

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

draft-choi-6lo-owc-00

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# IPv6-over-foo Technologies...

- IPv6 over **IEEE 802.15.4** (RFC4944, Sep. 2007)
- IPv6 over **ITU-T G.9959** (RFC7428, Feb. 2015)
- IPv6 over **Bluetooth LE** (RFC7668, Oct. 2015)
- IPv6 over **DECT ULE** (RFC8105, May 2017)
- IPv6 over **MS/TP** (RFC8163, May 2017)
- IPv6 Mesh over **Bluetooth LE** (RFC9159, Dec. 2021)
- IPv6 over **PLC** (RFC9354, Jan. 2023)
- IPv6 over **NFC** (RFC9428, Jul. 2023)
- **What else for IPv6 over foo?**

⇒ IPv6 over **OWC (IEEE 802.15.7)**



LED



# Short-Range Optical Wireless Communications (OWC) ?

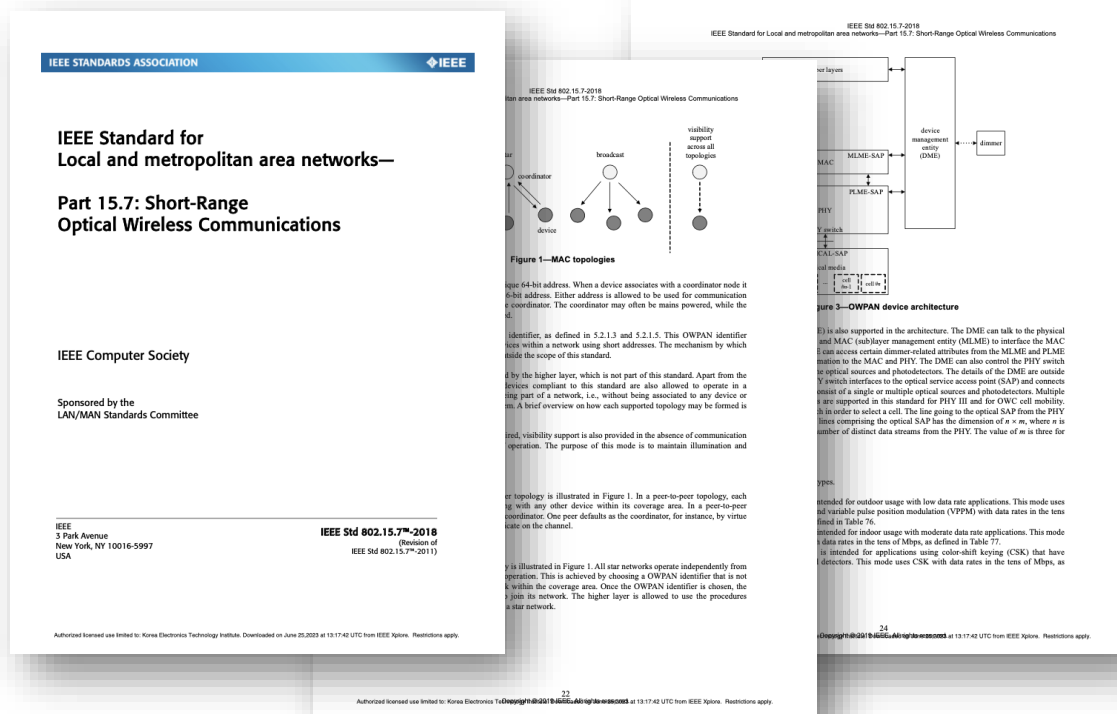
- OWC uses **intensity modulation of optical sources**, such as **Light Emitting Diodes (LEDs)**.
- OWC combines lighting and **data communications**.
- OWC can be finding applications in various domains including area **lighting, signboards, streetlights, vehicles, traffic signals, displays, LED panels,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



# OWC & IEEE 802.15.7

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

**Visible Light Communication (VLC), Short-Range Communication, Line-of-Sight (LOS) & Non-Line-of-Sight (NLOS) Support, High and Low Data Rates, Energy Efficiency, and Secure Communication.**



