IETF 117 in San Francisco

IPMON: IPv6 Mobile Object Networking - Problem Statement and Use Cases

draft-jeong-6man-ipmon-problem-statement-01

July 25, 2023

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Motivation of IPMON

- IPMON aims at the provisioning of **IPv6 networking over 5G V2X (Vehicle-to-Everything) for mobile objects** such as terrestrial, aerial, and marine vehicles.
  - Those vehicles are mentioned as **vehicles** in **draft-jeong-6man-ipmon-problem-statement-01**

- IPMON fills in the **gap of IPv6-related standards in 3GPP V2X** to provide those vehicles with the communication among them or with 5G infrastructure nodes for the Internet connectivity.
  - **IPMON Communication Types in 5G Networks:** Vehicle-to-Everything (V2X), Vehicle-to-Vehicle (V2V), and Vehicle-to-Infrastructure (V2I)

- IPMON considers (1) multihop IPv6 address autoconfiguration, (2) proactive mobility management, (3) light-weight routing, and (4) security and privacy in 5G V2X:
  - IPMON aims at **developing protocols for IPv6 networking over 5G V2X**:
    - **e.g., draft-jeong-6man-ipv6-over-5g-v2x-01**

Mobile Objects (MO) in IPMON

- Vehicle, Motorcycle, Scooter, Pedestrian, Unmanned Aerial Vehicle (UAV), Drone, Urban Air Mobility (UAM), Train & Ship.

