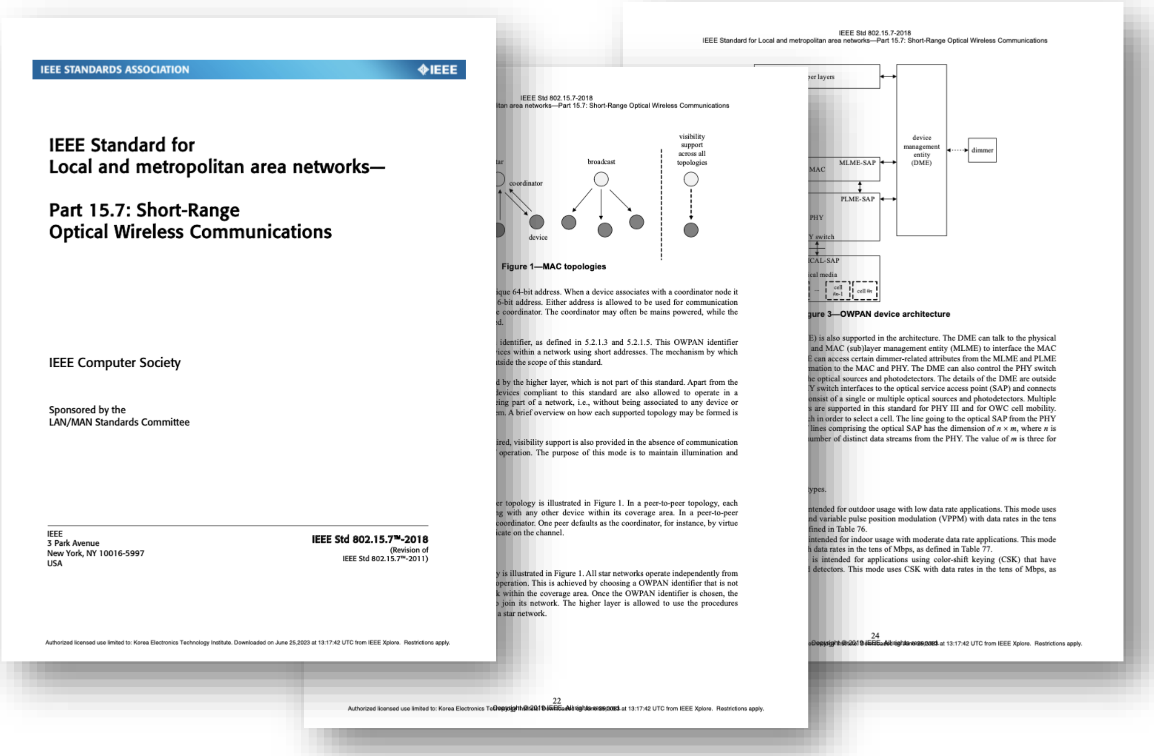
- **draft-choi-6lo-owc-02 (IETF 119, Brisbane, March 2024)**
  - **Revision incorporating comments from IETF118**
  - **Addition of SCHC in IPv6 over OWC**

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



IEEE STANDARDS ASSOCIATION

IEEE Standard for
Local and metropolitan area networks—

Part 15.7: Short-Range
Optical Wireless Communications

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std 802.15.7™-2018
(Revision of
IEEE Std 802.15.7™-2011)

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Visible Light Communication (VLC),

