Problem Statement for IP Wireless Access in Vehicular Environments

(draft-ietf-ipwave-problem-statement-00)

IETF 99, Prague, Czech

July 20, 2017

Jaehoon (Paul) Jeong*, Alex Petrescu, Tae (Tom) Oh, Dapeng Liu, and Charles E. Perkins

Merging Two Drafts into WG Document

- This document became a WG document by merging the following two individual drafts:
  - draft-jeong-ipwave-v2i-problem-statement-00
    - Vehicle-to-Infrastructure (V2I) Networking
  - draft-petrescu-its-problem-03
    - Vehicle-to-Vehicle (V2V) Networking

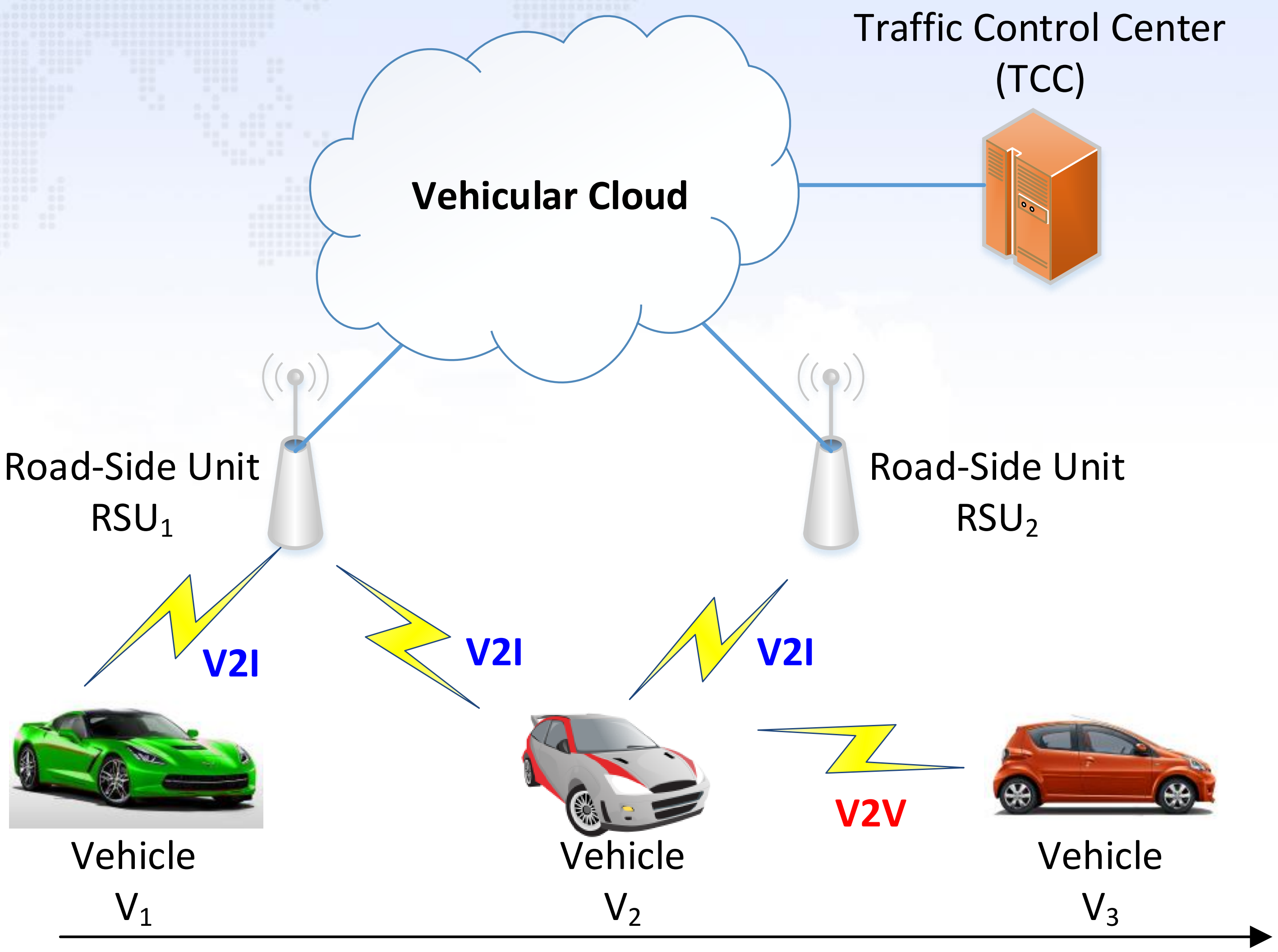
Introduction to Vehicular Networking

- Objective of this document
  - To specify the problem statement for **IPv6-based** **Vehicle-to-Infrastructure (V2I)** or **Vehicle-to-Vehicle (V2V)** networking.

