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**IPv6 Neighbor Discovery for Prefix and Service Discovery in Vehicular
Networks
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Abstract

This document specifies an extension of IPv6 Neighbor Discovery (ND) for rapid network prefix and service discovery in vehicular networks. It is assumed that a vehicle or a Road-Side Unit (RSU) have an external network interface and their internal network. The extended IPv6 ND called vehicular ND can support vehicle-to-infrastructure communications as well as vehicle-to-vehicle communications. This document defines new ND options to allow a vehicle to announce the network prefixes and services inside its internal network to another vehicle or RSU.

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[1.](#) Introduction

Vehicular Ad Hoc Networks (VANET) have been researched for the networking on intelligent services in road networks, such as driving safety, efficient driving, and entertainment. To enable this VANET in road networks, Dedicated Short-Range Communications (DSRC) [[DSRC-WAVE](#)] has been standardized as IEEE 802.11p [[IEEE-802.11p](#)], which is an extension of IEEE 802.11a [[IEEE-802.11a](#)], considering the characteristics of vehicular networks, such as high-speed mobility and network fragmentation. Note that IEEE 802.11p was renamed IEEE 802.11 Outside the Context of a Basic Service Set (OCB) [[IEEE-802.11-OCB](#)] in 2012. For Wireless Access in Vehicular Environments (WAVE) [[DSRC-WAVE](#)][[WAVE-1609.0](#)], the IEEE has standardized IEEE 1609 family standards, such as IEEE 1609.2, 1609.3, and 1609.4 [[WAVE-1609.2](#)][[WAVE-1609.3](#)][[WAVE-1609.4](#)]. The IEEE 1609 standards specify IPv6 as the network-layer protocol [[WAVE-1609.3](#)].

Many automobile vendors are replacing Controller Area Networks (CANs) with Ethernet for high-speed interconnectivity among Electronic Control Units (ECUs) in a vehicle. The sensing information of the ECUs can be delivered to the service centers of those automobile vendors for remote diagnosis for driving safety using DSRC between vehicles and Road-Side Units (RSUs) having the Internet connectivity toward the service centers in a vehicular cloud.

With this trend, it is time to enable vehicular networking with IPv6 to let various Internet-based applications (e.g., remote vehicle diagnosis) run on top of transport-layer protocols, such as TCP, UDP, and SCTP. IPv6 [[RFC8200](#)] is suitable for a network layer in vehicular networks in that the protocol has abundant address space, autoconfiguration features, and protocol extension ability through extension headers.

To support the interaction between vehicles or between a vehicle and an RSU, this document specifies an extension of IPv6 ND [[RFC4861](#)] for rapid network prefix and service discovery in vehicular networks with new ND options. That is, the extended IPv6 ND in this document, which is called vehicular ND, can support not only vehicle-to-infrastructure (V2I) communications but also vehicle-to-vehicle (V2V) communications.

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 [[RFC4861](#)] and [[RFC4862](#)]. In addition, four new terms are defined below:

- o Road-Side Unit (RSU): A node that has a Dedicated Short-Range Communications (DSRC) device for wireless communications with the vehicles and is connected to the Internet. Every RSU is usually deployed at an intersection so that it can provide vehicles with the Internet connectivity.
- o Vehicle: A node that has the DSRC device for wireless communications with vehicles and RSUs. Every vehicle may also have a GPS-navigation system for efficient driving.
- o Traffic Control Center (TCC): A node that maintains road infrastructure information (e.g., RSUs and traffic signals), vehicular traffic statistics (e.g., average vehicle speed and

vehicle inter-arrival time per road segment), and vehicle information (e.g., a vehicle's identifier, position, direction, speed, and trajectory). TCC is included in a vehicular cloud for vehicular networks.

4. Overview

This document specifies an IPv6 ND extension for vehicle-to-vehicle (V2V) or vehicle-to-infrastructure (V2I) networking.

Figure 1 shows the V2V networking of two vehicles whose internal networks are Moving Network1 and Moving Network2, respectively. Vehicle1 has the DNS Server (RDNSS1), the two hosts (Host1 and Host2), and the two routers (Router1 and Router2). Vehicle2 has the DNS Server (RDNSS2), the two hosts (Host3 and Host4), and the two routers (Router3 and Router4).

It is assumed that Host1 and Host3 are running a Cooperative Adaptive Cruise Control (C-ACC) program for physical collision avoidance. Also, it is assumed that Host2 and Host4 are running a Cooperative On-board Camera Sharing (C-OCS) program for sharing road hazards or obstacles to avoid road accidents. Vehicle1's Router1 and Vehicle2's Router3 use 2001:DB8:1:1::/64 for an external link (e.g., DSRC) for V2V networking for various vehicular services. The vehicular applications, such as C-ACC and C-BCS, can be registered into the DNS Server (i.e., RDNSS) through DNSNA protocol in [[ID-DNSNA](#)] along with IPv6 ND DNS options in [[RFC8106](#)].