Short-Range Bidirectional Communication,

Line-of-Sight (LOS) &

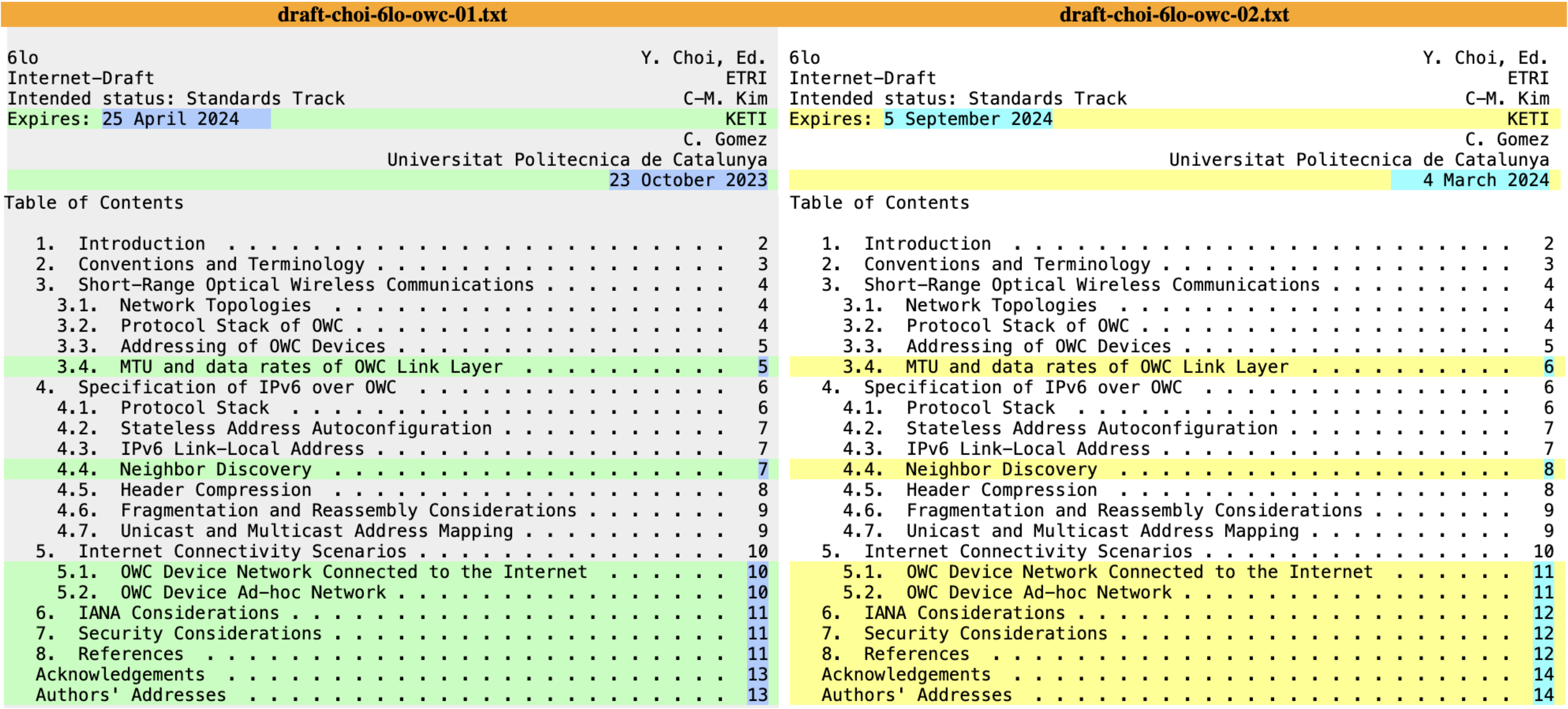
Non-Line-of-Sight (NLOS) Support,

High and Low Data Rates,

Energy Efficiency,

and Secure Communication.

