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Context-Aware Navigation Protocol for IP-Based Vehicular Networks

Abstract

This document proposes a Context-Aware Navigation Protocol (CNP) for IP-based vehicular networks for cooperative navigation among vehicles in road networks. This CNP aims at the enhancement of driving safety through a light-weight driving information sharing method. The CNP protocol uses an IPv6 Neighbor Discovery (ND) option to convey driving information such as a vehicle's position, speed, acceleration/deceleration, and direction, and a driver's driving action (e.g., braking and accelerating).

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1. Introduction

The enhancement of driving safety is one of objectives of cooperative driving in vehicular networks. Dedicated Short-Range Communications (DSRC) is for vehicular communications [DSRC]. IEEE has standardized a family standard suite of Wireless Access in Vehicular Environments (WAVE) [WAVE]. Also, IETF has standardized an IPv6 packet delivery protocol over IEEE 802.11-OCB (Outside the Context of a Basic Service Set) [RFC8691], which is a MAC protocol for vehicles in WAVE.

A vehicle equipped with various sensors and a DSRC device can sense its surrounding environment including its neighboring vehicles, and share the sensed data and its mobility information (e.g., position, speed, acceleration/deceleration, and direction) with its neighboring vehicles. This information sharing allows vehicles to assess the collision risk and make their maneuvers to avoid an accident in a prompt way, for example, a Context-Aware Navigation Protocol (CNP) navigation system [CNP]. That is, the capability of sensing, computing, and communication of vehicles enables them to understand the driving environment and situation (i.e., context), and cooperate with each other during their navigation. In the CNP navigation system [CNP], a cluster head vehicle can control the maneuver of member vehicles (i.e., neighboring vehicles) of its cluster with their mobility information and a vehicle collision avoidance algorithm (i.e., Emergency Maneuver Lane Determination).

The driving information sharing enables context-aware navigation where each vehicle can display its neighboring vehicles, pedestrians, and obstacles in the CNP navigation system [CNP]. With the CNP navigation system, a driver can make a better decision on driving to avoid an accident, and an autonomous vehicle can control its maneuver to escape from a possible fatality in advance.

For this CNP navigation system, this document proposes a light-weight data sharing protocol using a new IPv6 Neighbor Discovery (ND) option for Vehicle Mobility Information, which is called Vehicle Mobility Information (VMI) option. This VMI option can be included by a Neighbor Advertisement (NA) message in Vehicular Neighbor Discovery (VND) [ID-Vehicular-ND].

There are two messages for vehicle collision avoidance in this CNP navigation system with the VMI option such as Cooperation Context Message (CCM) and Emergency Context Message (ECM). The CCM is a message to deliver a vehicle's motion information (e.g., position, speed, acceleration/deceleration, direction) and a driver's driving action (e.g., braking and accelerating) to its neighboring vehicles for cooperative driving. The ECM is a message to notify a vehicle's neighboring vehicles of an emergency situation (e.g., an accident and dangerous situation). The ECM has a higher priority than the CCM such that the ECM needs to be disseminated faster than the CCM in vehicular networks.

2. Requirements Language

The key words "MUST", "MUST NOT", "REQUIRED", "SHALL", "SHALL NOT", "SHOULD", "SHOULD NOT", "RECOMMENDED", "MAY", and "OPTIONAL" in this document are to be interpreted as described in RFC 2119 [RFC2119].

3. Terminology

This document uses the terminology described in [RFC9365].

4. Vehicle Mobility Information Option

Vehicle Mobility Information (VMI) option is an IPv6 ND option to convey either a CCM or ECM. Figure 1 shows the format of the VMI option.

```
 0                   1                   2                   3
 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|     Type      |    Length     |    Message    |  Reserved1    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                           Reserved2                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:                      Mobility Information                     :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

Figure 1: Vehicle Mobility Information (VMI) Option Format

Fields:

Type — 8-bit identifier of the VMI option type as assigned by the IANA: TBD

Length — 8-bit unsigned integer. The length of the option (including the Type and Length fields) is in units of 8 octets. The value is 3.

Message — 8-bit identifier of the VMI message type as CCM (0) and ECM (1).

Reserved1 — This field is unused. It MUST be initialized to zero by the sender and MUST be ignored by the receiver.

Reserved2 — This field is unused. It MUST be initialized to zero by the sender and MUST be ignored by the receiver.

Mobility Information — 128-bit mobility information. It contains a vehicle's motion information (e.g., position, speed, acceleration/deceleration, direction) and a driver's driving action (e.g., braking and accelerating) for CCM. Also, it contains a vehicle's emergency information (e.g., obstacle information and accident information).

A CCM in a VMI option can be included in an NA message that a vehicle transmits periodically to announce its existence and routing information to its one-hop neighboring vehicles [ID-Vehicular-ND].

An ECM in a VMI option can be included in an NA message that a vehicle transmits to immediately announce an emergency situation to its one-hop neighboring vehicles [ID-Vehicular-ND].

To let the vehicles take an immediate action on an emergency situation, the ECM has a higher priority than the CCM. Thus, if a vehicle has an ECM and a CCM to send, it SHOULD transmit the ECM earlier than the CCM.

5. Security Considerations

This document shares all the security issues of the IPv6 ND protocol. This document can get benefits from Secure Neighbor Discovery (SEND) [RFC3971] in order to protect exchanged messages from possible security attacks.

6. References

6.1. Normative References

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Appendix A. Acknowledgments

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Appendix B. Contributors

This document is made by the group effort of IPWAVE working group. Many people actively contributed to this document, such as Carlos J. Bernardos and Russ Housley. The authors sincerely appreciate their contributions.

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Appendix C. Changes from draft-jeong-ipwave-context-aware-navigator-08

The following changes are made from draft-jeong-ipwave-context-aware-navigator-08:

*This version updates the the author list and referenced drafts.

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