IPv6 Vehicular Communications over IEEE 802.11-OCB Wireless Link

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***Abstract*—Vehicular communications can provide a prompt means to improve safety of vehicle driving, and produce many emerging services when vehicles are easily and securely connected to the Internet. To facilitate the IPv6 adoption in vehicular communications, this paper presents an implementation of IPv6 vehicular communications over IEEE 802.11-OCB mode.**

***Index Terms*—Vehicular Communications, IPv6, IEEE 802.11, Vehicular Networks, Internet of Vehicles.**

I. Introduction

Recently, vehicular communications has been drawing significant attentions due to its potential benefits for autonomous driving vehicles. Connected autonomous vehicles cannot only have another safe driving system for themselves, but also introduce other emerging services based on the connections, such as entertainment-in-vehicle, fast automobile insurance process, and advanced vehicle navigation services [1], [2]. Both IEEE and 3GPP have proposed vehicle-to-everything (V2X) communication standards. IEEE 802.11-Outside the Context of a Basic service set (OCB) mode (called IEEE 802.11-OCB) [3] based on the Dedicated Short-Range Communications (DSRC) technology (also called ITS-G5 in EU) has provided a basic way for vehicles to communicate with each other. Meanwhile, 3GPP has also suggested a Cellular-V2X (C-V2X) communication approach [4] in 4G/LTE and 5G networks.

However, for IEEE 802.11-OCB, enabling vehicles to directly connect with the Internet has not been explored much, especially in the context of IPv6. This paper presents an implementation of IPv6 vehicular communications over IEEE 802.11-OCB mode. We leverage the existing Linux kernel implementation for the OCB mode, and use two laptops to simulate two vehicles' communications. To demonstrate a possible use case of this implementation, we set up the GStreamer to stream the webcam of one laptop to the other. Based on this implementation, one can develop more advanced functions for vehicular communications. Note that this implementation has been released and demonstrated in the hackathon of the 106th Internet Engineering Task Force (IETF) meeting for the IP Wireless Access in Vehicular Environments (IPWAVE) working group [5].

The rest of this paper is organized as follows. Section II summarizes the related work. Section III describes the design and experiment. Finally, in Section IV, we conclude this paper along with future work.

Note: the implementation can be accessed on the IPWAVE Github repository: https://github.com/ipwave-hackathon-ietf/ipwave-hackathon-ietf-106

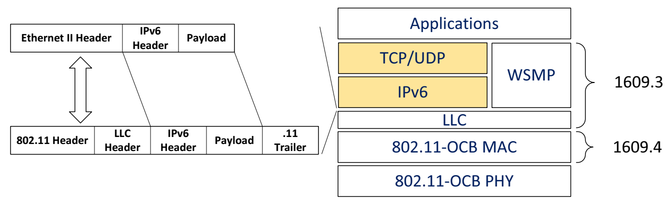

Fig. 1. IP protocol stack over IEEE 802.11-OCB mode.

II. Related Work

The DSRC technology was proposed to facilitate Intelligent Transportation Systems (ITS) by vehicular communications in the automobile industry. It defines seven channels at 5.9GHz band, including one control channel and four service channels, with a communication range up to 1 km. On top of DSRC, IEEE 802.11-OCB along with IEEE WAVE standards suggests several functions to further detail the use of those DSRC channels, such as MAC operations, channel switching mechanisms, and WAVE Short Message Protocols (WSMP). In the IEEE WAVE 1609.3 standard, a basic IP networking is suggested based on the standard IPv6 operations. The specific configurations of IPv6, however, are not well defined in this standard, which may hinder a fast adoption for IPv6-based vehicular networking services. Meanwhile, 3GPP has proposed a C-V2X communication approach in 4G/LTE and 5G networks. The approach employs sidelinks of the cellular networks to support both managed communications (Mode 3) and autonomous communications (Mode 4) for vehicles. The Mode 4 as the baseline mode allows vehicles to autonomously select their radio resources by a distributed scheduling scheme to communicate with other vehicles.