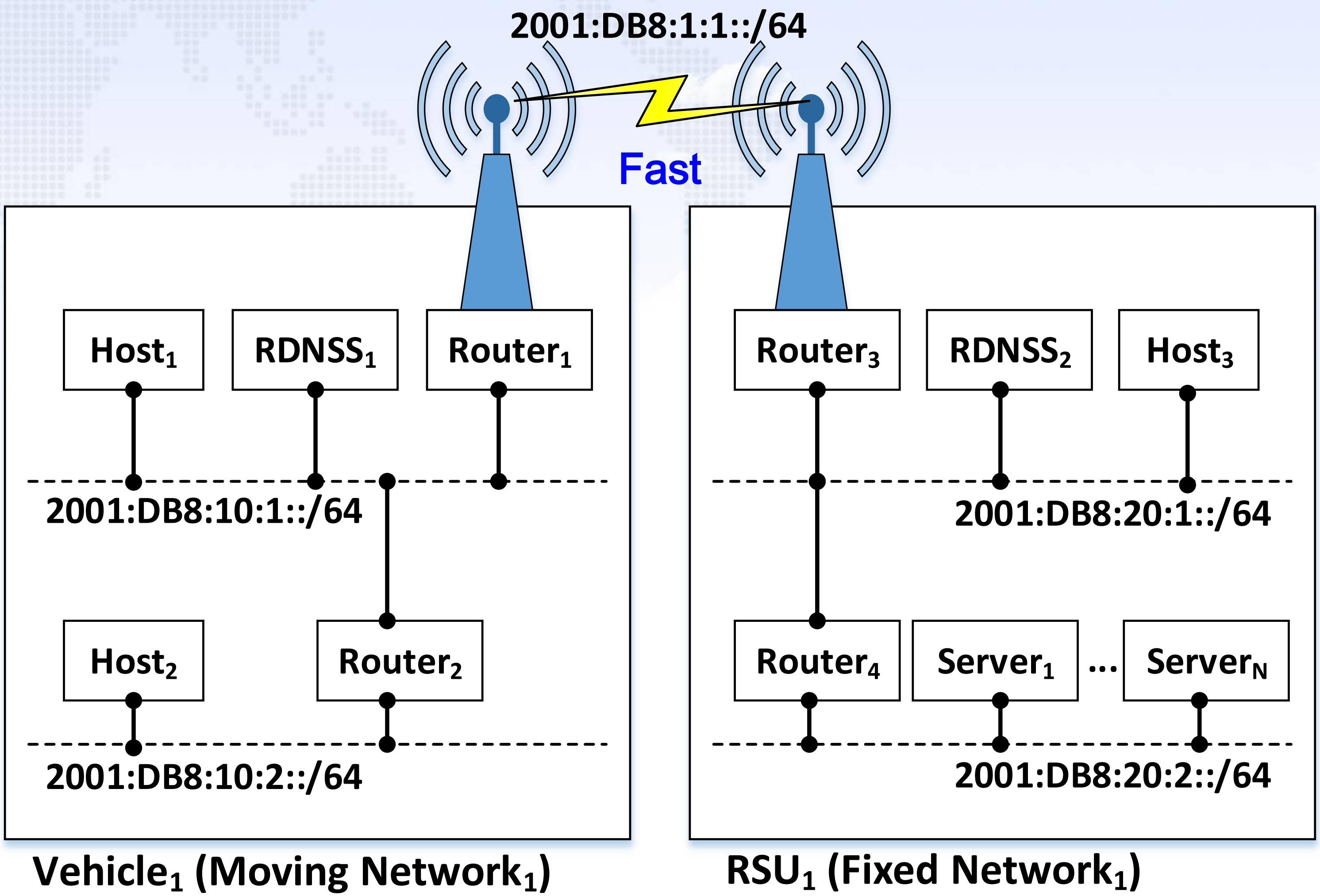
- Assumptions
  - IEEE 802.11-OCB or Cellular Links (3G-UMTS, WCDMA, 4G-LTE, 5G-New Radio (NR)) are considered as link types.
  - IPv6 is considered as the Network-layer protocol.
  - Road-Side Unit (RSU) is connected to the Internet as an access point for vehicles.