Vehicle1's Router1 and Vehicle2's Router3 can know what vehicular applications exist in their internal network by referring to their own RDNSS through the DNSNA protocol [[ID-DNSNA](#)]. They can also know what network prefixes exist in their internal network through an intra-domain routing protocol, such as OSPF. Each vehicle announces its network prefixes and services through ND options defined in [Section 5](#).

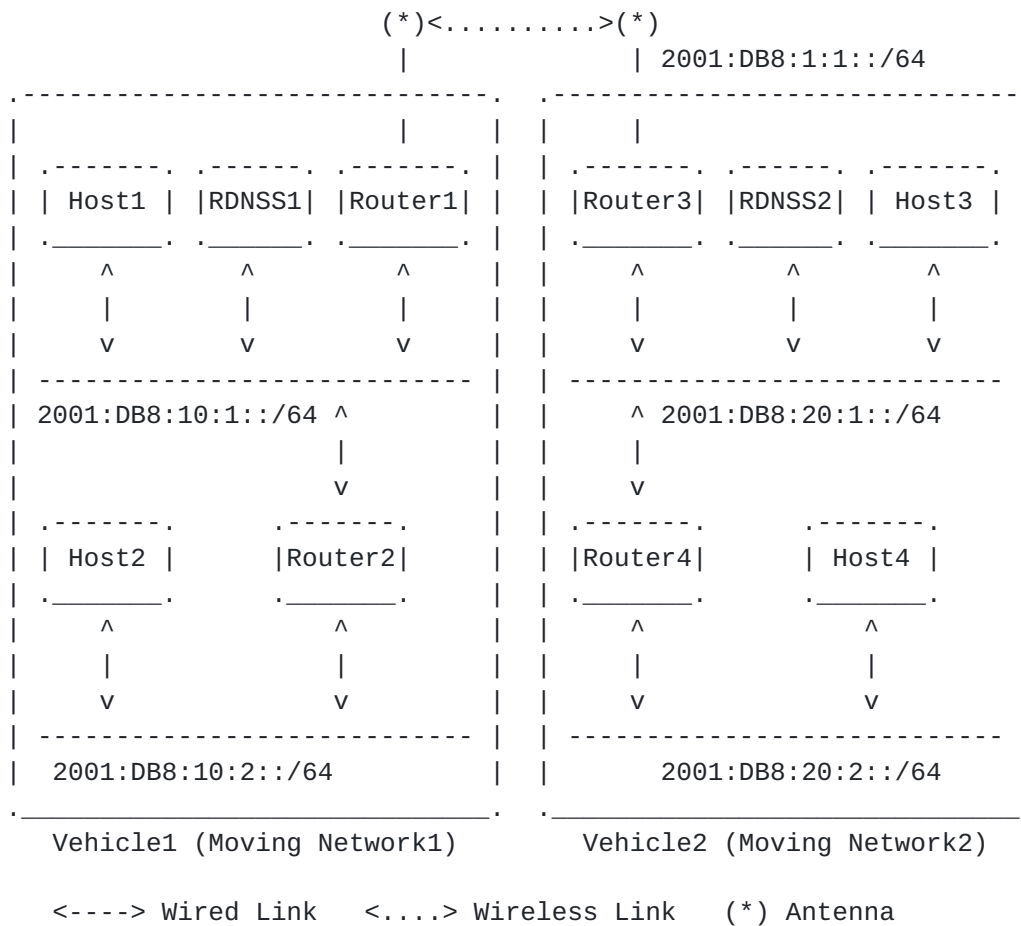


Figure 1: Internetworking between Vehicle Networks

Figure 2 shows the V2I networking of a vehicle and an RSU whose internal networks are Moving Network1 and Fixed Network1, respectively. Vehicle1 has the DNS Server (RDNSS1), the two hosts (Host1 and Host2), and the two routers (Router1 and Router2). RSU1 has the DNS Server (RDNSS2), one host (Host3), the two routers (Router3 and Router4).

It is assumed that RSU1 has a collection of servers (Server1 to ServerN) for various services in the road networks, such as road emergency notification and navigation services. Vehicle1's Router1 and RSU1's Router3 use 2001:DB8:1:1::/64 for an external link (e.g., DSRC) for I2V networking for various vehicular services. The vehicular applications, such as road emergency notification and navigation services, can be registered into the DNS Server (i.e., RDNSS) through DNSNA protocol in [[ID-DNSNA](#)] along with IPv6 ND DNS options in [[RFC8106](#)].