Updates btw -01 v.s. -02



draft-choi-6lo-owc-01.txt	draft-choi-6lo-owc-02.txt
6lo Y. Choi, Ed.	6lo Y. Choi, Ed.
Internet-Draft ETRI	Internet-Draft ETRI
Intended status: Standards Track C-M. Kim	Intended status: Standards Track C-M. Kim
Expires: 25 April 2024 KETI	Expires: 5 September 2024 KETI
C. Gomez	C. Gomez
Universitat Politecnica de Catalunya	Universitat Politecnica de Catalunya
23 October 2023	4 March 2024
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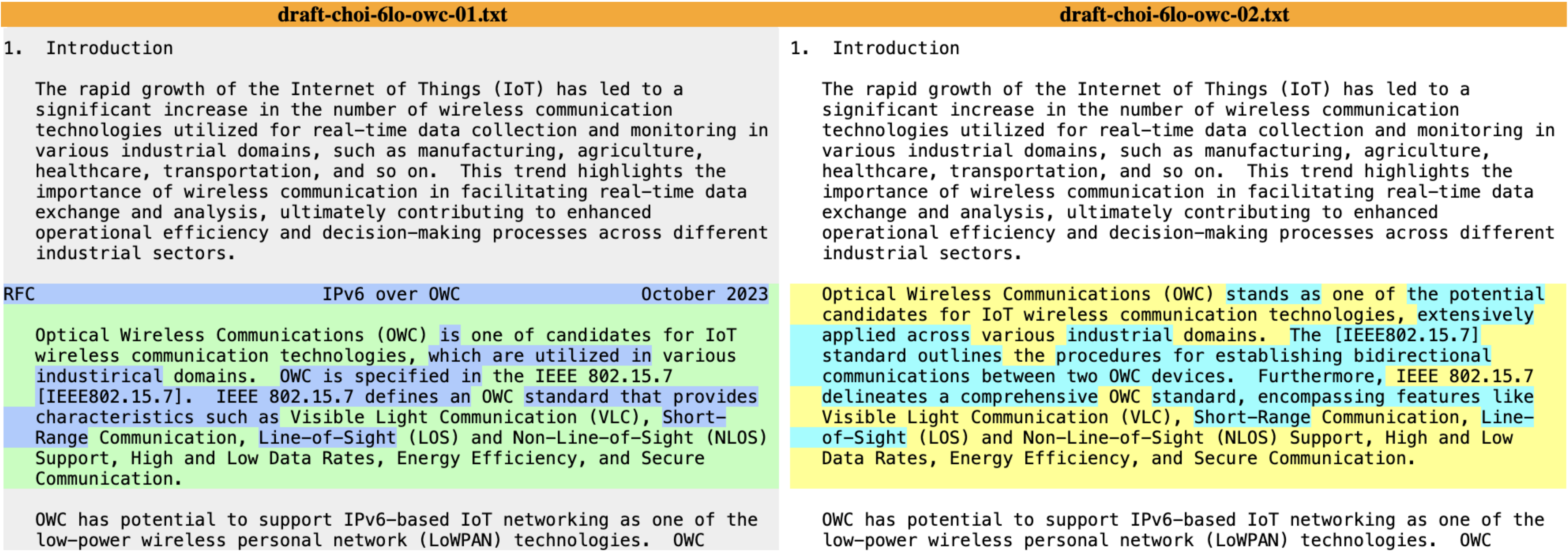
Comment in IETF 118