- **Focus of this document**
  - Networking issues in **one IP hop communications** between RSU and vehicles or among vehicles.
  - **Internetworking** between the internal networks of cars and RSUs.

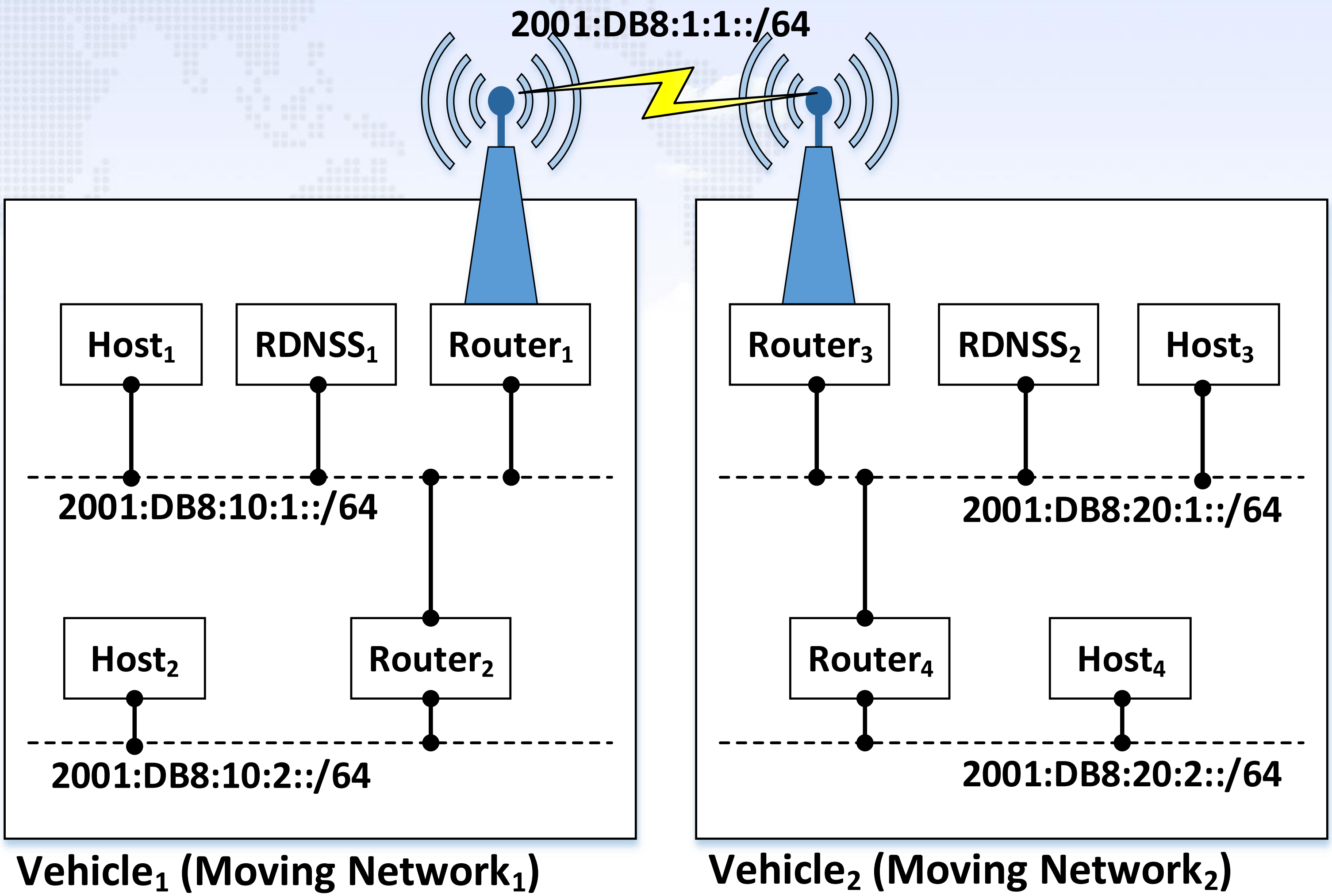
Vehicular Network Configuration



Internetworking between Vehicle Network and RSU Network



Internetworking between Two Vehicle Networks



Issues for IPv6 Vehicular Networking (1/6)

