    Service and Neighbor Vehicle Discovery in IPv6-Based Vehicular Networks
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Abstract

   For Cooperative Adaptive Cruise Control (C-ACC), platooning and other
   typical use cases in Intelligent Transportation System (ITS), IPv6
   communication between neighbor vehicles and between vehicle and
   server pose the following two issues: 1) how to discover a neighbor
   vehicle and the demanded service; and 2) how to discover the link-
   layer address and other metadata of the neighbor vehicle and selected
   server. This document presents a solution to these problems based on
   DNS-SD/mDNS [RFC6762][RFC6763].

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.

Status of This Memo

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1. Introduction

   As illustrated in [DNS-Autoconf], a naming scheme is needed for the
   vehicle devices to support the unique name auto-configuration. This
   can support the location based communication and scalable information
   organization in Intelligent Transportation Systems (ITS). Based on
   the naming scheme like this and the widely-used DNS-SD/mDNS protocol,
   this document illustrates how to discover a neighbor vehicle or the
   required services with DNS resolution logic. Before this, we make
   the following assumptions:

   o Name: A vehicle SHOULD have at least one temporary name which may
      be related with its geo-location or provided services. This name
      is related with the service or identifier of the particular
      vehicle.

   o Address: A vehicle SHOULD have at least one global IP address
      which is routable for the IPv6 communications. This address acts
      as the Home Address (HoA) of vehicle to facilitate its mobility.

In this way, a standardized, efficient and scalable scheme should be
used to retrieve the necessary information of the corresponding node
(domain name, IP address, geo-location, link-layer address, key and
so on) for the further communications based on the DNS-SD/mDNS
functions. In addition, the IPv6 Neighbor Discovery (ND)'s messages
(e.g., RA and RS messages) can also be used to exchange some required
information (e.g., mobile network prefixes) in ITS in combination
with DNS-SD/mDNS [MNPP].

2. Name and address configurations

Typically, the Road-Side Unit (RSU) acts as an Access Router (AR) to
serve for the static and moving vehicles which want to be connected
into the networks locally or publically.

Based on [RFC3646], [RFC6106] or extended WAVE Service Announcement
(WSA) message, the RSU can announce its location based name prefix to
the vehicles covered by the RSU. This location based prefix may
contain information such as country, city, street and so on, which
will act as the "domain_name" of the vehicle device name as specified
in [DNS-Autoconf].

The RSU may also advertise the IPv6 prefix to support the IPv6
Stateless Address Auto-configuration (SLAAC) operation of vehicle
devices and movement detection (in the IP layer). If the DHCPv6 is
used for the address configuration, RSU also acts as functional
entity such as a DHCP proxy and DHCP server.

3. Service and neighbor vehicle discovery

Vehicular network is a dynamic environment, then the following two
modes should be supported based on different connection conditions of
the vehicle.

(1) RSU based

Vehicles may have direct connection with the serving RSU and join the
same link with the serving RSU. Then the RSU can maintain the
registered vehicles and services in its serving domain. Otherwise,
the RSU acts as a proxy node for discovering in a proxy manner
[DNSSD-Hybrid].

When a vehicle wants to locate the potential service or the nearby
neighbor and further establish the communication, the vehicle will
trigger the direct unicast query to port 5353 or legacy unicast DNS
query to the RSU. RSU may respond directly if it has the related
information, otherwise, the RSU multicasts the DNS query to the
multicast group to retrieve the related information. A unicast

response is the first recommendation here because it can suppress the
flooding, but of course, the DNS response message can also be
multicasted as an active announcement of the vehicle or service
existence.

(2) Ad-hoc based

Vehicles may communicate with each other or sense the front and rear
neighbor vehicles with DSRC, WiFi, Bluetooth or other short-distance
communication technologies, connecting each other in the Ad-hoc
manner. Then the discovery can also be executed in an
infrastructure-less manner with the following phases, as specified in
the plain mDNS.

o Probing: When a vehicle starts up, wakes up from sleeping mode or
   the Vehicular Ad Hoc Networks (VANET) topology changes (after
   configuration of the name and address), it should probe the
   availability of the service with which it can provide other
   vehicles. Then the vehicle periodically announces the service and
   its existence with unsolicited multicast DNS response containing,
   in the Answer Section, all of its service name, DNS name, IP
   address and other information. The vehicle also updates the
   related information actively if there is any change.

o Discovering: To support the service and neighbor vehicle discovery
   in the dynamic and fragmentation-possible environment in VANET,
   different query modes of mDNS can be used for different scenarios:
   1) One-Short Multicast DNS Query can be used to locate a specific
   vehicle. 2) Continuous Multicast DNS Query can be used to locate
   the nearby vehicles which are moving.

o Refreshing: After the neighbor discovery as illustrated above, the
   vehicles should continually exchange their DNS name, IP address,
   geo-location and other information in order to refresh the
   established communications. For example, the Multiple Questions
   Multicast Responses can be used to update the caches of receivers
   efficiently and Multiple Questions Unicast Responses can be used
   to support the fast bootstrapping when a new vehicle joins.

o Goodbye: When the vehicle arrives at its destination, stops
   temporarily or shuts down its communication or sensing devices, it
   will announce the service suspending and its inexistence with an
   unsolicited multicast DNS response packet, giving the same
   Resource Records (RRs) (containing its DNS name and IP address),
   but with zero Time-To-Live (TTL).

4. Mobility support

   During the movement of the vehicle, it may cross different RSUs.
   When a vehicle enters the coverage of a new RSU, the new domain
   prefix and new IPv6 prefix may be learned. Generally, there are the
   following three main cases for the mobility:

   o The domain name changes and the IP prefix remains. The vehicle
      will configure a new DNS name from the new RSU. Then the vehicle
      should update the new DNS name in the local database (e.g., RSU)
      with DNS Update [RFC2136], DNS Push Notifications [DNSSD-Push],
      Service Registration Protocol (SRP) [DNSSD-SRP] or just actively
      announce its new name information with plain mDNS notification
      scheme. If the service is registered in the RSU, then the stale
      service should be withdrawn in order to reduce the management load
      [DNSSD-Lease].

   o The domain name remains and the IP prefix changes. The vehicle
      will configure a new IPv6 temporary address (e.g., CoA) form the
      new RSU. Then the IP-layer mobility management protocols should
      be used to update the binding entry of the vehicle (e.g., Mobile
      IPv6 [RFC6275]).

   o Both the domain name and IP prefix change, the name information
      should be updated as in the first case and then the IP-layer
      mobility management protocols (e.g., Mobile IPv6 [RFC6275] and
      Proxy Mobile IPv6 [RFC5213]) as in the second case should also be
      triggered.

5. Signaling messages

   To facilitate the further communication, the link-layer address,
   public Key, geo-information and other metadata may be included in the
   DNS message in a piggyback manner. Specially, the TXT RR in DNS-SD
   can be used to include these information with multiple key: value
   pairs.

   Besides, this kind of information may be obtained through the
   following IPv6 Neighbor Discovery Protocol (NDP) or other procedures
   (e.g., DHCP and WSA).

6. Security considerations

   In order to reduce the DNS traffic on the wireless link and avoid the
   unnecessary flooding, the related schemes in mDNS can be used, such
   as: Known-Answer Suppression, Multipacket Known-Answer Suppression,
   Duplicate Question Suppression and Duplicate Answer Suppression.

In order to guarantee the origination of the DNS message and avoid
the DNS message tampering, the security consideration in mDNS should
also be adopted.

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