Vehicle1's Router1 and RSU1's Router3 can know what vehicular applications exist in their internal network by referring to their

own RDNSS through the DNSNA protocol [[ID-DNSNA](#)]. They can also know what network prefixes exist in their internal network through an intra-domain routing protocol, such as OSPF. Each vehicle and each RSU announce their network prefixes and services through ND options defined in [Section 5](#).

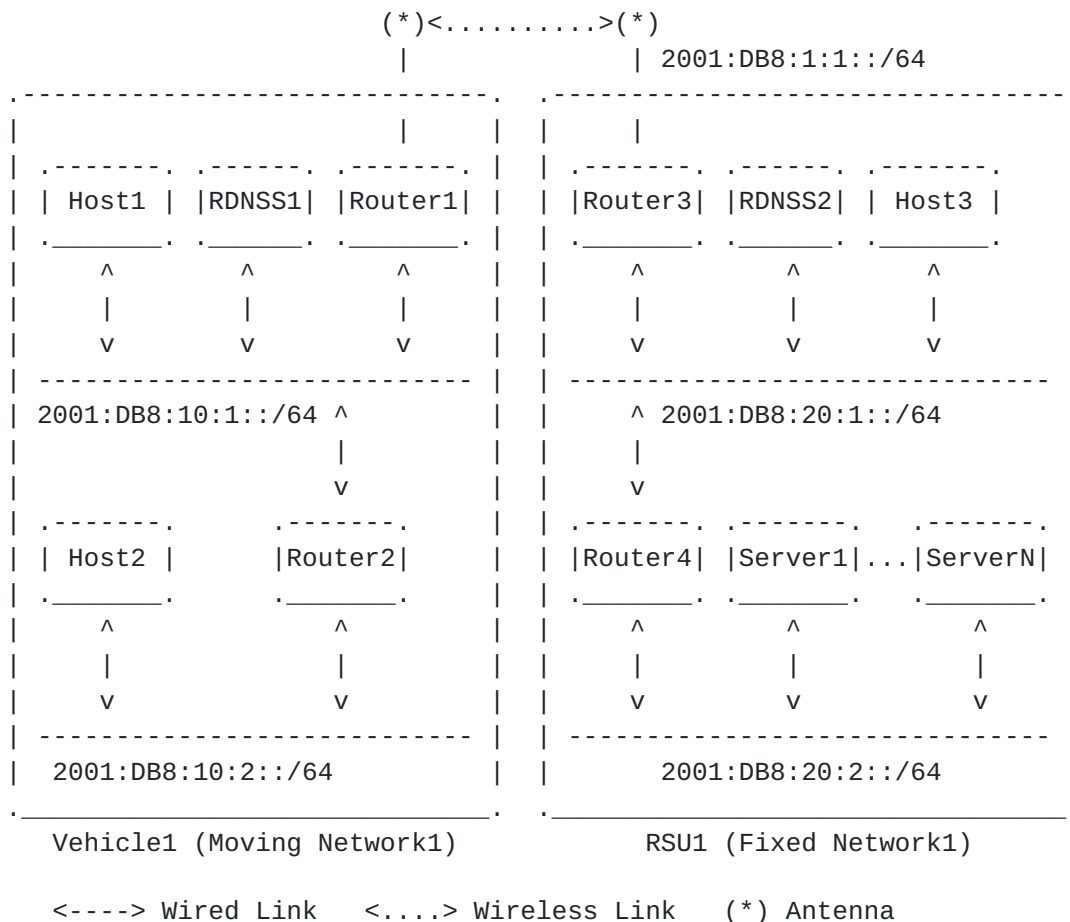


Figure 2: Internetworking between Vehicle Network and RSU Network

5. ND Extension for Prefix and Service Discovery

This section defines two new ND options for prefix and service discovery: (i) the Vehicular Prefix Information (VPI) option and (ii) the Vehicular Service Information (VSI) option. It also describes the ND protocol for such prefix and service discovery.

5.1. Vehicular Prefix Information Option

The VPI option contains one IPv6 prefix in the internal network. Figure 3 shows the format of the VPI option.