- **IPv6 Addressing Problem for V2I**
  - Two policies for IPv6 addressing
    - Local IPv6 addresses for vehicular networks
    - Global IPv6 addresses for internetworking
  - Local IPv6 addresses
    - Usage for road network services (e.g., emergency notification and navigation)
    - e.g., **Unique Local IPv6 Unicast Addresses (ULAs)**
  - Global IPv6 addresses
    - Usage for general Internet services (e.g., email, web surfing, and entertainment)
  - Policies for global IPv6 addresses
    - Multi-link subnet for multiple RSUs and cars
    - Single subnet per RSU
    - Single subnet between neighboring cars

Issues for IPv6 Vehicular Networking (2/6)

- **IPv6 Addressing Problem for V2V**
  - **Address Configuration Problem**
    - **In-vehicle addresses** may be pre-configured or configured dynamically from a network deployed along the road (for 802.11-OCB or cellular NIC).
  - **Communication Path Setup Problem**
    - How to establish **IP communication paths** between the computers in one vehicle and a nearby vehicle?
  - **Discovery and Exchange Sub-problems**
    - **Discovery Sub-problem**
      - How can edge routers in vehicles discover each other?
    - **Prefix Exchange Sub-problem**
      - How can edge routers in vehicles exchange routing information?

Issues for IPv6 Vehicular Networking (3/6)

- Adaptation of Neighbor Discovery (ND)
  - Adjusts ND time-related parameters (e.g., router lifetime and NA interval), considering high-speed vehicles and vehicle density.
- IP Address Autoconfiguration (SLAAC and DHCPv6)
  - Supports the fast configuration, considering high-speed vehicles.
  - RSU can perform IPv6 Stateless Address Autoconfiguration (SLAAC) including the Duplicate Address Detection (DAD) proactively on behalf of the vehicles as an ND proxy.
  - DHCPv6, DHCPv6-PD or Stateless DHCPv6 need to be adapted for fast moving vehicles in the vehicular network whose RSUs have different subnets.
  - Signal strength measurement from IP RA or WAVE Short Message (WSM) can be used to evaluate stable links.

Issues for IPv6 Vehicular Networking (4/6)

- DNS Naming Service
  - **IPv6 host DNS configuration** for Recursive DNS Server (RDNSS) and DNS Search List (DNSSL)
    - Through RA Options [RFC 8106] and DHCP Options [RFC 3646].
  - **DNS name resolution** through an appropriate RDNSS
    - Within a vehicle's moving network or an RSU's fixed network.
  - **DNS name autoconfiguration** of in-vehicle devices
    - Through DNS Name Autoconfiguration (DNSNA) [draft-jeong-ipwave-iot-dns-autoconf-00], mDNS [RFC 6762], and DNS Update [RFC 2136].
    - In-vehicle devices or hosts need to register their DNS name and IPv6 address into a local DNS server in a vehicle or an RSU.

Issues for IPv6 Vehicular Networking (5/6)

