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Jaehoon (Paul) Jeong [Editor], Nabil Benamar, Sandra Cespedes, Jerome Haerri, Dapeng Liu, Tae (Tom) Oh, Charles E. Perkins, Alexandre Petrescu, Yiwen (Chris) Shen, and Michelle Wetterwald
Update from -02 and -03 Versions

• This document (-04) is updated from
  – draft-ietf-ipwave-vehicular-networking-02
  – draft-ietf-ipwave-vehicular-networking-03

• Major Updates
  – Reorganization of Table of Contents (TOC) for problem statement and use cases in IPWAVE:
    • The request from AD (Suresh Krishnan) and IPWAVE Chairs.
    • TOC was from consensus in IETF-102 Meeting.
  – Key Work Items for IPWAVE Problem Statement
    • Neighbor Discovery
    • Mobility Management
    • Security and Privacy
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  3.2. V2I
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Appendix A. Relevant Work Items for IPWAVE
  A.1. Vehicle Identity Management
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    A.5.1. Cellular V2X (C-V2X) Using 4G-LTE
    A.5.2. Cellular V2X (C-V2X) Using 5G
Use Cases (1/3)

- **V2V**

  **Collision Avoidance**

  ![Collision Avoidance Diagram](image1)

  **Cooperative adaptive cruise control**

  ![Cooperative Adaptive Cruise Control Diagram](image2)

  **Cooperative environment sensing**

  ![Cooperative Environment Sensing Diagram](image3)

  **Platooning**

  ![Platooning Diagram](image4)

  Source: Daimler Trucks North America LLC.
Use Cases (2/3)

- V2I

**Navigation service**

Traffic Control Center (TCC) for Vehicular Cloud

**Energy-efficient speed recommendation**

The car at the front only saved 2 minutes.

**Accident notification service**
Use Cases (3/3)

- **V2X**
  - **Pedestrian protection service**
Analysis for Current Protocols (1/2)

• The Survey of Current Protocols
  – Survey is from IP-based vehicular networking research.
  – Protocols of each subject were summarized.

• Current Protocols for Vehicular Networking
  – IPv6 over 802.11-OCB
  – IP Address Autoconfiguration
  – Routing
  – Mobility Management
  – DNS Naming Service
  – Service Discovery
  – Security and Privacy
Analysis for Current Protocols (2/2)

- **General Problems**
  - Vehicular Network Architecture
  - Latency
  - Security
  - Pseudonym Handling
General Problems: Vehicular Network Architecture (1/3)

Figure 1: A Vehicular Network Architecture for V2I and V2V Networking

Vehicle $V_1$  V2V  Vehicle $V_2$  V2V  Vehicle $V_3$  V2V
General Problems: Vehicular Network Architecture (2/3)

Figure 2: **Internetworking** between Vehicle Network and RSU Network
Figure 3: **Internetworking between Two Vehicle Networks**

Vehicle₁ (Moving Network₁) --- Vehicle₂ (Moving Network₂)
Problem Exploration

• **Key Work Items in IPWAVE**
  – Neighbor Discovery
  – Mobility Management
  – Security and Privacy

• **Relevant Work Items to IPWAVE**
  – Vehicle Identity Management
  – Multihop V2X
  – Multicast
  – DNS Naming Services and Service Discovery
  – IPv6 over Cellular Networks
Neighbor Discovery (ND) (1/3)

• IPv6 ND needs to be tailored for vehicular networking (V2V, V2I, and V2X) having
  – dynamically change topology,
  – multihop forwarding, and
  – high-speed vehicles.

• ND Parameter Adjustment is required:
  – Router lifetime, and
  – Neighbor Advertisement (NA) interval
Neighbor Discovery (ND) (2/3)

• Link Model
  – IPv6 protocols have an invalid link model in WAVE:
    • The IPv6 link model’s assumption for symmetry in connectivity between neighboring interfaces.
    • The existence of unidirectional links due to interference and different Tx power levels.
    • Unreachability between two nodes with the same prefix due to node mobility and highly dynamic topology in VANET.
  – IPv6 ND should be extended to support the concept of a WAVE link in terms of multicast in VANET.
Neighbor Discovery (ND) (3/3)

• **MAC Address Pseudonym**
  – MAC address change should consider the maintenance of end-to-end transport-layer session according to IPv6 address change.