- #1: “Explicitly state how to get bidirectional” by Esko



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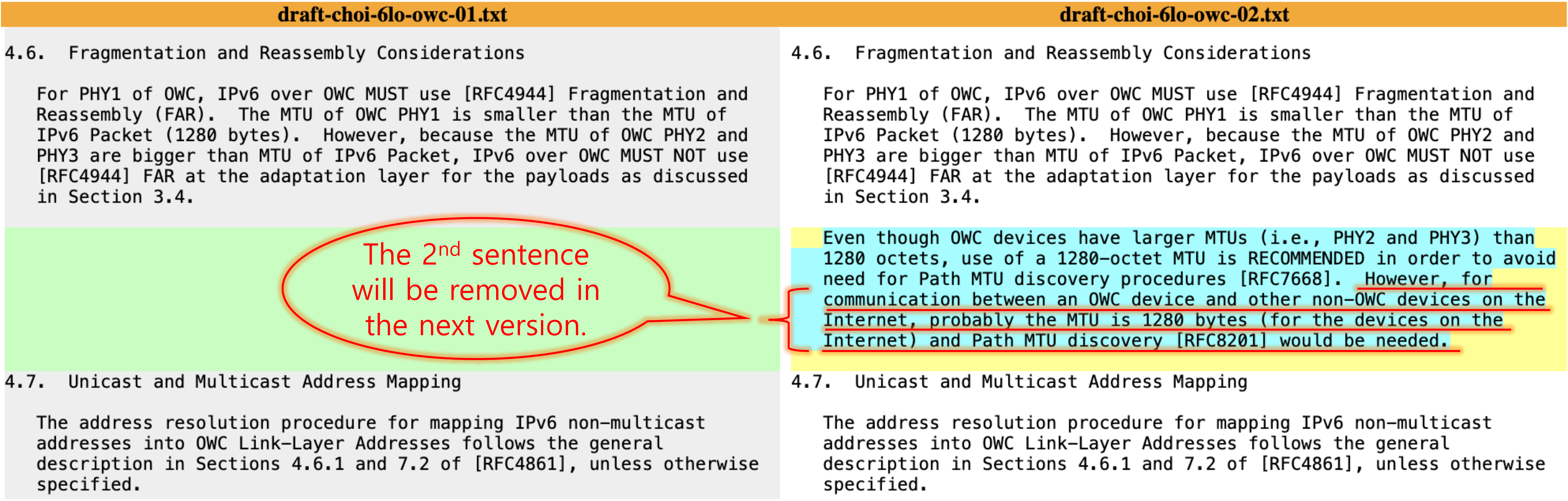
1. Introduction	1. Introduction
The rapid growth of the Internet of Things (IoT) has led to a significant increase in the number of wireless communication technologies utilized for real-time data collection and monitoring in various industrial domains, such as manufacturing, agriculture, healthcare, transportation, and so on. This trend highlights the importance of wireless communication in facilitating real-time data exchange and analysis, ultimately contributing to enhanced operational efficiency and decision-making processes across different industrial sectors.	The rapid growth of the Internet of Things (IoT) has led to a significant increase in the number of wireless communication technologies utilized for real-time data collection and monitoring in various industrial domains, such as manufacturing, agriculture, healthcare, transportation, and so on. This trend highlights the importance of wireless communication in facilitating real-time data exchange and analysis, ultimately contributing to enhanced operational efficiency and decision-making processes across different industrial sectors.
RFC IPv6 over OWC October 2023 Optical Wireless Communications (OWC) is one of candidates for IoT wireless communication technologies, which are utilized in various industirical domains. OWC is specified in the IEEE 802.15.7 [IEEE802.15.7]. IEEE 802.15.7 defines an OWC standard that provides characteristics such as Visible Light Communication (VLC), Short-Range Communication, Line-of-Sight (LOS) and Non-Line-of-Sight (NLOS) Support, High and Low Data Rates, Energy Efficiency, and Secure Communication.	Optical Wireless Communications (OWC) stands as one of the potential candidates for IoT wireless communication technologies, extensively applied across various industrial domains. The [IEEE802.15.7] standard outlines the procedures for establishing bidirectional communications between two OWC devices. Furthermore, IEEE 802.15.7 delineates a comprehensive OWC standard, encompassing features like Visible Light Communication (VLC), Short-Range Communication, Line-of-Sight (LOS) and Non-Line-of-Sight (NLOS) Support, High and Low Data Rates, Energy Efficiency, and Secure Communication.
OWC has potential to support IPv6-based IoT networking as one of the low-power wireless personal network (LoWPAN) technologies. OWC	OWC has potential to support IPv6-based IoT networking as one of the low-power wireless personal network (LoWPAN) technologies. OWC

Comment in IETF 118

- #2: “Consider whether Path MTU discovery is needed” by Pascal



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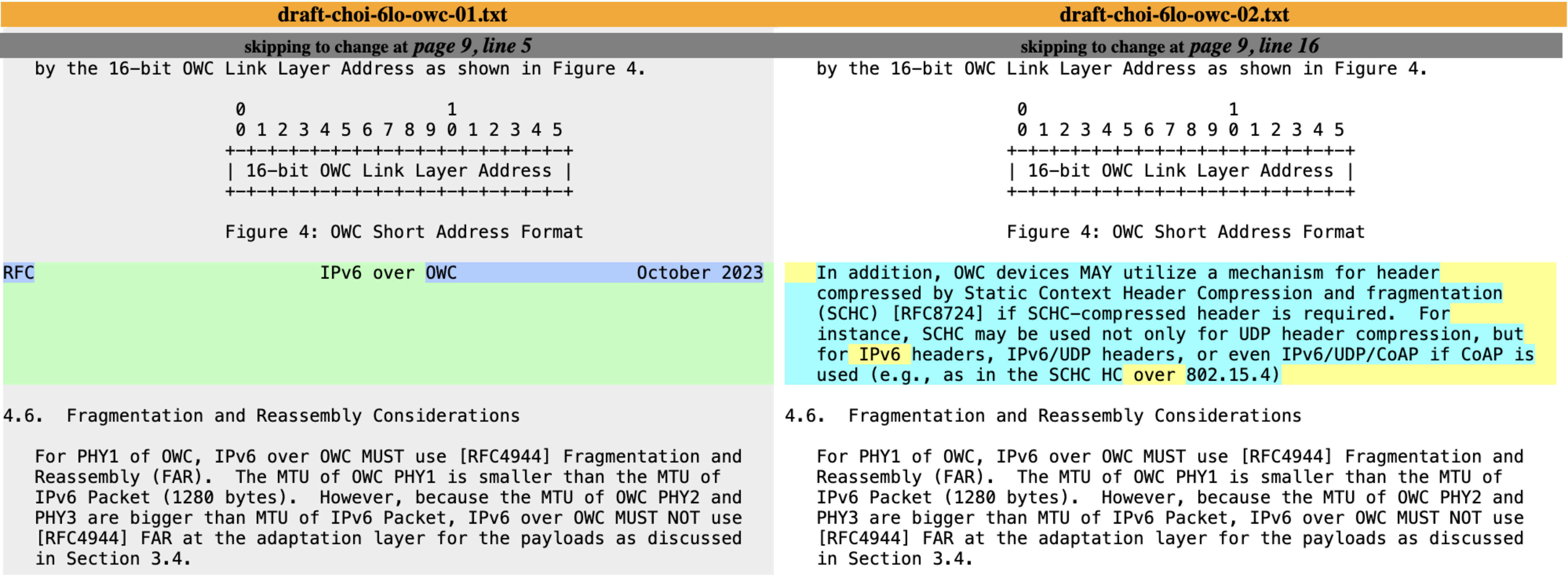
4.6. Fragmentation and Reassembly Considerations	4.6. Fragmentation and Reassembly Considerations
For PHY1 of OWC, IPv6 over OWC MUST use [RFC4944] Fragmentation and Reassembly (FAR). The MTU of OWC PHY1 is smaller than the MTU of IPv6 Packet (1280 bytes). However, because the MTU of OWC PHY2 and PHY3 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.	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	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 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 will be removed in the next version.

