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            Publish-Subscribe Service in ICN-based Vehicular Network
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Status of this Memo

Abstract

   As autonomous vehicle is becoming a major research in automotive
   engineering, the importance of vehicular network is also increasing.
   Content-oriented vehicular network requires new communication

   architecture that is different from the existing IP-based
   architecture. ICN is one of the best alternatives for vehicular
   network to serve as communication infrastructure. ICN only supports
   pull-based communication. Therefore, an efficient communication
   method is needed for disseminating safety information for vehicles,
   and the publish/subscribe(pub/sub) system can be a good alternative.
   This document proposes a pub/sub service architecture and procedures
   for disseminating safety information between vehicles and
   infrastructure.

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1. Introduction

   ICN is one of the future internet alternatives, which focuses on
   contents rather than connectivity. ICN has unique attributes such as
   location independent naming, in-network caching, name-based routing
   and built-in security [BARI12].

   The vehicular network helps to exchange information between
   infrastructure and vehicles by providing driver assistance such as
   safety, traffic information and other value-added services [WANG19].
   ICN is one of the best alternatives to efficiently communicate the
   safety information in the vehicular network [KHEL19].

   The pub/sub system supports asynchronous one-to-many communication
   and is one of best ways to broadcast events [TARA12]. The pub/sub
   system in ICN-based vehicular network can be a solution to
   efficiently disseminate information in terms of events to vehicle

users who desire the information. The advantage of this architecture
has in-network caching of ICN and information dissemination of the
pub/sub system.

This document represents an ICN-based pub/sub service architecture
for V2I communication on the vehicular Network and describes a
publish and subscribe procedures under the proposed architecture. It
also describes future research issues required for enhanced pub/sub
services in ICN-based vehicular network.

2. Pub/Sub Service Architecture for ICN-based Vehicular Network

2.1. Pub/Sub Applications

In [KHEL19], VANET applications was classified into three main
categories: safety applications, traffic information applications,
and comfort applications. This document also classifies applications
into three categories:

o Safety Applications : It concerns lives of the drivers and the
  passengers

o Traffic Information Applications : It provides up-to-date traffic
  information

o Infotainment Applications : It aims to improve the drivers and
  the passengers comfort and provide an information

Among these applications, safety applications and infotainment
applications are suitable for pub/sub services because the intent of
subscribers is important.

2.2. Pub/Sub Service Architecture

For the proposed architecture, this document assumes the running
environment of vehicular network. First, there are multiple
brokers(rendezvous nodes) for wide service coverage. Second, each
broker shares topic information with each other. For this purpose,
brokers need synchronization protocol such as PSync. Third, A
publisher/subscriber communicates with a closest broker.

Our proposed pub/sub service architecture uses immobile rendezvous nodes to decouple publishers and subscribers. The rendezvous nodes store and manage information about important events on the road. A publisher sends important event information, such as a car accident on the road, to the closest rendezvous node. Publishers and subscribers can be both vehicles and persons. A subscriber registers the closest rendezvous node and receives subscribed information. A rendezvous node store published event information, and synchronizes the stored information of other rendezvous node using a data sharing protocol. Therefore, subscribers only can subscribe to a rendezvous node and receive information from the rendezvous node. The subscriber does not need to have information about publishers and can obtain event data only by having the information on the rendezvous node. Publishers and subscribers only need FIB entry about the rendezvous node to send packets it. Thus, the routing of proposed architecture is very simple. In addition, the rendezvous node can process published event data to create useful information for subscribers.

```
   +-------------------+                 +-------------------+
   | Rendezvous Node-1 | <-------------> | Rendezvous Node-N |
   +-------------------+      Sync       +-------------------+
          ^                                       ^
          |Subscribe                     Publish  |
          |                                       |
 ==================================================================
          |                                       |
     +-----------+                         +-----------+
     | Vehicle-1 |                         | Vehicle-m |
     +-----------+                         +-----------+


 ==================================================================
```

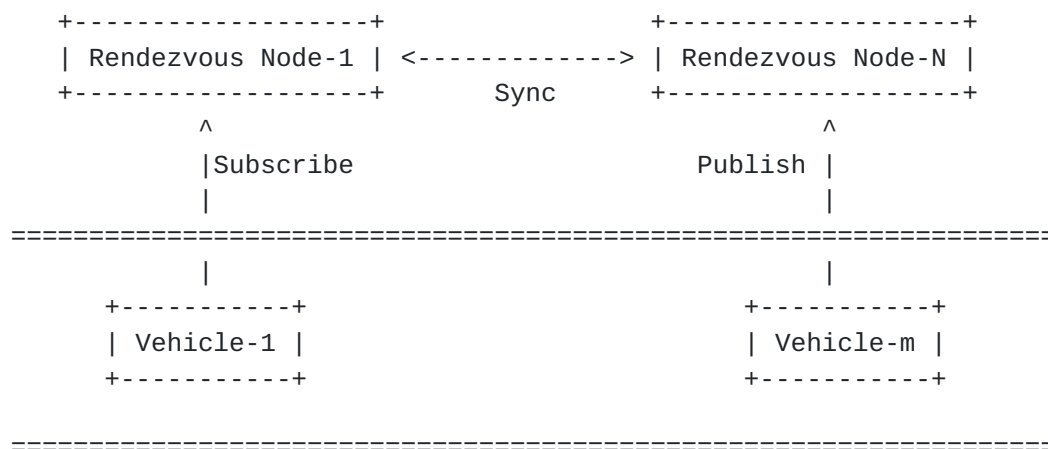   Figure 1: Pub/Sub Service in ICN-based Vehicular Network