To make IPv6 better support vehicle communications, IETF IPWAVE working group has published a Request for Comments (RFC) 8691 [6] Internet standard to support IPv6 operations over IEEE 802.11-OCB mode. RFC 8691 details several operations for IPv6 over 802.11-OCB, such as frame format, link-local address configuration, stateless autoconfiguration, address mapping for unicast and multicast, and subnet structure. The IPWAVE problem statement document [7] also points out several limitations of the legacy IPv6 for vehicular networks, such as IPv6 Neighbor Discovery (ND), IPv6 Mobility Management (MM), and IPv6 Security and Privacy (SP). It also specifies the requirements of IPv6 based vehicular

TABLE I
IMPLEMENTATION CONFIGURATION

Parameter	Content
OS	Ubuntu 18.04
Linux Kernel	Modified OCB-enabled kernel (version 4.4)
WiFi card	Qualcomm Atheros AR9462 PCI-E
Laptop model	Samsung NT900X3E
Antenna	Two internal antennas of the laptop
Streaming software	GStreamer

Fig. 2. Implementation setup.

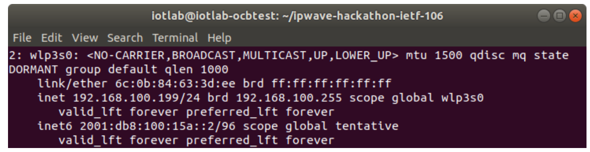

Fig. 3. IPv6 global and link-local addresses configuration.

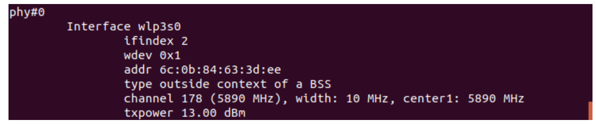

Fig. 4. Interface information of OCB-enabled WiFi module.

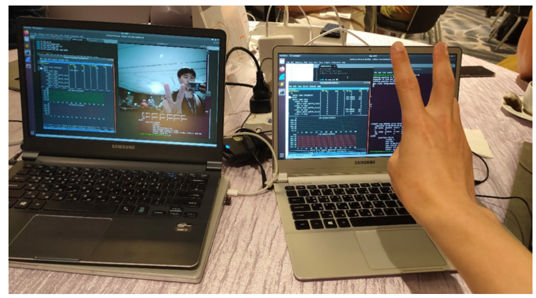

Fig. 5. Webcam streaming experiment by two OCB-mode enabled laptops.

networkings in terms of those three aspects (i.e., IPv6 ND, MM, and SP). Fig. 1 shows the protocol stacks of both IP-based networks and IEEE WAVE.

III. DESIGN AND EXPERIMENT

This section presents how we implemented the IPv6 over IEEE 802.11-OCB. Table I shows the hardware and software information for this implementation. To run OCB mode in Linux kernel, we need to

install the WiFi cards into the experiment laptop,
enable OCB mode and recompile the Linux kernel,
modify regulatory information to allow 5.9GHz band,
set up wireless link and configure IPv6 address.

The detailed steps are described in the source code manual in our IPWAVE Github repository. Fig. 2 shows the implementation setup.

We recompiled a modified Linux kernel to stream a webcam from one laptop to the other laptop by a DSRC channel. We manually configured IPv6 addresses of the two laptops as 2001:db8:100:15a::2 and ::3, respectively. After this IPv6 global address is configured, a link-local IPv6 address is also automatically configured by the interface MAC address of a laptop. Fig. 3 shows the configuration of IPv6 global and link-local addresses. Fig. 4 shows that WiFi module interface of a laptop is configured to run channel 178 (DSRC 5.89GHz channel) with 10 MHz bandwidth and 13 dBm transmission power. Fig. 5 shows that the webcam of one laptop could deliver a video stream to the other laptop.

IV. CONCLUSION

This paper presented an implementation of IPv6 vehicular communications over IEEE 802-OCB link. This implementation builds a foundation for other advanced applications based on IPv6-based vehicular networks. Through this work, we found that the IPv6 link-local address was not automatically configured, and the IPv6 ND protocol was either not automatically running. As future work, we will further improve those mechanisms.

V. ACKNOWLEDGMENT

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