Drone

Ship

Train

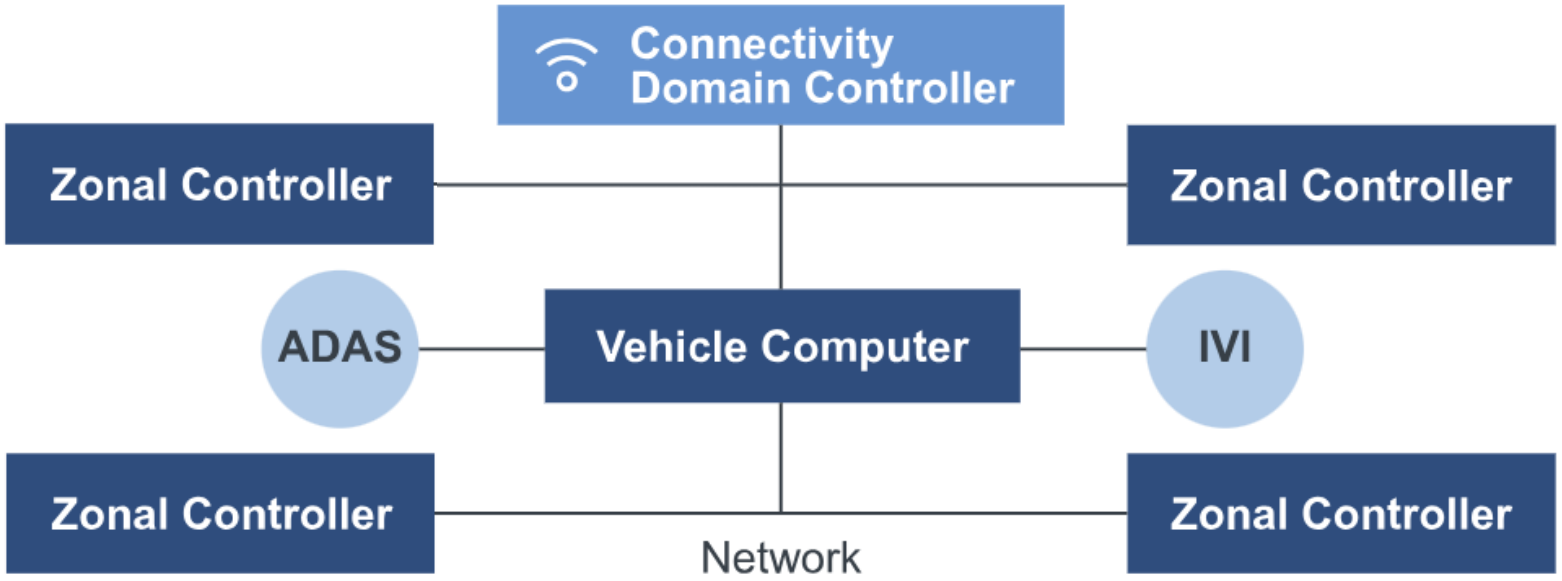
Motorcycle

Vehicle

Pedestrian

Scooter

Software-Defined Vehicle (SDV) defined as MO



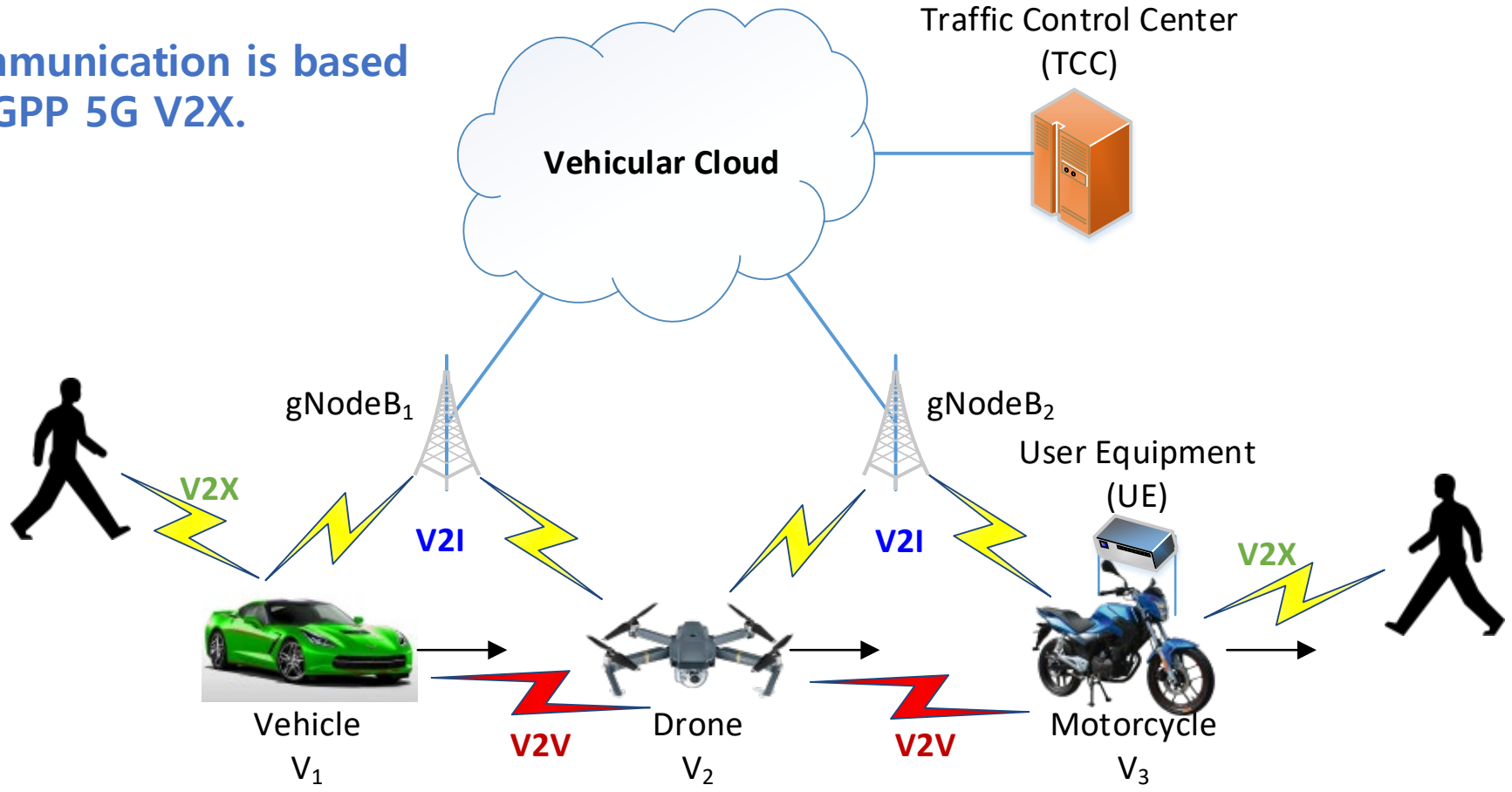
- **Vehicle Computer**
  - Safety, security, real-time and application processing with in-vehicle and vehicular cloud
- **Connectivity Domain Controller**
  - Secure car access, 5G V2X, Wi-Fi, and UWB with other cars and infrastructure nodes
- **In-Vehicle Networking**
  - Safe and secure flexible backbone of Ethernet, CAN, LIN and FlexRay
- **Zonal Controller**