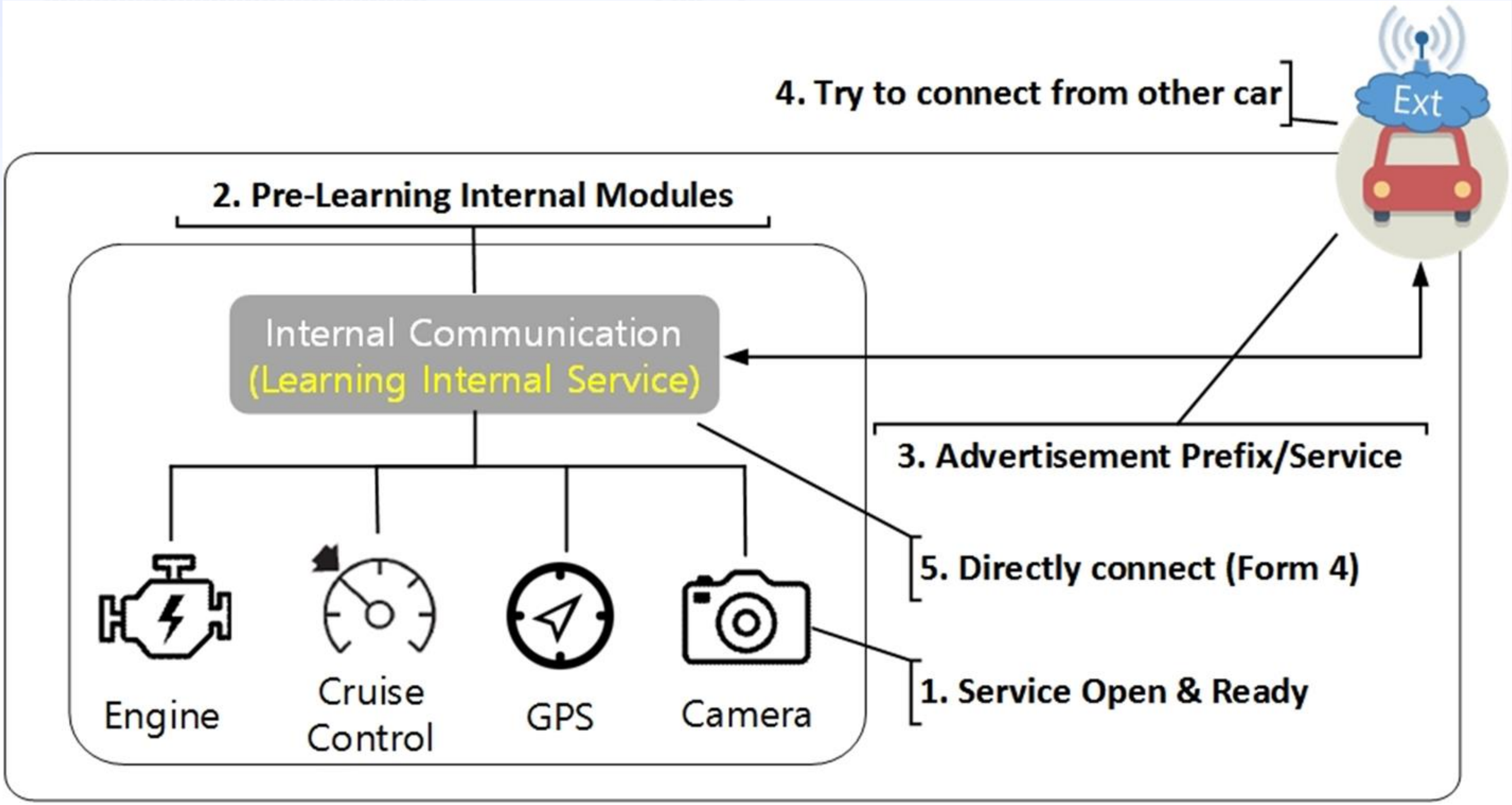
- IP Mobility Support for V2I
  - In a single subnet per RSU, vehicles keep crossing the **merged communication coverage** of adjacent RSUs.
  - During this crossing, TCP/UDP sessions can maintained by IP mobility support, such as **Mobile IPv6** (MIPv6) [RFC 3775], **Proxy MIPv6** [RFC 5213], and **Distributed Mobility Management** (DMM) [RFC 7333, RFC 7429].
  - The **parameter adjustment** is required for high-speed vehicles.
  - With the periodic reports of the mobility information from the vehicles, TCC can coordinate RSUs for the proactive mobility management of the moving vehicles.

Issues for IPv6 Vehicular Networking (6/6)

- Service Discovery
  - Vehicles need to discover services (e.g., road condition notification, navigation service, and entertainment) provided by internal nodes in an RSU’s network.
  - Possible Solutions
    - DNS-based Service Discovery (DNS-SD) [RFC 6763]
      - Uses Service (SRV), Pointer (PTR), and Text (TXT) records
    - IPv6 ND Extension for the Prefix and Service Discovery
      - **A piggyback service discovery** during the prefix exchange of network prefixes for the networking between a vehicle's moving network and an RSU's fixed network.

Service Discovery (1/2)

- Internal Service Registration into a Vehicle



Service Discovery (2/2)

