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 \Rightarrow 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]TypeMaximum packet size
(aMaxPHYFrameSize)Data ratePHY 11,023 bytes11.67 kbps ~ 266.6 kbpsPHY 265,535 bytes1.25 Mbps ~ 96 MbpsPHY 365,535 bytes12 Mbps ~ 96 Mbps

+	+	Upper-Layer Protocols
Logical Link Control (LLC) Sublayer	 +	IPv6
Service-Specific Convergence Sublayer	OWC Link Layer	Adaptation Layer for IPv6 over OWC
MAC Sublayer		 OWC Logical Link Layer
Physical Layer	OWC Physical Layer	 OWC Physical Layer

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"

Wireshark captured

• Ping responses

Time Destination Protocol Length Info Source PING 2001:db8:aaaa::1cfd:08ff:fe73:8567(2001:db8:aaaa:0:1cfd:8ff:fe73:8567) 100 data bytes 1 0.000000000 ::e0:4cff:fe5a:dd06 ::1cfd:8ff:fe73:8567 UDP 134 51991 → 1234 Len=100 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seq=1 ttl=63 time=1.65 ms 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=100 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=2 ttl=63 time=1.68 ms 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=3 ttl=63 time=1.68 ms Frame 1: 134 bytes on wire (1072 bits), 134 bytes captured (1072 bits) on interface enx988389fde577, id 0 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=4 ttl=63 time=1.65 ms Ethernet II, Src: Realteks_5a:dd:06 (00:e0:4c:5a:dd:06), Dst: SamsungE_fd:e5:77 (98:83:89:fd:e5:77) 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seq=5 ttl=63 time=1.67 ms 6LoWPAN, Src: ::e0:4cff:fe5a:dd06, Dest: ::1cfd:8ff:fe73:8567 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seq=6 ttl=63 time=1.65 ms IPHC Header 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=7 ttl=63 time=1.65 ms 011. = Pattern: IP header compression (0x03) 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=8 ttl=63 time=1.67 ms ...0 1... = Traffic class and flow label: ECN and flow label inline (0x1) 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seq=9 ttl=63 time=1.65 ms1.. = Next header: Compressed 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=10 ttl=63 time=1.65 ms 0.... = Context identifier extension: False 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=11 ttl=63 time=1.65 ms1.. .1.. = Source address compression: Stateful 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=12 ttl=63 time=1.65 ms 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=13 ttl=63 time=1.65 ms 0... = Multicast address compression: False 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=14 ttl=63 time=1.63 ms1.. = Destination address compression: Stateful 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=15 ttl=63 time=1.65 ms01 = Destination address mode: 64-bits inline (0x0001) 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seq=16 ttl=63 time=1.62 ms 00.. = ECN: 0 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=17 ttl=63 time=1.67 ms ..00 = Padding: 0x00 1100 1011 0001 1001 0000 = Flow label: 0x0cb190 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=18 ttl=63 time=1.65 ms [Source: ::e0:4cff:fe5a:dd06] 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=19 ttl=63 time=1.62 ms Destination: ::1cfd:8ff:fe73:8567 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=20 ttl=63 time=1.62 ms UDP header compression 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=21 ttl=63 time=1.68 ms 1111 0... = Pattern: UDP compression header (0x1e) 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seq=22 ttl=63 time=1.62 ms0.. = Checksum: Inline 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seq=23 ttl=63 time=1.64 ms00 = Ports: Inline (0) 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seq=24 ttl=63 time=1.65 ms Source port: 51991 Destination port: 1234 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=25 ttl=63 time=1.67 ms UDP checksum: 0xc4fa 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp_seq=26 ttl=63 time=1.62 ms Internet Protocol Version 6, Src: ::e0:4cff:fe5a:dd06, Dst: ::1cfd:8ff:fe73:8567 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=27 ttl=63 time=1.66 ms User Datagram Protocol, Src Port: 51991, Dst Port: 1234 108 bytes from 2001:db8:aaaa:0:1cfd:8ff:fe73:8567: icmp seg=28 ttl=63 time=1.64 ms Data (100 bytes)

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.