# Considering on "IPv6 over OWC"

- **Network Topologies**

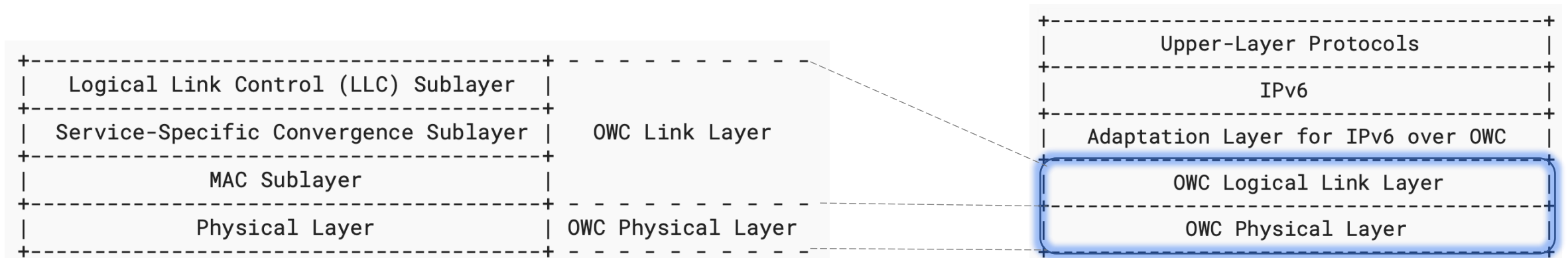
- OWC ⇒ P2P, Star
- IPv6 over OWC ⇒ more complicated topologies like Mesh

- **Addressing of OWC**

- 16-bit short address or
- Unique 64-bit address

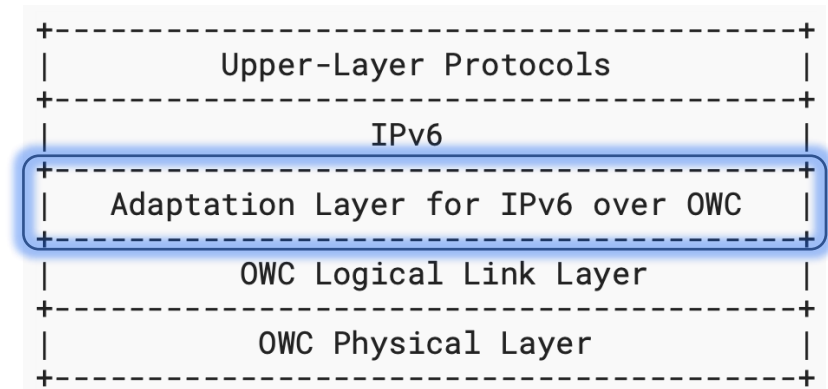
- **MTU & Bit Rates of OWC**

Type	Maximum packet size ( <i>aMaxPHYFrameSize</i> )	Data rate
PHY 1	1,023 bytes	11.67 kbps ~ 266.6 kbps
PHY 2	65,535 bytes	1.25 Mbps ~ 96 Mbps
PHY 3	65,535 bytes	12 Mbps ~ 96 Mbps



# Technical Issues of "IPv6 over OWC"

- Stateless Address Autoconfiguration
- IPv6 Link-Local Address (IID)
- Neighbor Discovery
- Header Compression
- Fragmentation and Reassembly
- Unicast/Multicast Address Mapping
- Internet Connectivity



# Test-bed for "IPv6 over OWC"



# 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)  
6LoWPAN, Src: ::e0:4cff:fe5a:dd06, Dest: ::1cfd:8ff:fe73:8567

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

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. IEEE WCL about "IPv6 over OWC"

The screenshot shows the IEEE Xplore article page for the paper "6LoWPAN Over Optical Wireless Communications for IPv6 Transport in Internet of Things Networks". The page includes the IEEE logo, search bar, and navigation options. The article title is prominently displayed, along with the authors' names: Cheol-Min Kim, Sang-Kyu Lim, Jin-Doo Jeong, Younghwan Choi, and Seok-Joo Koh. The abstract is visible, discussing the use of 6LoWPAN over OWC networks for IoT services. The page also features a "More Like This" section with related articles and a "Get Published in the IEEE Open Journal of Circuits and Systems" banner.

**6LoWPAN Over Optical Wireless Communications for IPv6 Transport in Internet of Things Networks**  
Publisher: IEEE  
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Cheol-Min Kim ; Sang-Kyu Lim ; Jin-Doo Jeong ; Younghwan Choi ; Seok-Joo Koh All Authors

3 Paper Citations 417 Full Text Views

**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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**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.**

# Concluding remarks

- **The 1<sup>st</sup> Individual I.D., “draft-choi-6lo-owc-00” for IPv6 over OWC;** get started & published
- LEDs; **being widely used anywhere for lightening** (& nature-friendly)
- **OWC; data transmission** by using LEDs **based on the std. IEEE 802.15.7**
- **“IPv6 over OWC”** has shown promising results **as one of the IPv6-over-foo technologies** based on the test-bed experimental outcomes.