Addition about SCHC

- **SCHC in IPv6 over OWC** (Further considerations required)



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```
   by the 16-bit OWC Link Layer Address as shown in Figure 4.

                        0                   1
                        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
                       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       | 16-bit OWC Link Layer Address |
                       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

                       Figure 4: OWC Short Address Format

RFC                              IPv6 over OWC                  October 2023

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.
```

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```
   by the 16-bit OWC Link Layer Address as shown in Figure 4.

                        0                   1
                        0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5
                       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
                       | 16-bit OWC Link Layer Address |
                       +-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+

                       Figure 4: OWC Short Address Format

   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)

4.6.  Fragmentation and Reassembly Considerations

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   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.
```
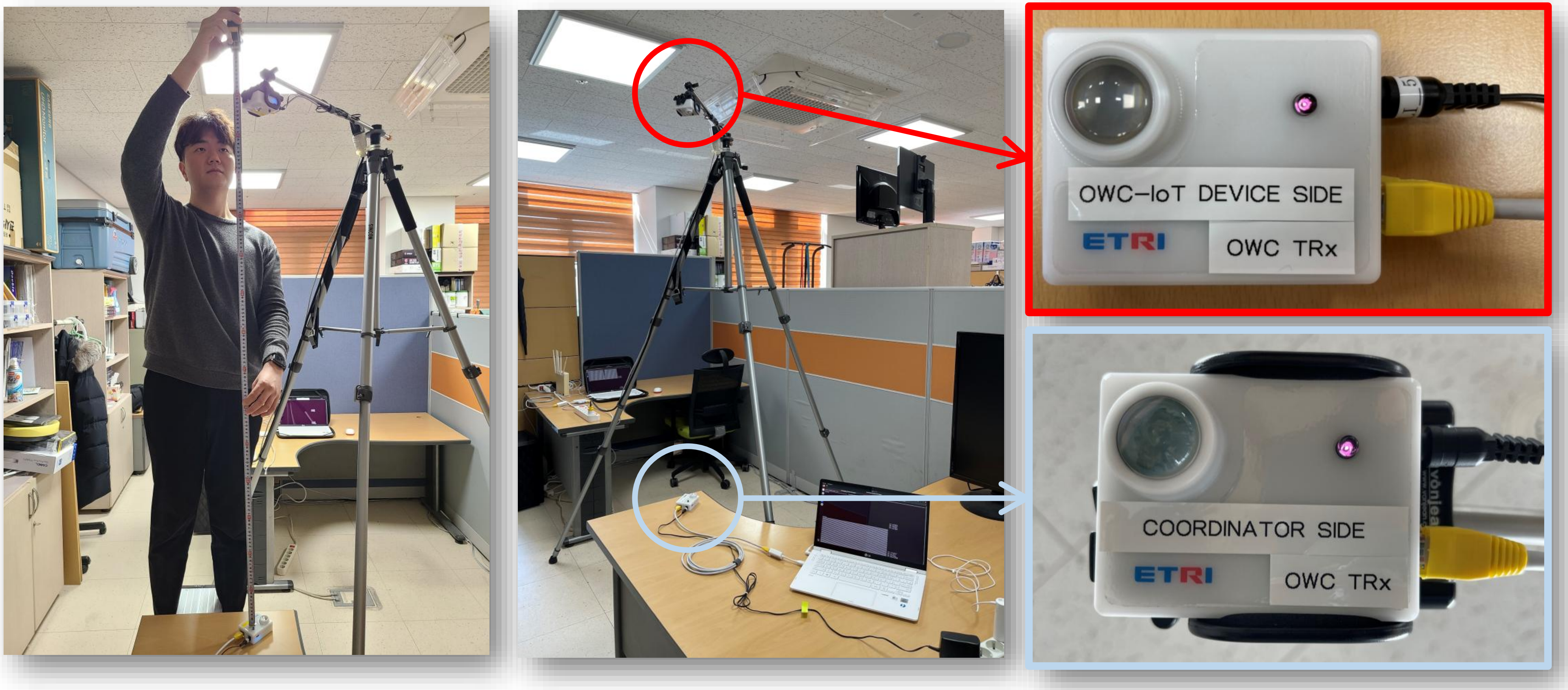

