TrafficCam: Sharing Traffic Information based on Dynamic IPv6 Multicast Group Assignment using Smartphone Sensors

Yohei Kanemaru, Satoru Noguchi, Atsuo Inomata, Kazutoshi Fujikawa
Graduate School of Information Science, Nara Institute of Science and Technology, Japan
{yohei-ka,satoru-n}@is.naist.jp, {atsuo,fujikawa}@itc.naist.jp

***Abstract*—Exchanging traffic information among nearby vehicles is one of the communication scenarios in the field of intelligent transport systems (ITS). An important question in this scenario is *"How can traffic information be delivered to only one subset of nearby vehicles in the same road traffic situation?"*, for example, to only congested traffic in a certain lane. In this demonstration, we propose a dynamic IPv6 multicast group assignment mechanism using GPS, an accelerometer and a magnetometer embedded in smartphones. Our mechanism enables each vehicle to find the relevant vehicles, and to compose a temporary IPv6 multicast address. Our mechanism can deliver traffic information to a group of vehicles in a particular situation. This demonstration, carried out on virtual traffic congestion, shows an information-sharing scenario using a prototype of the proposed mechanism, implemented as an Android application called TrafficCam. Our application demonstrates the usefulness of the proposed mechanism.**

I. Introduction

Recently, a wide variety of location-based services has been developed. In the field of intelligent transport systems (ITS), a roadside infrastructure may provide traffic information to vehicles in the area. Some services have already been deployed, e.g., the Vehicle Information and Communication System (VICS) in Japan [1]. While these services focus on large scale scenarios (e.g., a nationwide-scale highway traffic information service), it is necessary to support also such small scale scenarios as exchanging information among nearby vehicles.

For instance, a vehicle v in congested traffic is *relevant* to nearby vehicles if they are in the same lane as v. To deliver traffic information only to relevant vehicles, the key issues are *how to determine the relevance of nearby vehicles* and *how to compose a temporary multicast group*. Broadcasting is the simplest solution; however, this may cause a scalability issue. Another solution is to use IP multicast, but, then, each vehicle would need to join preconfigured multicast groups in order to receive traffic information from relevant vehicles.

In this demonstration, we propose a dynamic IPv6 multicast group assignment mechanism using GPS, an accelerometer and a magnetometer embedded in smartphones. Our mechanism can deliver traffic information from a smartphone to a group of vehicles in a particular situation when the smartphone joins a temporary IPv6 multicast group generated with GPS and sensors. Each node can join to the IPv6 multicast group without any knowledge of other nodes; additional communication is therefore unnecessary.

We implemented a prototype of the proposed mechanism as an Android application called TrafficCam. A recent-model smartphone has GPS and various sensors, such as an accelerometer and a magnetometer; this model can therefore be used as an essential component of our mechanism. Our application can be installed on any Android smartphone equipped with GPS, an accelerometer, a magnetometer, and Wi-Fi with IPv6 connectivity. This demonstration shows the usefulness of the proposed mechanism in enabling relevant vehicles to communicate with each other.

II. Related work

A number of solutions for geographic addressing have been proposed. RFC 2009 has specified the format of encoding location into an IPv4 multicast address [2]. Although it generates an IPv4 multicast address using the names of the state, county, and town, it only focuses on geographical location.

The European GeoNet project has evaluated several approaches to delivering an IPv6 packet according to geographical information [3]. These approaches rely on modifying the IPv6 communication stack, so they are hard to install on existing devices such as smartphones.

III. Dynamic IPv6 Multicast Group Assignment

How to determine the relevance of nearby vehicles and how to compose a temporary multicast group are the key issues to solve in order to deliver messages among vehicles sharing a common situation. Relevant vehicles in a specific situation need to select the multicast group corresponding to the situation. This is generally done by using a list of multicast groups statically configured a priori. However, due to the huge number of situations, it is not practical to rely on static multicast group assignment.

We propose a dynamic IPv6 multicast group assignment mechanism that, by encoding a vehicle's orientation and geographical area into an IPv6 multicast address, enables organizing a set of vehicles into a multicast group according to their situation, such as traffic congestion in a certain lane. With this orientation and area information, vehicles running in the same direction inside a particular area can calculate an identical IPv6 multicast address without any additional communication.