- **Vehicular ND** vs. **mDNS** for Prefix and Service Discovery

Exchange of Prefix & Service Information

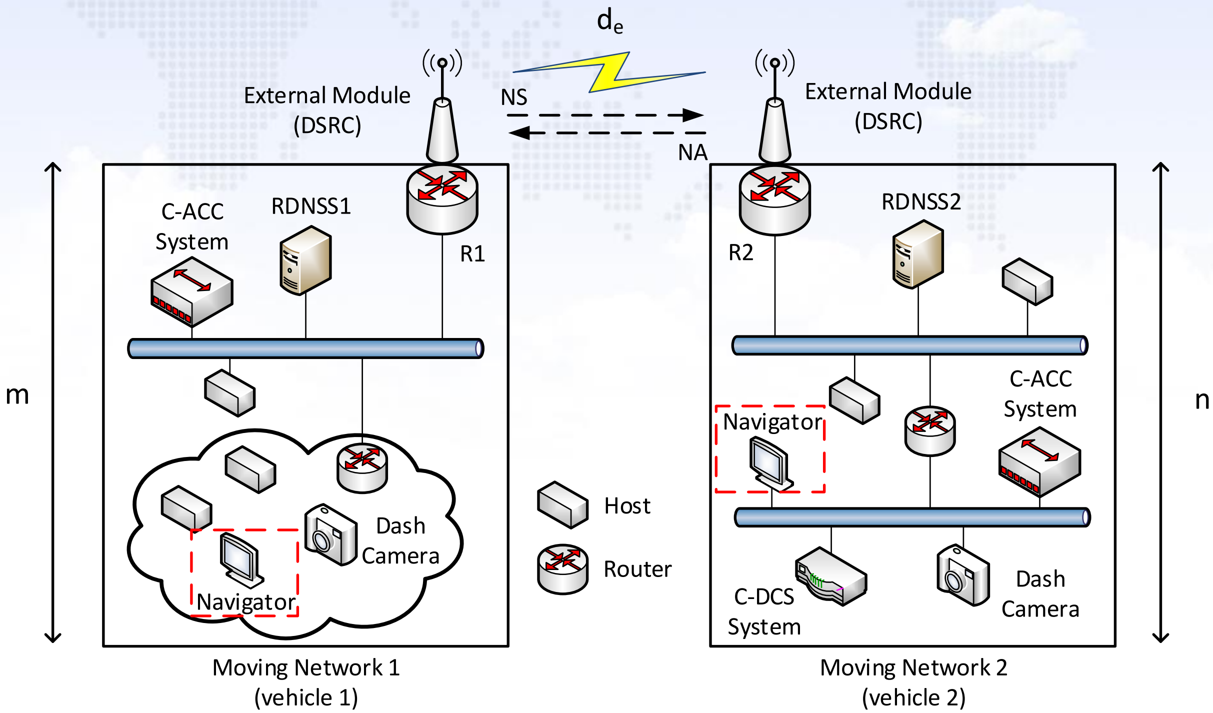


TABLE III
THE PARAMETERS FOR DELAY ANALYSIS

Parameter	Description
D_n	The delay of prefix and service discovery with the proposed IPv6 ND
D_o	The delay of prefix and service discovery with a routing algorithm and mDNS
D_{sd}	The delay of service discovery with mDNS
D_{pd}	The delay of prefix discovery with a routing algorithm
h_1	Hop count between a service querier (a host) and an external interface (a router) in MN1
h_2	Hop count between an external interface (a router) and a service querier (a host) in MN2
d_e	The E2E delay of MN1 and MN2
α	One-way link delay of one hop

Note: e is the number of hosts in a vehicle.

$$D_{pd} = \max(O(m), O(n)). \quad (1)$$
(1) The delay of the prefix discovery in the worst case

$$D_{sd} = (2\alpha \cdot (h_1 + h_2) + 2d_e) \cdot e. \quad (2)$$
(2) The delay of the service discovery of each host is executed sequentially

$$D_o = \max(O(m), O(n)) + (2\alpha \cdot (h_1 + h_2) + 2d_e) \cdot e. \quad (3)$$
(3) Total delay

$$D_n = \alpha \cdot \max(h_1, h_2) + d_e. \quad (4)$$
(4) Our proposed method with vehicular ND

Security and Privacy (1/3)

- **Authentication and Access Control**
  - A Vehicle Identification Number (VIN) for authentication
  - Multiple car certificates per vehicle for authentication
  - Cellular soldered SIM card, Software credentials, or Hardware Security Module (HSM) based Authentication
  - An RSU can be used to give vehicles the connectivity with an authentication server in TCC.
  - Transport Layer Security (TLS) [RFC 5246] certificates can be used for the authentication and access control in secure communications.

Security and Privacy (2/3)

- **Privacy Support by Periodic Change of MAC and IP Addresses**
  - To prevent a vehicle from being tracked by an adversary, the MAC and IP addresses of the vehicle can be changed periodically with randomness.
  - This address update should not interrupt the communications between a vehicle and an RSU
    - In the level of the network layer (i.e., IP) or transport layer (e.g., TCP and UDP).

