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

draft-choi-6lo-owc-01

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Status of “IPv6 over OWC”

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

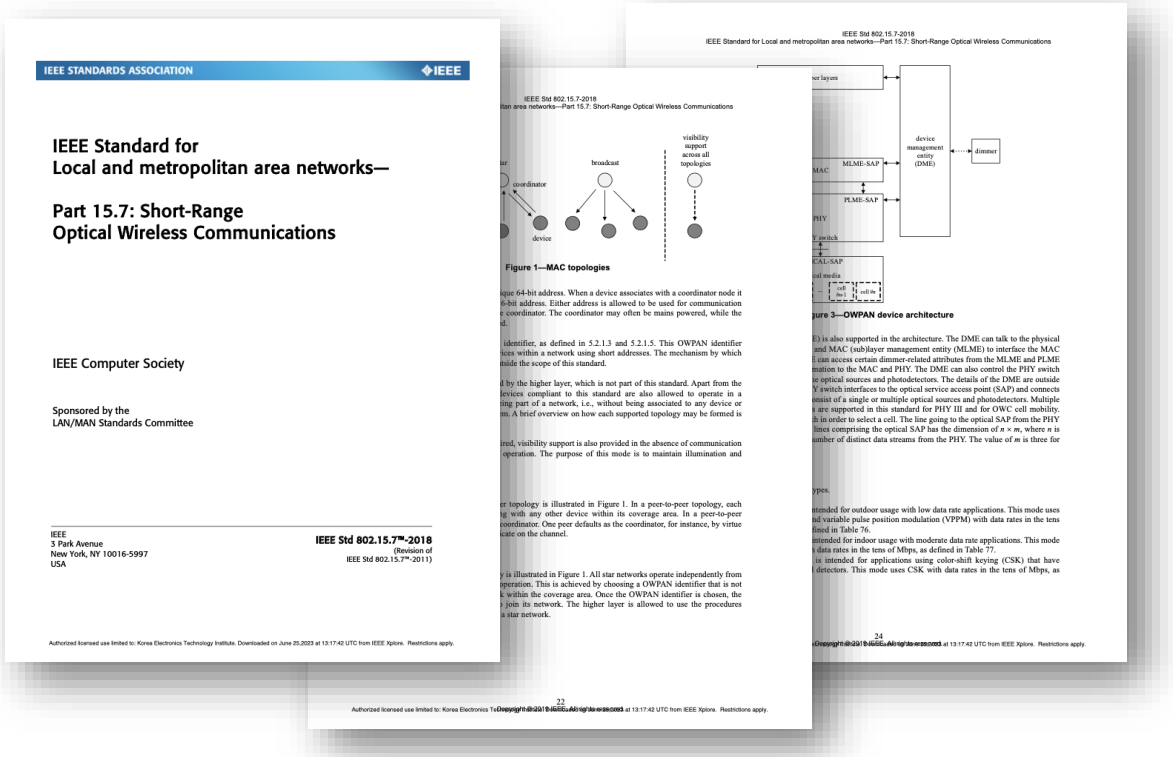
- draft-choi-6lo-owc-01 (IETF 118, Prague, November 2023)
  - Revision of “IPv6 over OWC” technical issues

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.

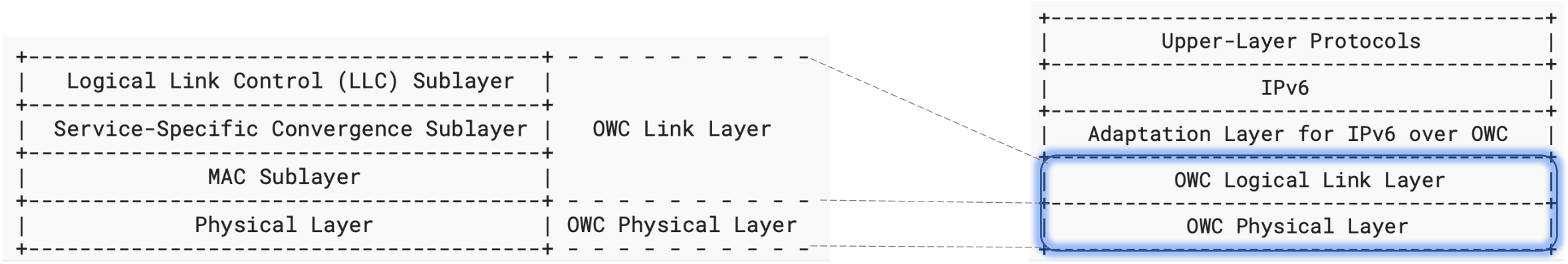
Considering on “IPv6 over OWC”