Concluding remarks

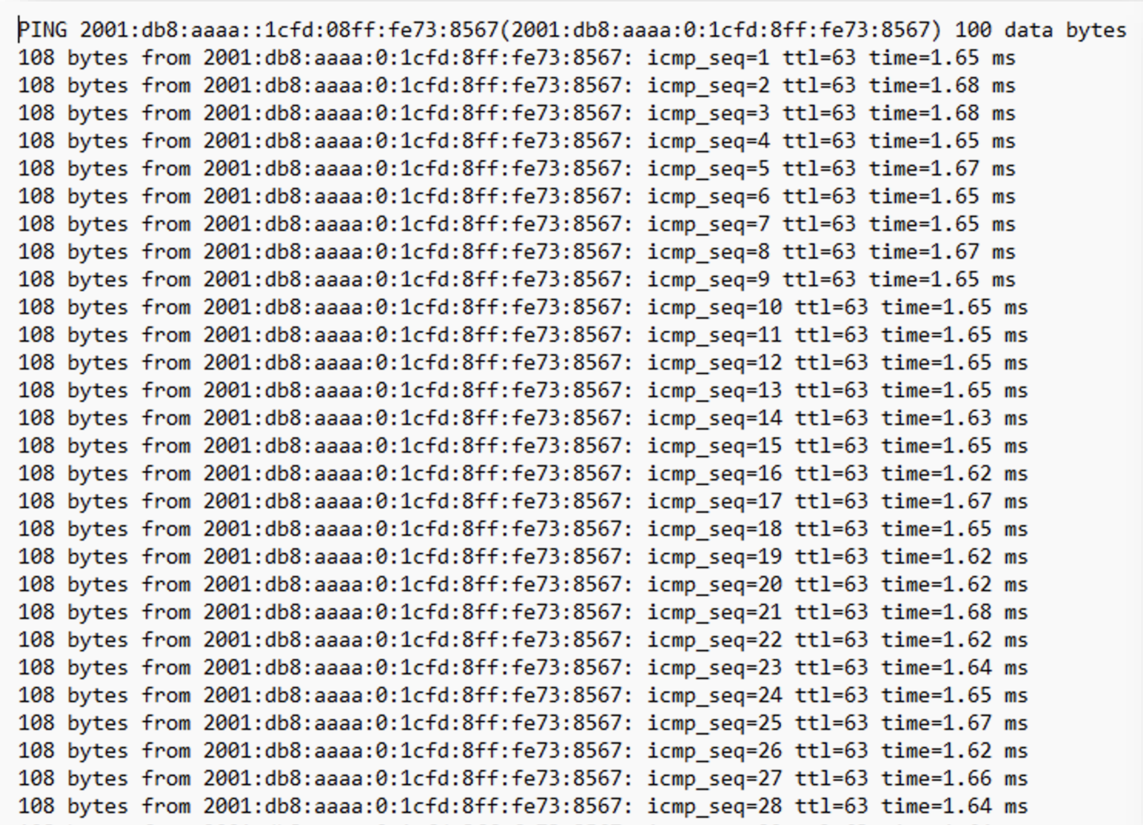
- **The 3rd Individual I.D., “draft-choi-6lo-owc-02” for IPv6 over OWC:** revised for comments in IETF118 & SCHC in IPv6 over OWC
- **We would like to ask for “WG-draft adoption“ of 6lo WG:** in IETF 119 (Brisbane, March 2024)
- **Please read the draft and welcome to any feedback !!**