Security and Privacy (3/3)

- **Confidential Data Exchange**
  - To protect data packets exchanged between a vehicle and an RSU, **IPsec** can be used.

  - **Confidentiality for Data Packets**
    - It can be provided by efficient encryption and decryption algorithms (e.g., **IP Encapsulating Security Payload (ESP)** [RFC 4303]).
    - It can use an efficient key management scheme (e.g., **Internet Key Exchange Protocol Version 2 (IKEv2)** [RFC 7296][RFC 4306]).

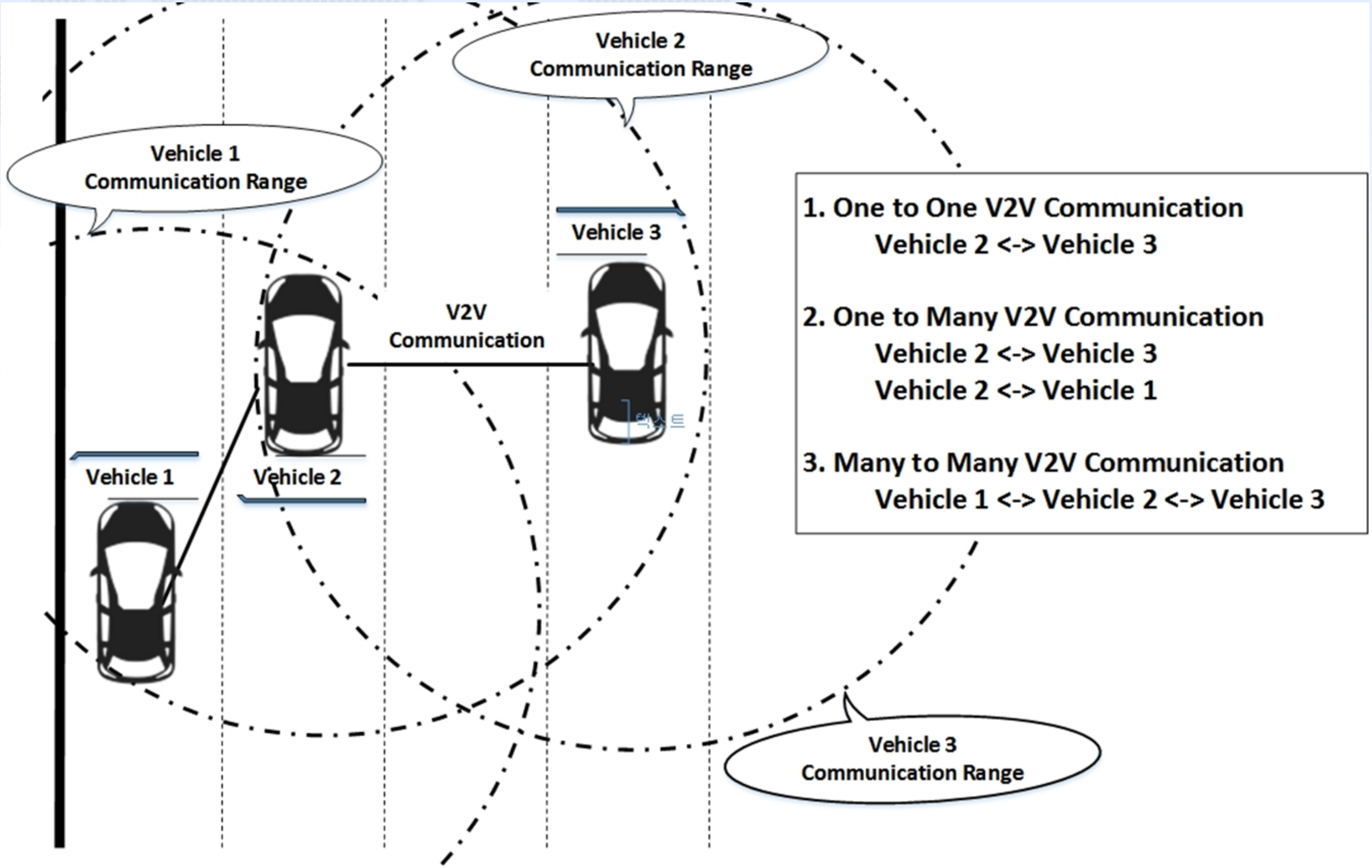
Next Steps

- Improvement with more in-depth technical details
  - The authors will keep working for IPWAVE problem statement with IPWAVE WG.
  - Reuse more of draft-petrescu-its-problem-03.
- Common Terminology Usage (e.g., RSU, RSE)
  - draft-ietf-ipwave-ipv6-over-80211ocb-03
  - ISO 21217 (ITS station/communication architecture) and ISO 21210 (IPv6 networking for ITS)
  - FCC (CFR 90.7 - 2010)
  - FHWA (Vehicle to Infrastructure Deployment Guidance and Products – 2015)
- Welcome Comments from IPWAVE WG.