- **Network Topologies**
  - OWC ⇒ P2P, Star
  - IPv6 over OWC ⇒ also more complicated topologies (including the mesh topology)
- **Addressing of OWC**
  - 16-bit short address or
  - Unique 64-bit address

- **MTU & Bit Rates of OWC**

MAXIMUM PACKET SIZE AND DATA RATES IN IEEE 802.15.7 [2]

Type	Maximum packet size (*aMaxPHYFrameSize*)	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



IPv6 over OWC - #1: Addressing

- **Stateless address autoconfiguration:** [RFC4862]
- **A 64-bit IID for an OWC interface** [RFC7136] - 16-bit or 64-bit address of OWC (in Figure 3)
- **Random Identifiers (RIDs)** [RFC7217] - F() with input parameters
  - **Net_Iface**: OWC 16-bit Link-Layer Address MUST be a source
  - **SHA-256**: secured and stable IIDs for OWC devices
  - **Network_ID**, is used to increase the randomness of the generated IID
  - **Secret key**: SHOULD be at least 128 bits and MUST be initialized to a pseudorandom number [RFC4086]

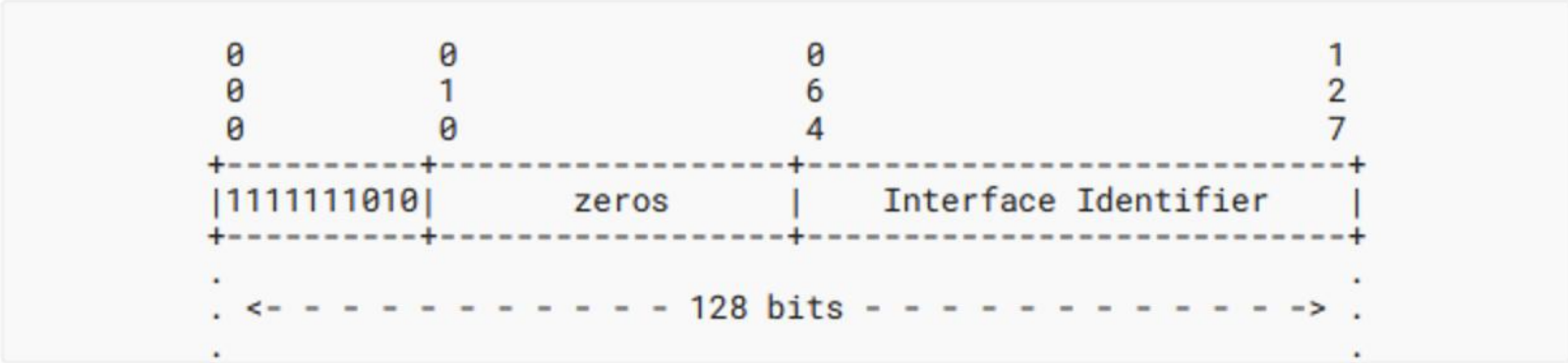


Figure 3: IPv6 Link-Local Address in OWC

IPv6 over OWC - #2: Neighbor discovery

- **IPv6 over OWC supports mesh topologies with route-over:** Neighbor Discovery Optimization for 6LoWPANs [RFC6775] [RFC8505]
  - **When an OWC 6LN is directly connected to a 6LBR:** The OWC 6LN MUST register its address with the 6LBR by NS with EARO [RFC8505]
  - **When OWC multi-hop topology connected to a 6LBR:** The 6LBR performs DAD [RFC6775] for the acquired link-local address of the 6LNs
  - **For receiving RSs and RAs:** The OWC 6LNs MUST follow Sections 5.3 and 5.4 of [RFC6775]
  - **An OWC 6LR (or 6LBR):** MUST follow Sections 6 and 7 of [RFC6775]

IPv6 over OWC - #3: HC & #4 FAR

- **Header Compression:** All headers be compressed according to the encoding formats described in [RFC6282].
- **Fragmentation and Reassembly (FAR)**
  - **PHY1 of OWC**: IPv6 over OWC MUST use FAR as defined in [RFC4944] (MTU of the OWC PHY1 < 1280 Bytes)
  - **PHY2 & PHY3 of OWC**: IPv6 over OWC MUST NOT use FAR in defined in [RFC4944] (MTU of the OWC PHY2 & PHY3 > 1280 Bytes)