Ref.#3: Test-bed for “IPv6 over OWC”



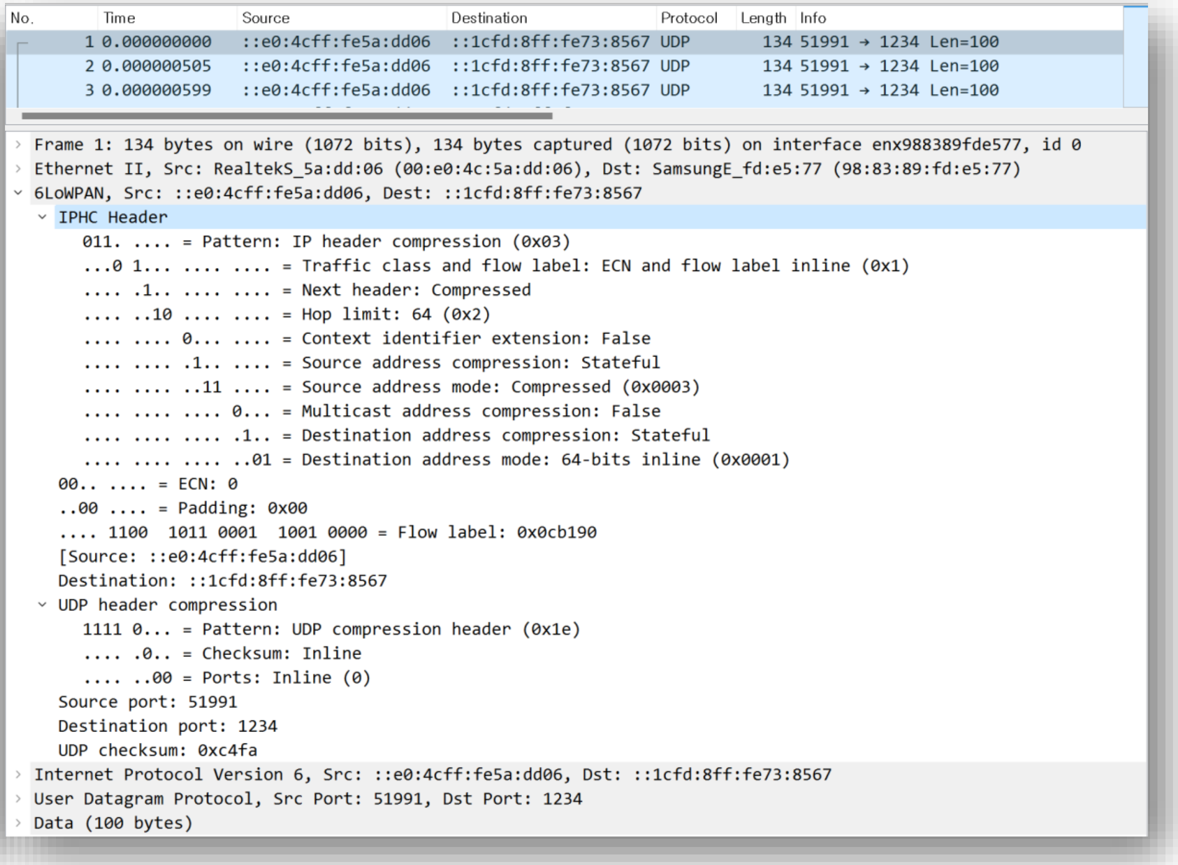
Ref.#4: Test Results of “IPv6 over OWC”