• **Prefix Dissemination/Exchange**
  – The communication of two nodes within different internal networks (i.e., vehicle and RSU) requires an ND extension or routing for efficient prefix dissemination/exchange.
Mobility Management

• **Efficient mobility management** is required for
  – seamless connectivity and timely data exchange between two end points.

• **GPS navigator-based trajectory** can be used for **proactive mobility management**:
  – A vehicle’s mobility information (e.g., position, speed, direction, and trajectory) is periodically reported to a Traffic Control Center (TCC).
  – With prediction of vehicle mobility, TCC supports RSUs to perform **DAD**, data packet forwarding, and **handover** in a proactive manner.
Security and Privacy (1/2)

• **Authorized Communication**
  – Only authorized nodes (e.g., vehicles, in-vehicle devices, and mobile devices) should be allowed to use vehicular networking (V2V, V2I, and V2X).

• **Authentication of Vehicle and User**
  – VIN and user certificate with in-vehicle device’s ID generation can be used for the authentication of a vehicle or a user.
  – This authentication can be performed by an RSU connected to an authentication server in TCC.
Security and Privacy (2/2)

- **Secure V2I/V2X Communication**
  - A secure channel between a vehicle’s mobile router and an RSU’s fixed router needs to be used for secure V2I communication.
  - A secure channel between a vehicle’s mobile router and another vehicle’s mobile router needs to be used for secure V2V communication.
  - Transport Layer Security (TLS) certificates can be used for secure end-to-end communications.

- **Privacy**
  - MAC address pseudonym can prevent an adversary from tracking a vehicle or user.
  - Such a pseudonym needs to consider the continuity of an end-to-end session.
Next Steps

• **WG Last Call**
  – During WGLC, we will collect feedback from IPWAVE WG and reflect it on the revisions.

• **IESG Submission**
  – We aim at submitting the document to the IESG before IETF-103 meeting.
APPENDIX:
RELEVANT WORK ITEMS TO IPWAVE
Vehicle Identity Management

• A vehicle can have multiple network interfaces for different access network technologies (e.g., DSRC, and 4G-LTE).
  – This means multiple identities of a vehicle.

• In this situation, a Vehicle Identification Number (VIN) can be used for a globally unique vehicle identifier.

• To support seamless connectivity over multiple identities,
  – A cross-layer network architecture is required with vertical handover functionality.
Multihop V2X

• Multihop packet forwarding among vehicles in 802.11-OCB mode shows an unfavorable performance due to the common known broadcast-storm problem.
  – Improvements in Layer-2 are
    • Probability-based methods,
    • Clustering-based methods, and
    • RSU-assisted methods.
Multicast

• IP multicast in vehicular network environments is especially useful for various services:
  – Multicast service notifications to a particular group/class/type of vehicles, and
  – Disseminate alert messages in a particular area.

• Some performance issues about multicast are found in [Multicast-802]
  – Neighbor Discovery and Service Discovery may fail.
  – DAD process may fail.
  – Router Advertisement (RA) messages can be lost.
DNS Naming Services and Service Discovery

• **DNS name-based communication** between IPv6 nodes (e.g., in-vehicle devices) requires **DNS name resolution**.
  – For this resolution, **Recursive DNS Servers** (RDNSSses) should be advertised to them.

• **Service discovery** is required for an in-vehicle device to **search for an application** (or server).
  – It resides in another internal network within another vehicle or an RSU.
  – **DNS-SD** and **Vehicular ND** can be used.
IPv6 over Cellular Networks (1/2)

- 3GPP-Release 14 (3GPP-R14) announced V2X services support;
  - Using the modified sidelink interface is previously designed for LTE Device-to-Device (LTE-D2D).
  - Only 3GPP-R14 supports IPv6 implementation.

- [TS-23.285-3GPP] instructs that a UE autoconfigures a link-local IPv6 address by following [RFC4862];
  - It does not sends Neighbor Solicitation and Neighbor Advertisement messages for DAD.
IPv6 over Cellular Networks (2/2)

- [TR-22.886-3GPP] is studying new use cases for V2X using 5G new radio in the future:
  - Platooning
  - Sensor and state map sharing
  - Remote driving
  - Automated cooperative driving
  - Dynamic ride sharing
  - Emergency trajectory alignment
  - Software update for ECU
  - etc.