  - Hub for power distribution and data connection to actuators and sensors

[Source] https://www.nxp.com/applications/automotive/software-defined-vehicle-infrastructure

IPMON Network Architecture (1/2)

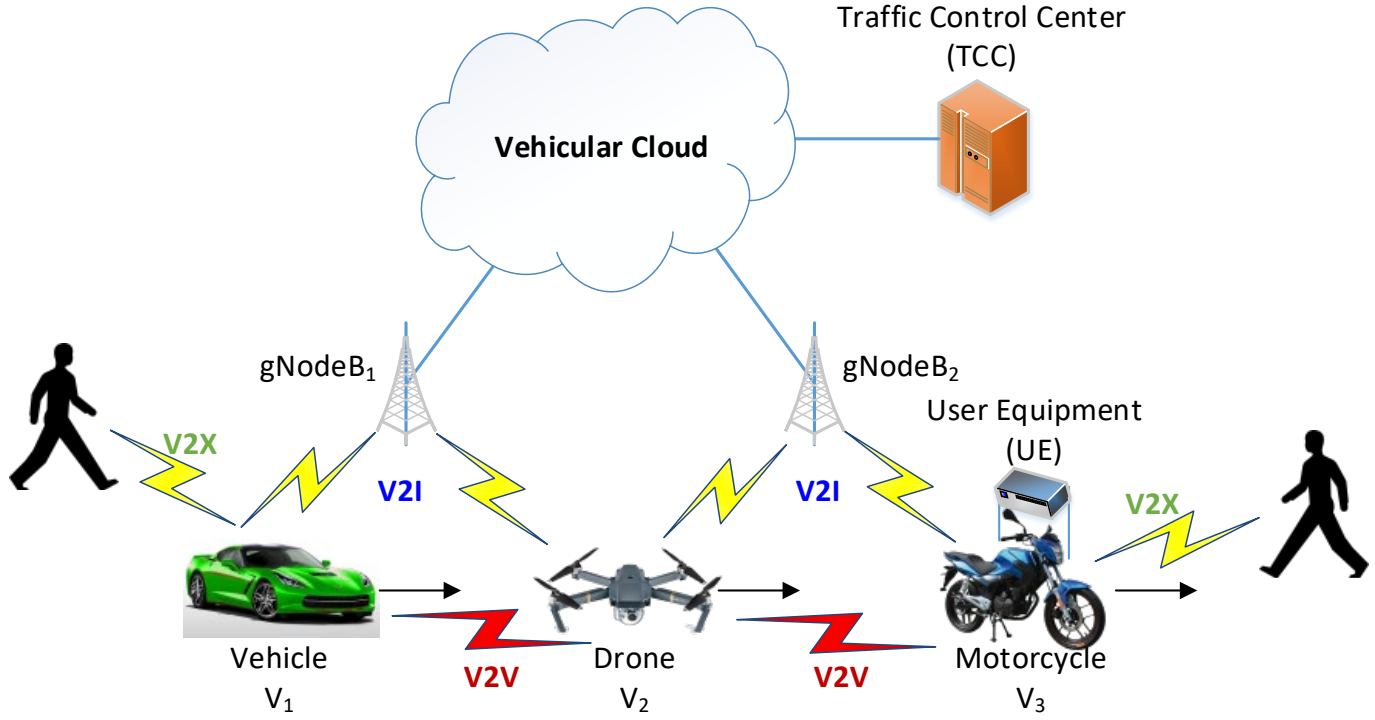
- An IPMON Network consists of Vehicular Ad Hoc Networks (VANET) and Radio Access Networks (RAN) for Internet connectivity.
- Wireless Communications supports 3GPP 5G V2X.
  - (i) V2V over PC5 Interface (i.e., Sidelink) and (ii) V2I2V over Uu and Uu Interfaces

Wireless Communication is based on 3GPP 5G V2X.