- 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
```

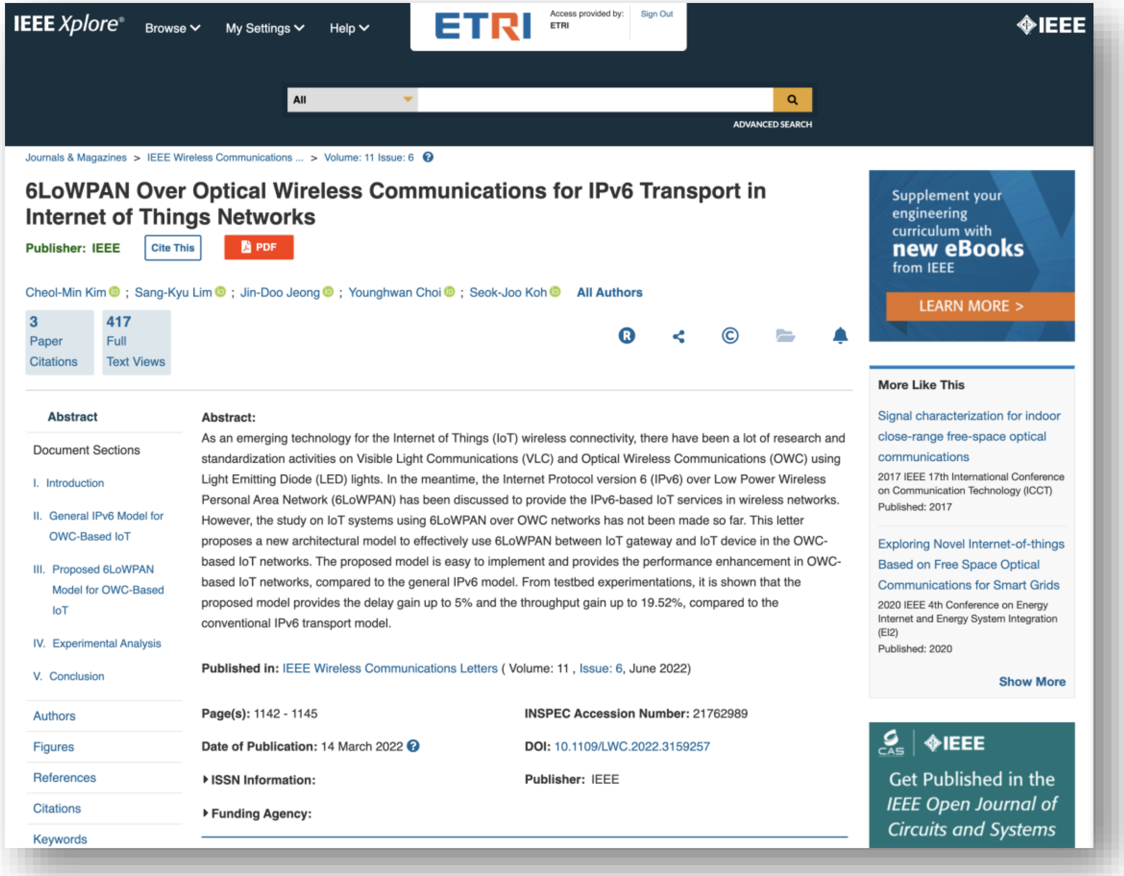
- Wireshark captured



```
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”



6LoWPAN Over Optical Wireless Communications for IPv6 Transport in Internet of Things Networks

Publisher: IEEE

Cheol-Min Kim ; Sang-Kyu Lim ; Jin-Doo Jeong ; Younghwan Choi ; Seok-Joo Koh

Abstract:

As an emerging technology for the Internet of Things (IoT) wireless connectivity, there have been a lot of research and standardization activities on Visible Light Communications (VLC) and Optical Wireless Communications (OWC) using Light Emitting Diode (LED) lights. In the meantime, the Internet Protocol version 6 (IPv6) over Low Power Wireless Personal Area Network (6LoWPAN) has been discussed to provide the IPv6-based IoT services in wireless networks. However, the study on IoT systems using 6LoWPAN over OWC networks has not been made so far. This letter proposes a new architectural model to effectively use 6LoWPAN between IoT gateway and IoT device in the OWC-based IoT networks. The proposed model is easy to implement and provides the performance enhancement in OWC-based IoT networks, compared to the general IPv6 model. From testbed experimentations, it is shown that the proposed model provides the delay gain up to 5% and the throughput gain up to 19.52%, compared to the conventional IPv6 transport model.

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