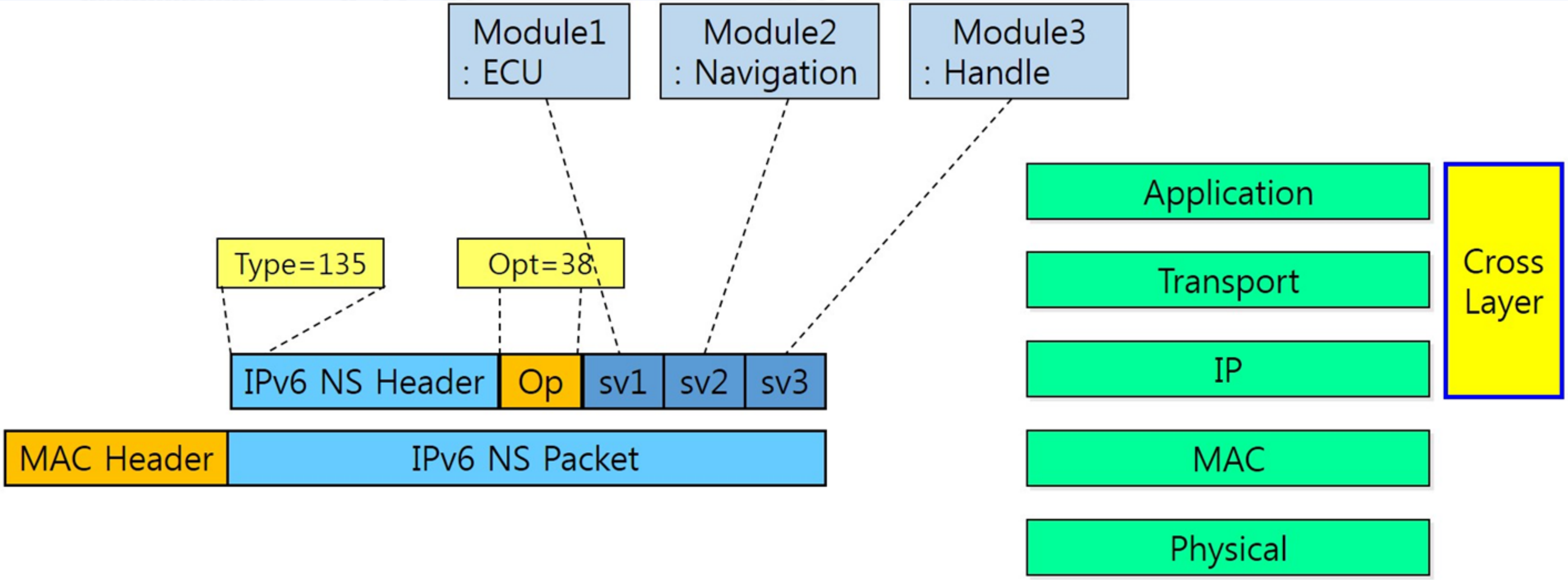
Appendix:
Vehicular Neighbor Discovery

(draft-jeong-ipwave-vehicular-neighbor-discovery-00)

V2V Communication



Rapid Service Discovery for V2V



Prefix Discovery

- Vehicular Prefix Information 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     | Prefix Length |   Distance    |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                            Reserved                           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:                             Prefix                            :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TABLE I
VEHICULAR PREFIX INFORMATION OPTION FIELDS

Field	Description
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.
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	A 128-bit IPv6 address or a prefix of an IPv6 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.

Service Discovery

- Vehicular Service Information 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     |           Reserved1           |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|   Protocol    |   Reserved2   |          Port Number          |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
|                                                               |
:                        Service Address                        :
|                                                               |
+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+-+
```

TABLE II
VEHICULAR SERVICE INFORMATION OPTION FIELDS

Field	Description
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 vehicular service.