IPMON Network Architecture (2/2)

- **Traffic Control Center**
  - A Control Entity that makes decisions for various services for mobile objects with information from the mobile objects.
- **Vehicular Cloud**
  - A cloud infrastructure for vehicular networks, having compute nodes, storage nodes, and network forwarding elements (e.g., switch and router).
- **Infrastructure Nodes**
  - Infrastructure nodes (e.g., gNodeB and IP-RSU) enable mobile objects on the road being connected to the networks.
- **Mobile Objects**
  - The objects that are running on the road or sidewalks while connected to networks. Those objects share mobility information and communicate with each other and TCC.



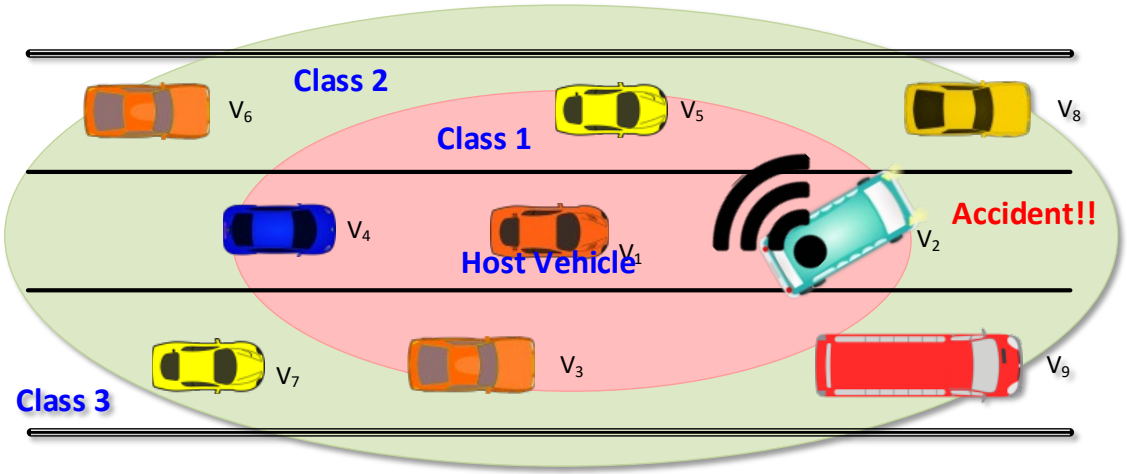
Target Scenarios of IPMON

- IPMON is used in various environments such as Highway, Urban Road Networks, Streets, Parking Lots, and Drone Networks.
- IPMON VANET is intermittently connected to the Internet infrastructure.
- IPMON MOs need to effectively configure their IPv6 addresses for both VANET and RAN.
- Packets of MOs need to be routed to destinations efficiently.

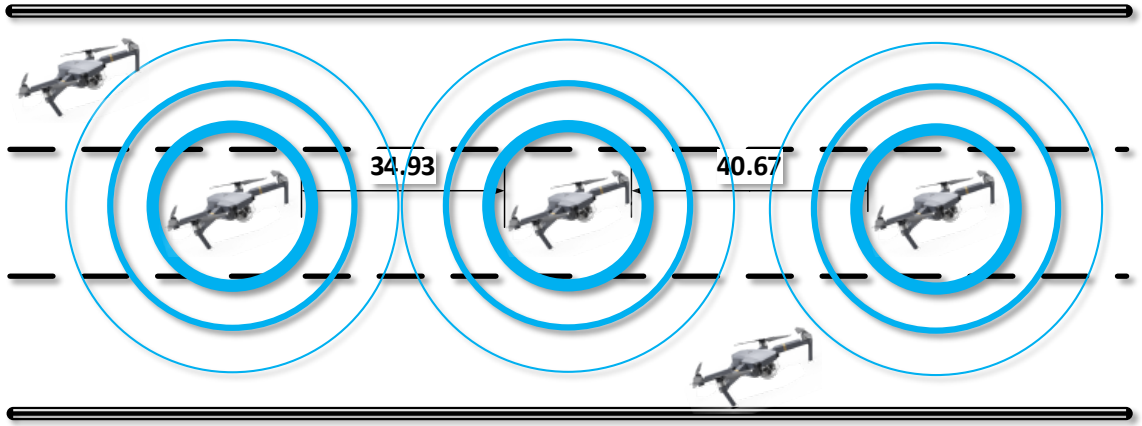
Use Cases of IPMON: V2V (1/2)

- Context-aware navigation for safe driving and collision avoidance
- Collision avoidance service of end systems of Urban Air Mobility (UAM)
- Cooperative adaptive cruise control in a roadway
- Platooning in a highway
- Cooperative environment sensing

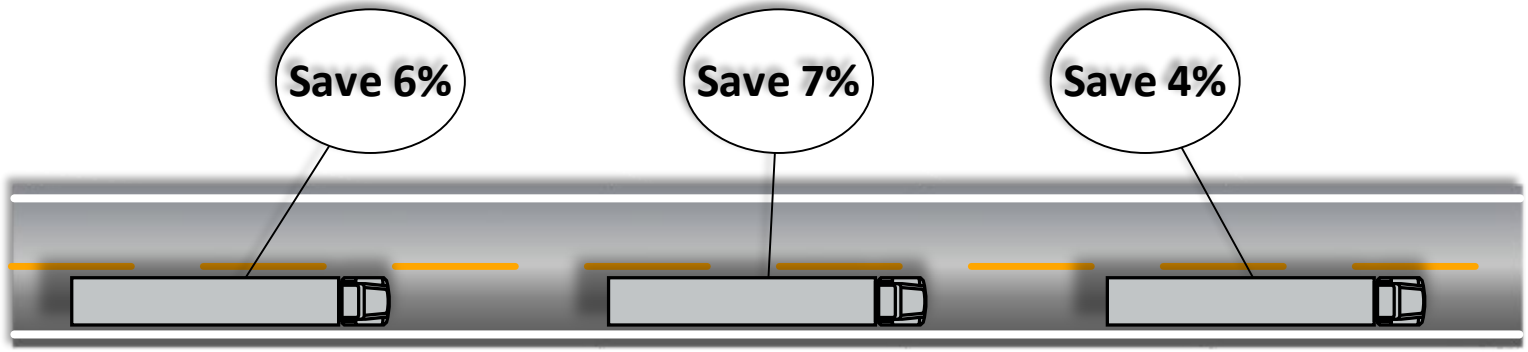
Use Cases of IPMON: V2V (2/2)