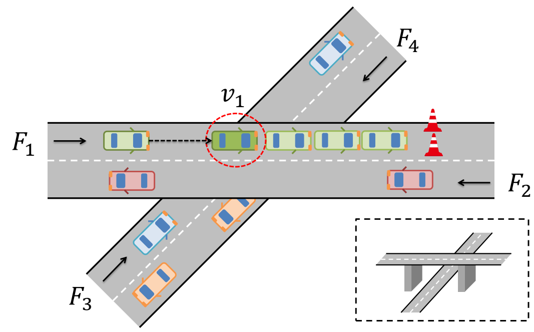

Fig. 1. Dynamic IPv6 multicast group assignment according to the vehicle's orientation

In other words, a set of vehicles in the same situation can exchange messages without any static configuration.

We considered a group communication scenario, shown in Fig. 1. In this scenario, four fleets of vehicles, denoted as F_1, F_2, F_3, and F_4, are moving in a grade separated-junction. Vehicles in F_1 are stopped because of an accident. The vehicle v_1 approaching the tail of F_1 wants to get a description of this traffic congestion. Since vehicles in F_2, F_3, and F_4 are not relevant to this congestion, v_1 sends a message only to the vehicles in F_1.

A vehicle sends a message to the vehicles in a certain situation by the following operations:

1) Obtain own location and orientation from GPS, accelerometer and magnetometer.
2) Construct a three dimensional vector

$$\boldsymbol{v} = (lat, long, o)$$

where lat is the latitude, $long$ is the longitude, and o is the orientation.

3) Normalize $\boldsymbol{v}$ to a four dimensional vector

$$\boldsymbol{v'} = (cc, lat', long', o')$$

where the cc denotes the country code corresponding to lat and $long$. The lat' and $long'$ denote normalized lat and $long$, a zone in a 2-dimensional virtual coordinate space covering only the cc area converted from the World Geodetic System. The lat' and $long'$ are given as follows:

$$lat' = \frac{N - lat}{N - S} \cdot p_{lat}$$
$$long' = \frac{E - long}{E - W} \cdot p_{long}$$

where N, S, E, W are the northern, southern, eastern, western borders of the country, respectively, and the p_{lat} and p_{long} are the numbers of partitions, representing the granularity of the partitioning.

The o' denotes eight normalized orientations:

$$o' = 8 \cdot \frac{o}{2\pi}$$

4) Encode $\boldsymbol{v'}$ into the IPv6 multicast address, as in, for example, ffxx::cc:o':lat':$long'$, as is shown in Fig. 2.

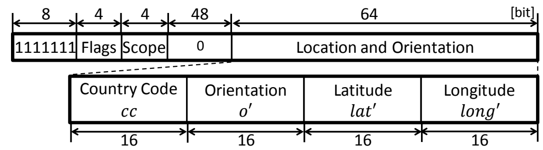

Fig. 2. Address format

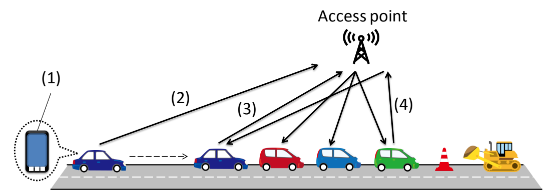

Fig. 3. Demonstration scenario. (1) Obtain own location and orientation (2) Join the multicast group (3) Request the description with multicast (4) Respond to the request

5) Join the assigned IPv6 multicast group.

Note that these operations are performed on each node without any communication.

While a vehicle encounters traffic congestion, it continues in the past multicast group in addition to joining a new multicast group, even if its orientation or location is changed. Therefore, vehicles in a same congestion can keep connectivity even if the traffic congestion takes in other multicast groups.

IV. Demonstration Scenario

We demonstrate a local traffic information sharing service for road congestion, shown in Fig. 3. In this demonstration, each driver has an Android smartphone equipped with GPS, an accelerometer, and a magnetometer.

First, smartphones establish a Wi-Fi connection via a roadside access point. When drivers launch our application, it periodically obtains current location and orientation from sensors, and then joins a corresponding IPv6 multicast group, as described in Section III. When a vehicle encounters traffic congestion, the driver operates the application to get descriptions of this congestion. The application then delivers a message to the corresponding IPv6 multicast group seeking information about the congestion. Applications that have joined the corresponding relevant multicast group receive the message. Some of those applications may know the description of the congestion (through video or photos of an accident/road work, etc.). In this case they respond to the request with specific information (text, photo, real-time video streaming, etc.).

References

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