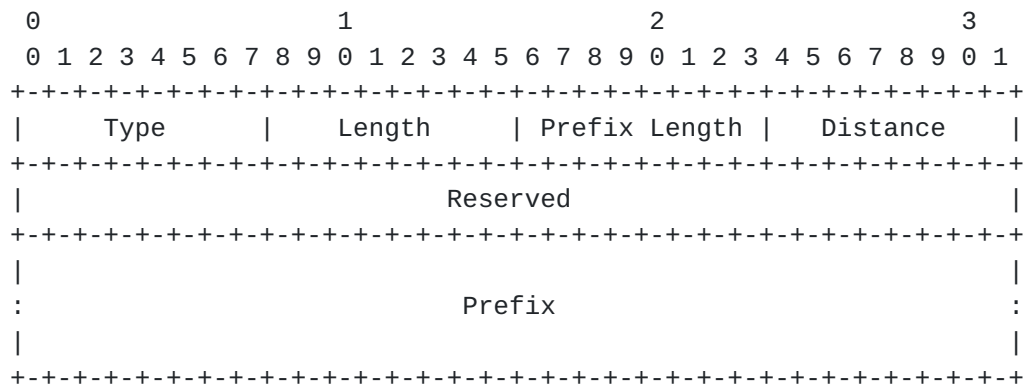


Figure 3: Vehicular Prefix Information (VPI) Option Format

Fields:

Type	8-bit identifier of the VPI 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.
Prefix Length	8-bit unsigned integer. The number of leading bits in the Prefix that are valid. The value ranges from 0 to 128.
Distance	8-bit unsigned integer. The distance between the subnet announcing this prefix and the subnet corresponding to this prefix in terms of the number of hops.
Reserved	This field is unused. It MUST be initialized to zero by the sender and MUST be ignored by the receiver.
Prefix	An IP address or a prefix of an IP address. The Prefix Length field contains the number of valid leading bits in the prefix. The bits in the prefix after the prefix length are reserved and MUST be initialized to zero by the sender and ignored by the receiver.

5.2. Vehicular Service Information Option

The VSI option contains one vehicular service in the internal network. Figure 4 shows the format of the VSI option.

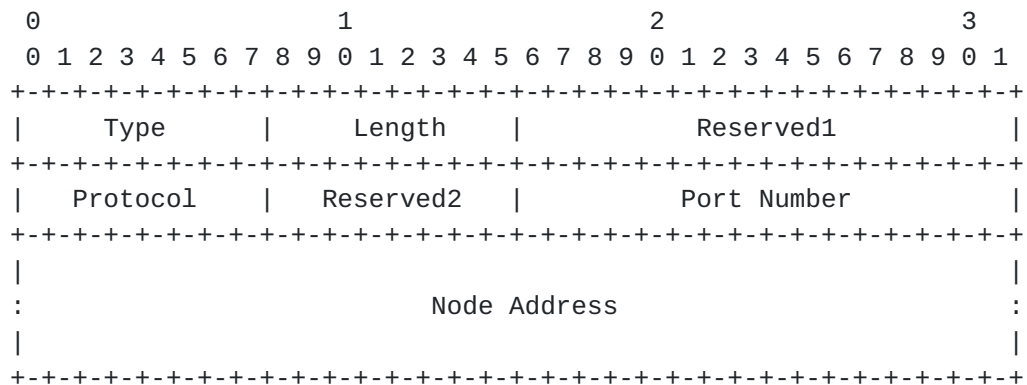


Figure 4: Vehicular Service Information (VSI) Option Format

Fields:

Type	8-bit identifier of the VSI 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.
Reserved1	This field is unused. It MUST be initialized to zero by the sender and MUST be ignored by the receiver.
Protocol	8-bit unsigned integer to indicate the upper-layer protocol, such as transport-layer protocol (e.g., TCP, UDP, and SCTP).
Reserved2	This field is unused. It MUST be initialized to zero by the sender and MUST be ignored by the receiver.
Port Number	16-bit unsigned integer to indicate the port number for the protocol.
Service Address	128-bit IPv6 address of a node proving this vehicular service.

5.3. Vehicular Neighbor Discovery

With VPI and VSI options, a node (e.g., vehicle or RSU) can announce the network prefixes and services in its internal network via ND messages, such as Neighbor Solicitation (NS) and Neighbor Advertisement (NA) [[RFC4861](#)].

A node periodically announces an NS message containing the VPI and VSI options with its prefixes and services in all-nodes multicast address to reach all neighboring nodes. When another neighboring node receives this NS message, it responds to this NS message by sending an NA message containing the VPI and VSI options with its prefixes and services via unicast toward the NS-originating node.

Through this procedure, vehicles and RSUs can rapidly discover the network prefixes and services of the other party without any additional service discovery protocol.

6. Security Considerations

This document shares all the security issues of the neighbor discovery protocol. This document can get benefits from secure neighbor discovery (SEND) [[RFC3971](#)] in order to protect ND from possible security attacks.

7. Acknowledgments

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