Safe Driving in Road Networks



Safe Flying in Drone Networks



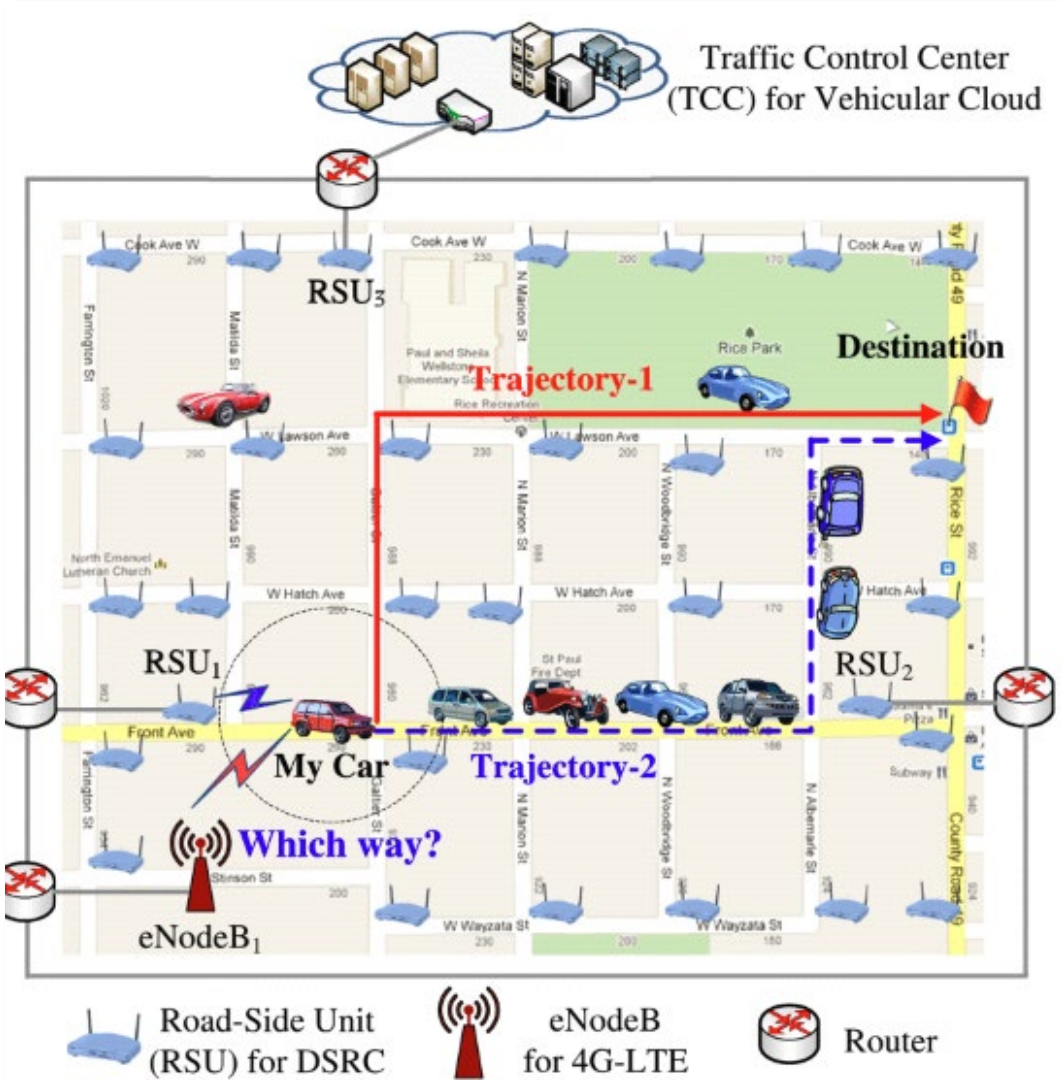
Total energy consumptions are saved by platooning.

Platooning for Efficient Driving

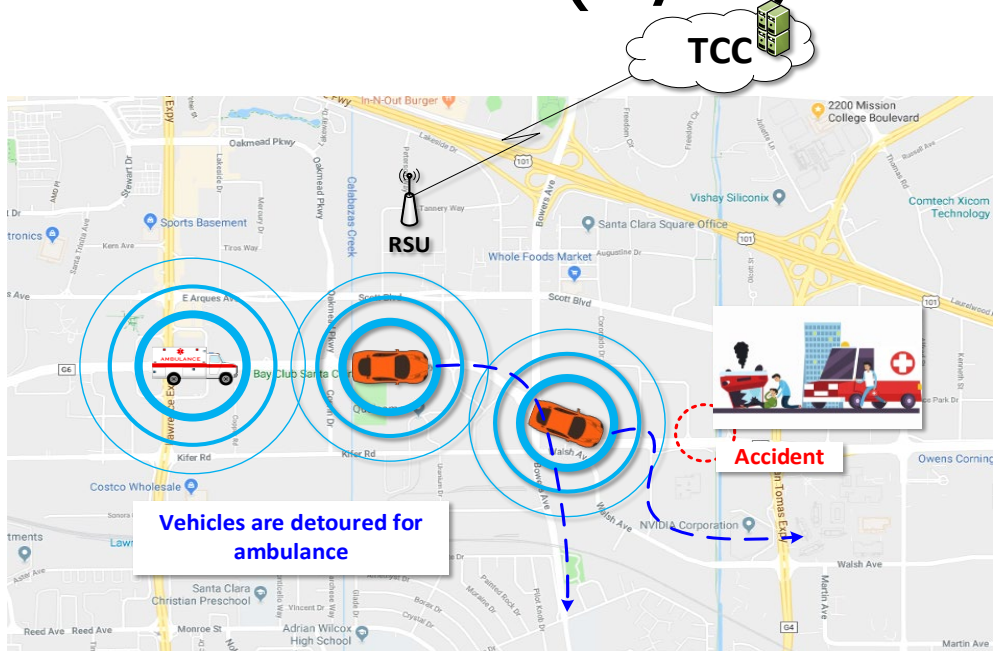
Use Cases of IPMON: V2I (1/2)