IPv6 over OWC - #5: Unicast & Multicast Addr. Mapping

- **The address resolution procedure for mapping IPv6 non-multicast addresses:** Sections 4.6.1 and 7.2 of [RFC4861]
- **6LBR MUST keep track of multicast listeners (at OWC link-level granularity not at subnet granularity):**
  a 6LN always has to send multicast packets through the 6LBR

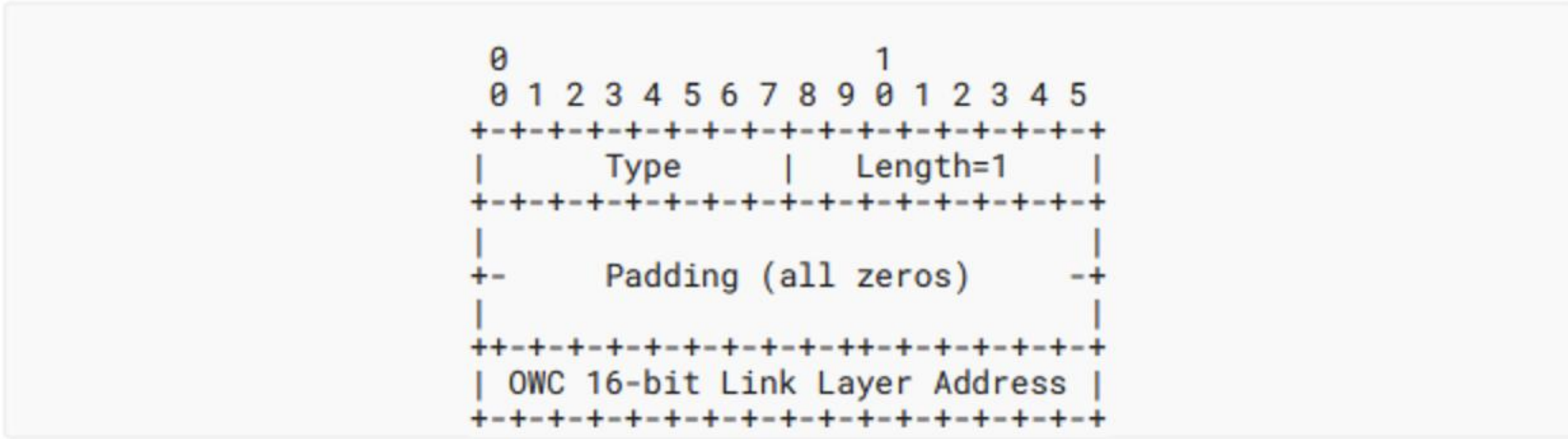


Figure 5: Unicast Address Mapping

IPv6 over OWC - #6: Connectivity scenarios

Figure 6: OWC Device Network Connected to the Internet

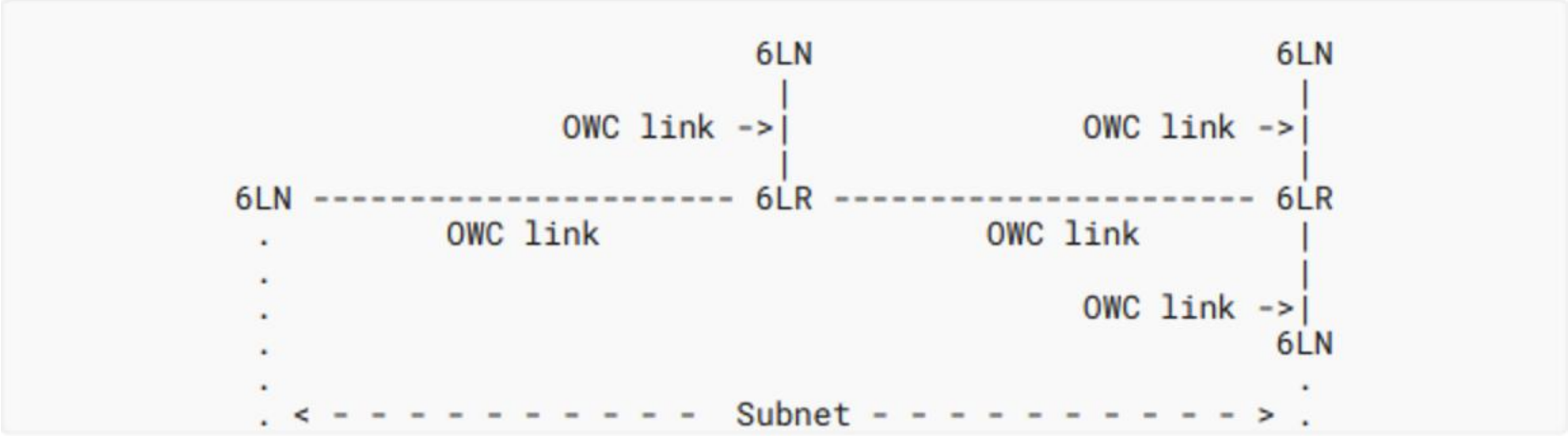