2.3. Name Structure

Naming is the pinnacle of NDN that differentiates it from traditional networks. NDN names should be globally unique, secure, location-independent, and human-readable [BARI12]. Khelifi et al. analyzed existing naming solutions in the context of VANET [KHEL19]. Wang et al. proposed a data naming structure for V2V traffic

   information dissemination [WANG12]. However, this structure is for
   V2V communication. This document proposes a name structure for V2I
   communication by expanding that.
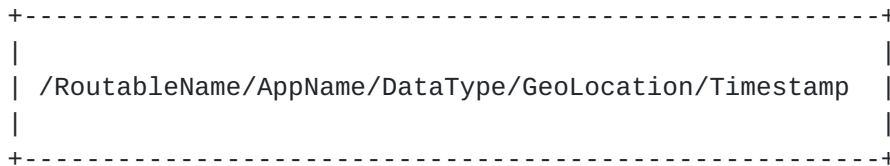

```
        +-------------------------------------------------------+
        |                                                       |
        | /RoutableName/AppName/DataType/GeoLocation/Timestamp  |
        |                                                       |
        +-------------------------------------------------------+
            Figure 2: Name Structure for Pub/Sub in ICN-VN
```


   o RoutableName : routing prefix toward rendezvous node

        Ex) /rendezvous

   o AppName : application name

        Ex) safety, infotainment, traffic

   o DataType : occurred event type

        Ex) alarm, advertisement, speed

   o GeoLocation : geolocation information

        Ex) /RoadID/Direction/ZoneNo

   o Timestamp : specific time (Optional)

        Ex) 20190721113000 (YYYYMMDDHHMMSS)

3. Pub/Sub Service Procedure

   This document describes publish and subscribe procedure using the
   safety applications.

3.1. Publish Procedure

   An example of publication is as follow;

   o There is an accident on the road.

   o The vehicle or person is aware of an accident.

   o The publisher generates data names according to the proposed
      naming structure for publishing events.

   o The publisher creates an Interest packet with event information.
      (Use Application Parameter for NDN packet)

   o The publisher sends an Interest packet to the rendezvous node.

   o The rendezvous node receives an interest packet with published
      event.

   o The rendezvous node stores a received event.


```
   +---------------------------------------------------------------+
   |                                                               |
   | /RN_prefix/safety/alarm/road1-north-zone12/now/car-accident |
   |                                                               |
   +---------------------------------------------------------------+
```
                     Figure 3: Publish Name Example

3.2. Data Synchronization Procedure

   An example of Synchronization is as follow;

   o A publisher publishes the event at the nearest rendezvous node.

   o The rendezvous node stores published events.

   o The rendezvous node synchronizes the list of topics on which the
      change occurred with other rendezvous nodes. Specific methods
      require further study.

   o The rendezvous node uses a synchronized list of topics to
      communicate information to subscribers.

3.3. Subscribe Procedure

An example of subscription is as follow;

o A subscriber(vehicle) generates name to obtain data.

o A subscriber creates an Interest packet under the name structure
   and sends it to the rendezvous node.

o The rendezvous node receives a subscription interest packet, and
   analyzes the name from an interest packet.

o The rendezvous node searches its repository for data that a
   subscriber wants.

o The rendezvous node generates a manifest based on the retrieved
   information and forwards it to the subscriber.

o The subscriber requests rendezvous nodes, which store the real
   data based on the information from the received manifest.

o Each rendezvous node creates data packets for the information and
   transmits.

o A subscriber receives the data packet, and extracts information
   from it.

```
       +-------------------------------------------------------+
       |                                                       |
       |        /RN_prefix/safety/alarm/road1-north-zone12/    |
       |                                                       |
       +-------------------------------------------------------+
                   Figure 4: Subscribe Name Example
```

4. Open Research Challenges

The proposed architecture in Section 3 described how pub/sub service
over ICN operate. However, several research challenges remain open
and still need to be addressed. The list that need further study is
as follows:

o A study on the name structure to provide various vehicular
   network applications

The name structure may vary depending on the nature of
applications in the vehicular network. For example, the name of
navigation application may be preferable to express the origin
and destination address in the name.

o A study on subscriber certification for provision of premium
   pub/sub services

   In order to provide special services to some subscribers, the
   rendezvous node needs to perform subscriber authentication.
   Because ICN is content name communication, the rendezvous node
   should be a way to distinguish certified subscribers.

o A study on efficient push mechanism for pub/sub service

   ICN is a pull-mode communication. A push-type communication
   method is required that allows instantaneous delivery to
   subscribers in occurrence of urgent event.

o A study on the distributed rendezvous architecture for SPOF and
   service locality

   The distributed rendezvous node structure has advantages in terms
   of scalability. However, research is needed on how data is
   synchronized between multiple rendezvous nodes and how data
   residing on multiple rendezvous nodes is communicated to
   subscribers.

5. IANA Considerations

This memo includes no request to IANA.

6. Security Considerations

This document does not define a new protocol (or protocol extension)
or a particular mechanism, and therefore introduces no specific new
security considerations. General security considerations for
Information-Centric Networking are discussed in [RFC7945].

7. References

7.1. Normative References

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8. Acknowledgments

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