- Navigation service
- Energy-efficient speed recommendation service
- Accident notification service
- Electric vehicle (EV) charging service
- UAM navigation service with efficient battery charging

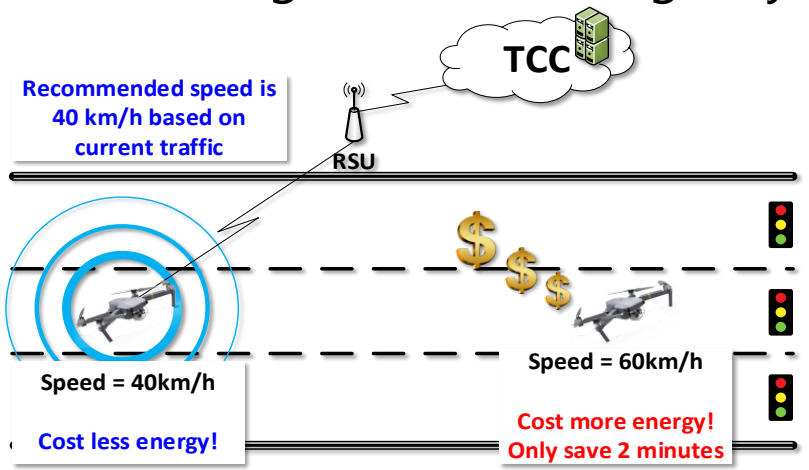
Use Cases of IPMON: V2I (2/2)



Efficient Navigation for Road Networks



Effective Navigation for Emergency



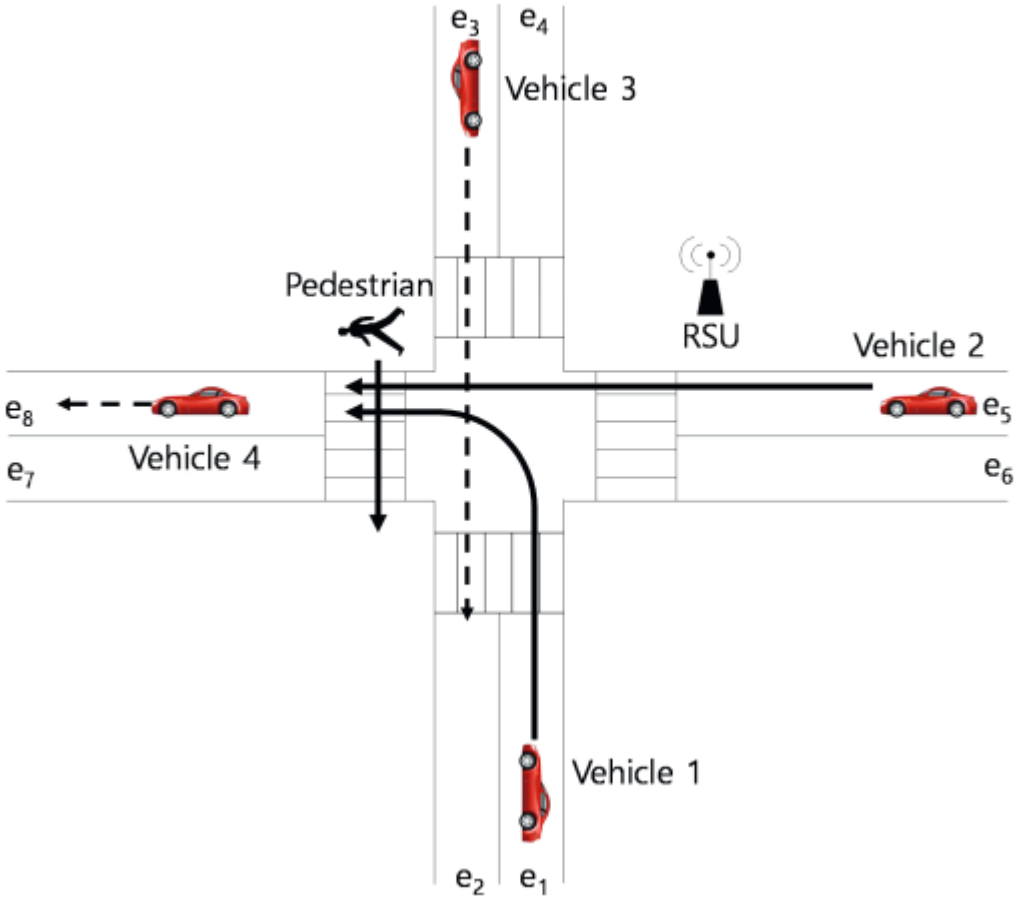
Speed Recommendation for Energy Efficiency

Use Cases of IPMON: V2X (1/2)

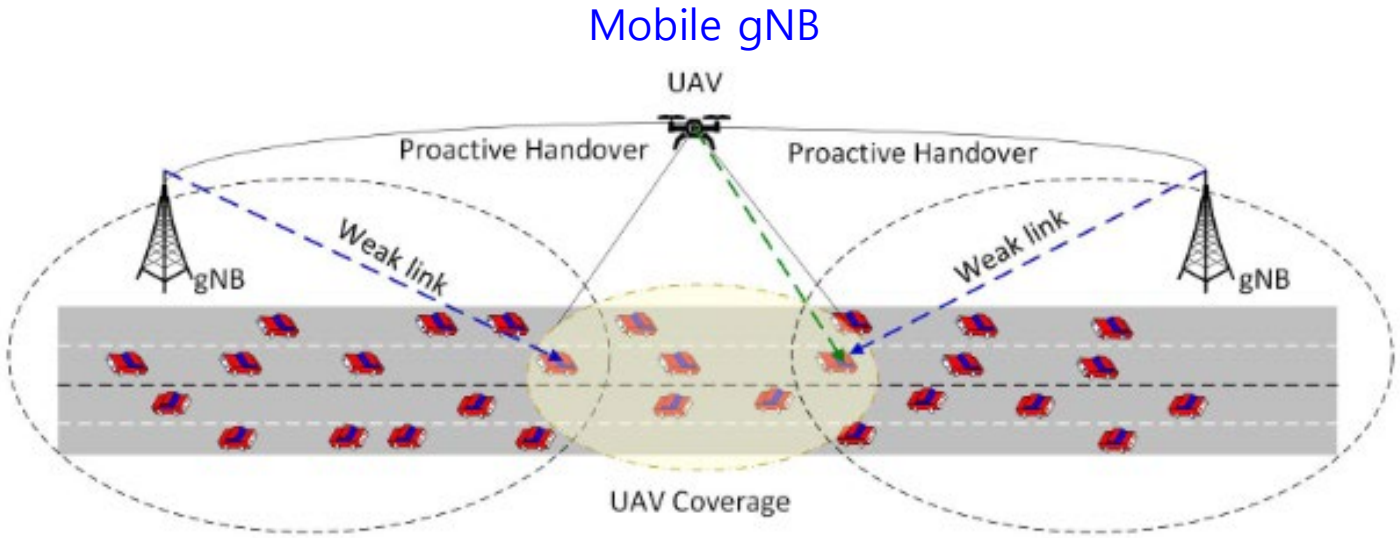
- Protection service for vulnerable road user (VRU)
  - e.g., pedestrian and cyclist