Figure 7: Isolated OWC Device Network

Concluding remarks

- **The 2st Individual I.D., "draft-choi-6lo-owc-01" for IPv6 over OWC:**
  revised for mature and detailed IPv6-over-OWC technologies
- **Further considerations for the next I.D.,-02:**
  SCHC for OWC
- **We plan to ask for WG adoption of 6lo WG:**
  in IETF119 (Brisbane, March 2024)
- **Please read the draft and provide feedback !!**

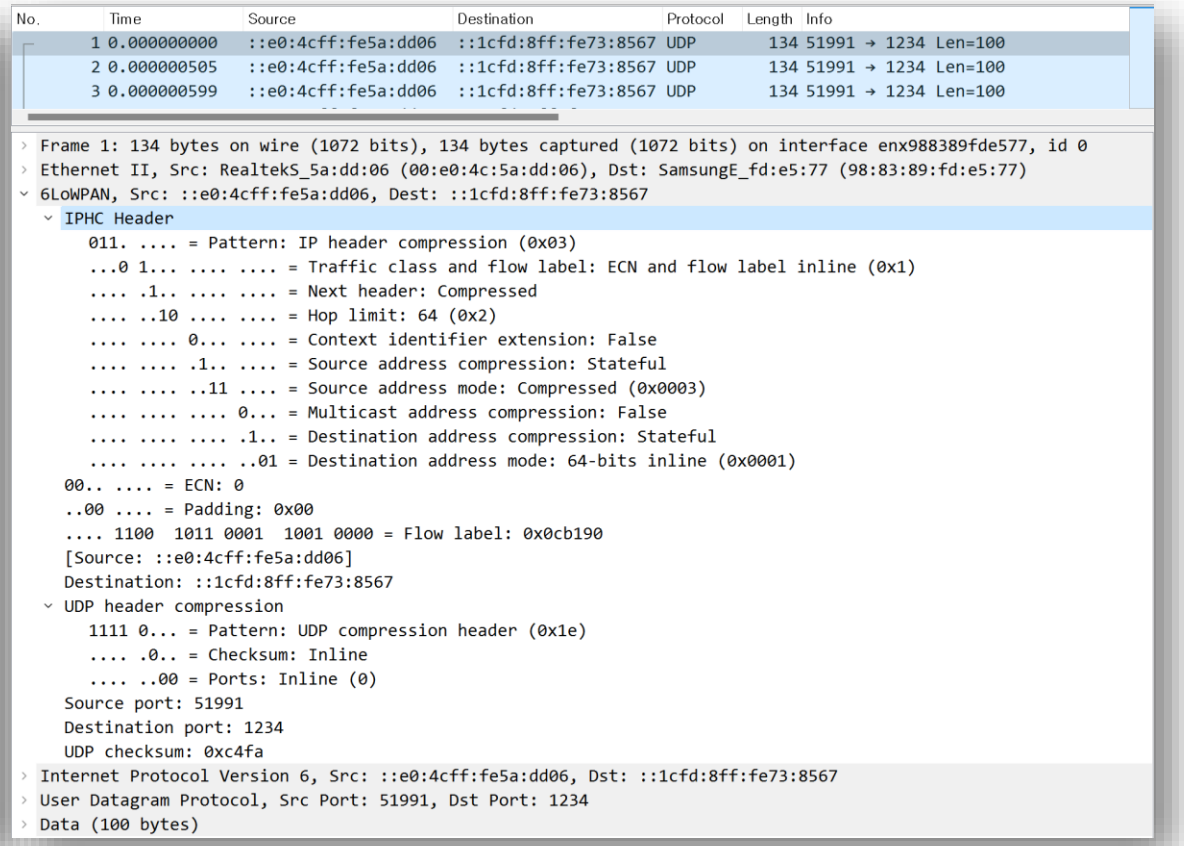
Ref. - Test-bed for “IPv6 over OWC”

Ref. - 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



Ref. - 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.