- Human sensing-based protection service for VRUs without smart devices

Use Cases of IPMON: V2X (2/2)



Pedestrian Protection

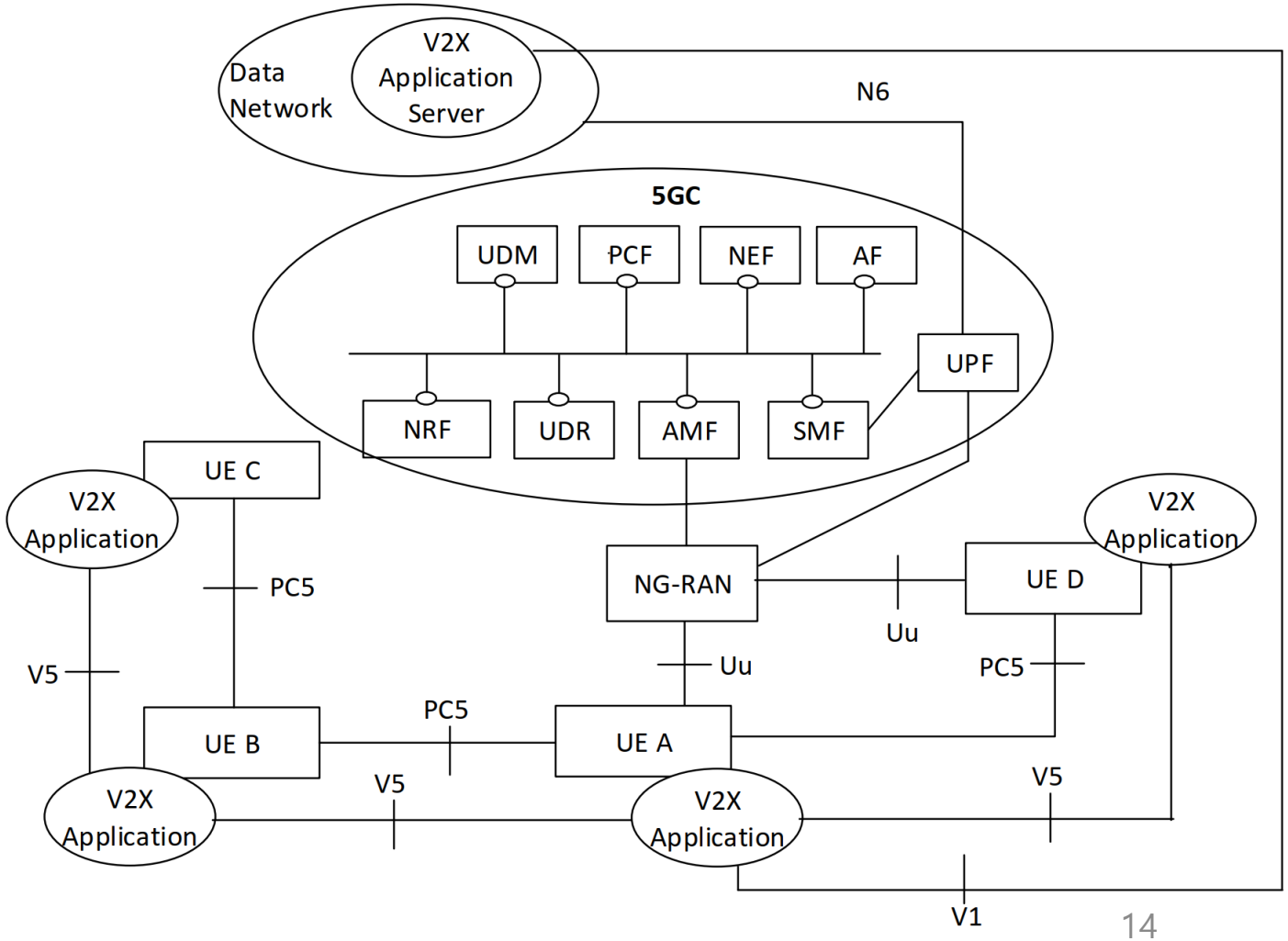


Blind Spot Coverage in Road Networks with Drones

5G System Architecture for V2X in **TS 23.287:**

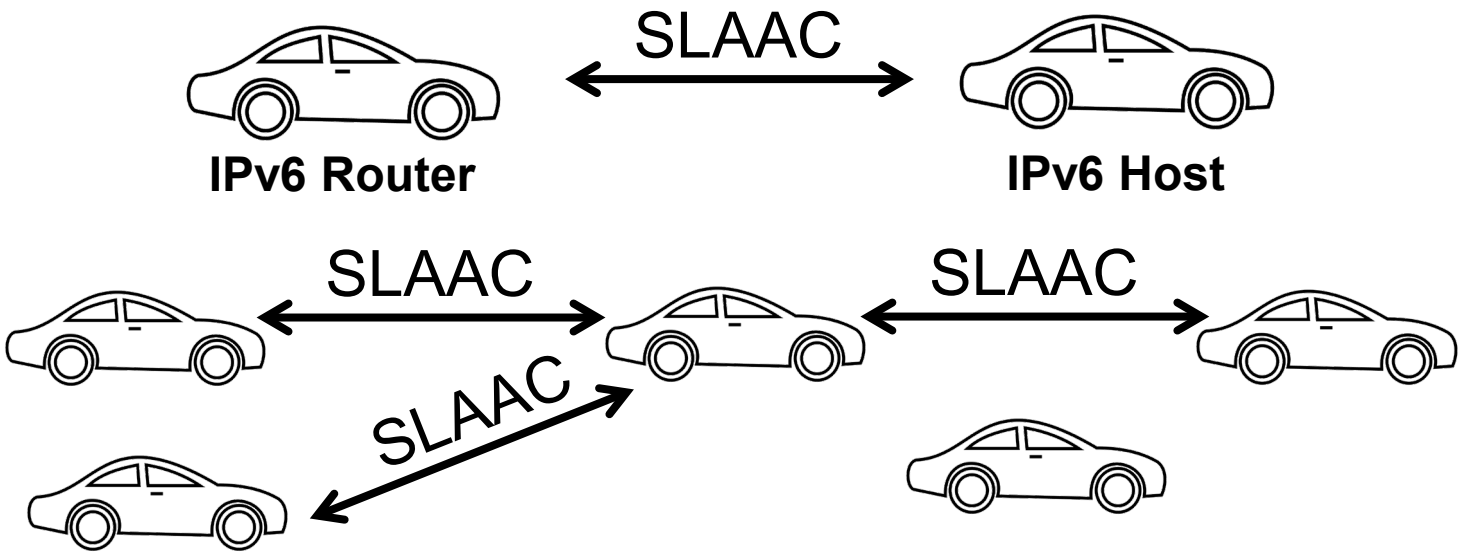
Architecture enhancements for 5G System (5GS) to support Vehicle-to-Everything (V2X) services

- V2V by PC5 reference point
- V2I by Uu reference point
- UEs can be ground vehicles, drones, pedestrian devices, scooters, etc.



Observation 1

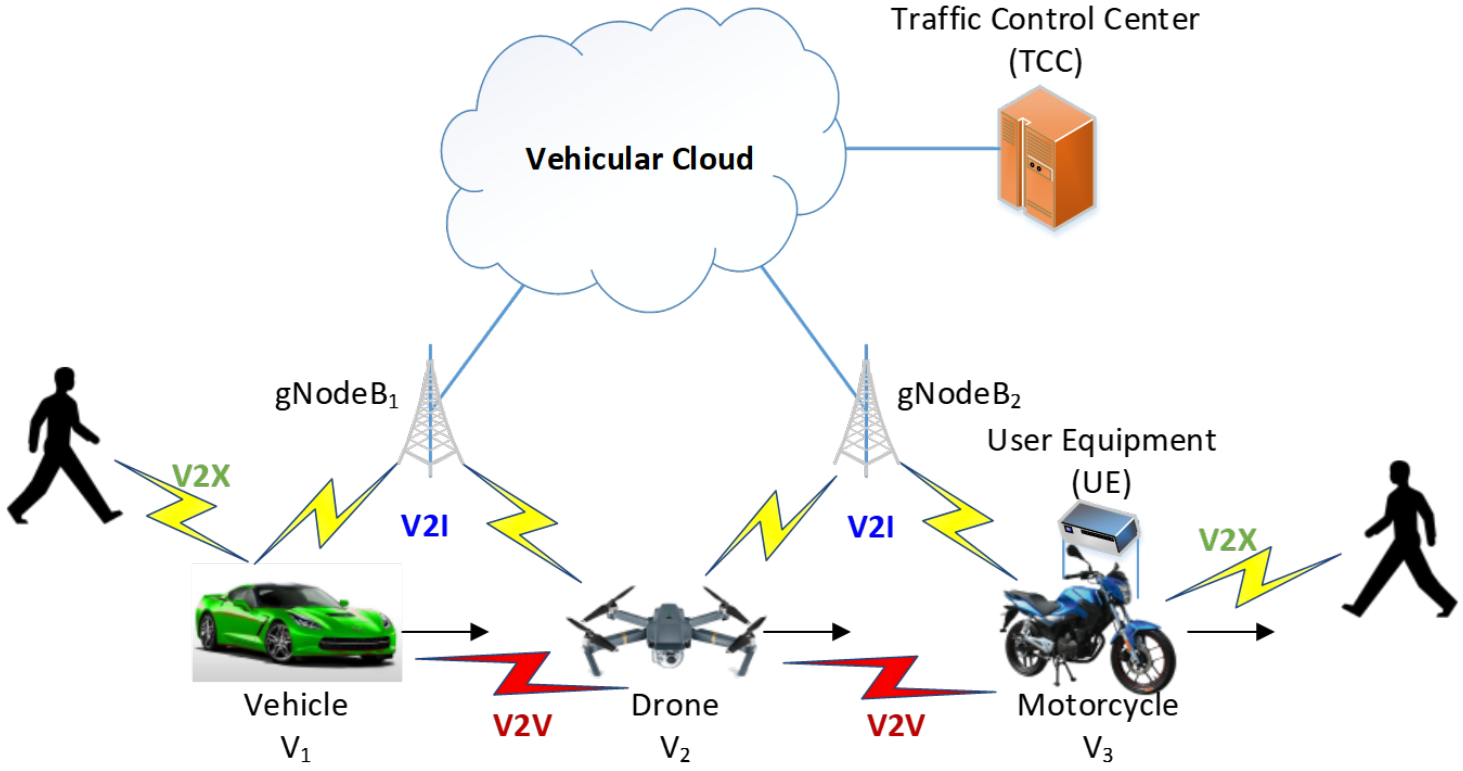
- For 5G V2V by PC5 in unicast mode, one vehicle UE (VehUE) needs to be an IPv6 router for SLAAC.



- ✓ **Which one shall be the IPv6 router for SLAAC?**
- ✓ **How many IPv6 addresses/prefixes will a vehicle have in this case?**

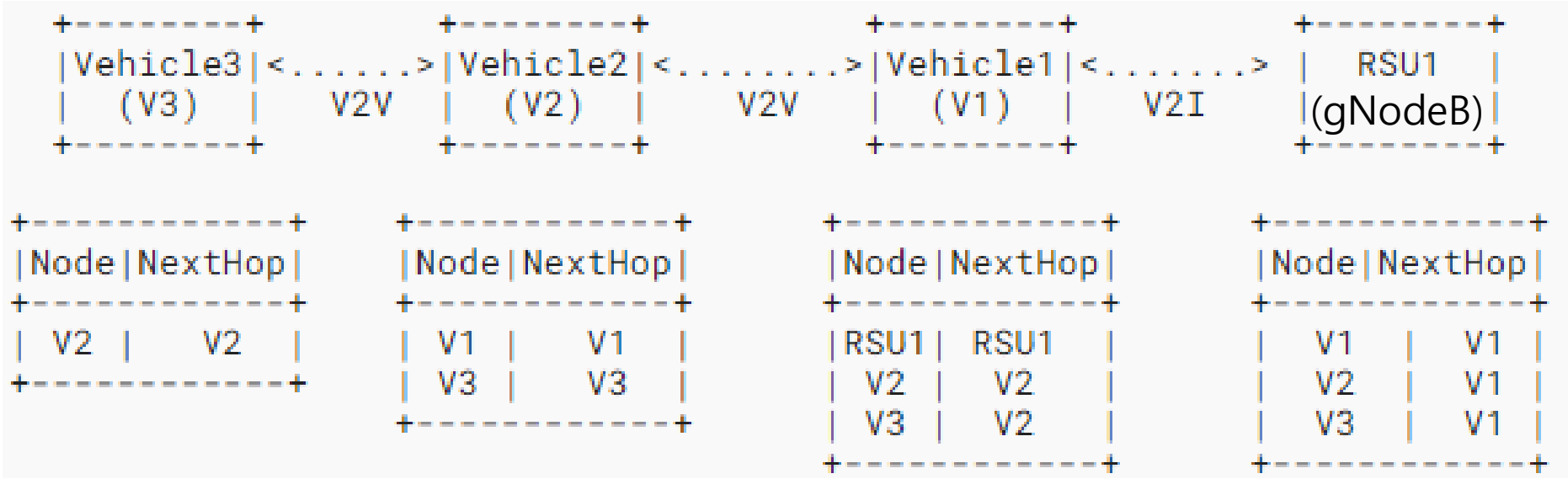
Observation 2

- For V2V and V2I communications in general, will they use the same IPv6 configuration?
  - Using the same prefix?
  - Using the different prefixes?



Observation 3

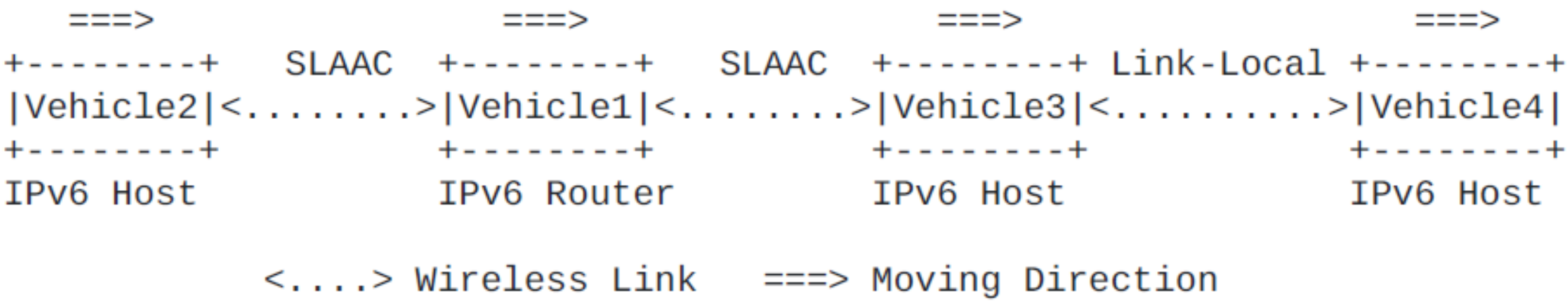
- For multihop V2V and V2I, existing routing protocols are costly to maintain routing table.
  - How to minimize control traffic overhead for both routing and IPv6 ND?



Observation 4

- Mobility Management in 5G V2X is required for the communications between a VehUE and a server in a Data Network (i.e., Internet).
  - How to manage mobility of vehicles that have connections with a server while they are moving along their moving paths?

Problem Statement in IPMON (1/2)



IPv6 Slateless Address Autoconfiguration (SLAAC)
in Unicast Mode by PC5 Interface of 5G V2V

Problem Statement in IPMON (2/2)

- Which VehUE shall be the IPv6 router for the role to assign IPv6 addresses/ prefixes if multiple VehUEs can be or want to be an IPv6 router?
- For a VehUE acting as an IPv6 router, how many IPv6 addresses/prefixes will it assign?
  - How much will the role of an IPv6 router burden the IPv6 router VehUE?
- For a VehUE receiving IPv6 addresses/prefixes from an IPv6 router VehUE, how many IPv6 addresses/prefixes will it have on the movement?
- If a VehUE does not have any connection with an IPv6 router VehUE, it will only use an IPv6 link local address for communications. In this case, multihop routing is triggered to forward IPv6 packets.
  - How will this scenario affect the IPv6 networking among VehUEs?

Work Items for IPMON

1. IPv6 Mobile Objects (IPMON): Problem Statement and Use Cases
2. Basic Support for IPv6 Networks Operating over 5G Vehicle-to-Everything (V2X) Communications
3. Vehicular Neighbor Discovery (VND) for Multihop IPv6 Address Autoconfiguration
4. Vehicular Mobility Management (VMM) for Proactive Mobility Support
5. Vehicular Packet Routing (VPR) with Light-Weight Routing Overhead
6. Vehicular Security and Privacy (VSP) for Mobile Objects
7. Context-Aware Navigation Protocol (CNP) for Safe Maneuver of Mobile Objects
8. Identifier and Locator Management for Mobile Objects

Next Step of IPMON

- **IPMON BoF in the IETF-118 Prague Meeting**
  - The Clarification of IPMON Charter
  - Forming of Interested Group from Automotive Vendors, Network Vendors, and Operators
  - Request for Non-WG Forming IPMON BoF
  - IPMON Hackathon Project: IPv6 Drone Networking over 5G V2X