Design and Implementation of Vehicular Network Platform using Wi-Fi Direct

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Abstract - The purpose of this paper is to design and implement a vehicular network platform based on Wi-Fi Direct. The platform can provide variety of services for vehicles such as information-sharing or safety service. In the platform, Wi-Fi Direct is a communication method of the network. However, Wi-Fi Direct is not suitable for the vehicular environment because it has difficulty of making a connection at high speed. So, we propose two adaptive methods to environment; first is fixed channel allocation with constant search technique (FAST) for device discovery and another is preparation for group formation in vehicular environment (PRE) for group formation. Experimental results show that the FAST and PRE respectively reduce the delay of device discovery and group formation.

Keywords: vehicular network platform; wi-fi direct; fast connection; scanning; grouping

1 Introduction

According to the advances in technology, there is a growing interest in a smart vehicle such as a Google’s driverless car. Because the smart vehicle is based on the communication and computing technology, management for safety and information on the smart vehicle is required. However, the infrastructure or platform for vehicle-to-vehicle (V2V) network is not sufficient. The technology for this has to be developed. We design and implement a platform for these services. Based on the characteristic of vehicular environment, we propose two methods; first is the method to quickly search the communication devices on vehicles and another is the group formation method minimizing the delay of group owner selection and establishing network group simultaneously. Through the experiments, we will verify the performance of these methods.

2 Vehicular Network Platform

In the section, we describe structure of the vehicular network platform and rapid network formation methods, called FAST and PRE.

2.1 Structure of the platform

Vehicular network platform is an infrastructure collecting useful information via the sensors and delivering it to the wireless network. Each vehicle may have to send the information extracted from the sensors to a management and service application. The communication between vehicles is based on the Wi-Fi Direct [1], also called Wi-Fi P2P [2]. As shown in Fig. 1, each vehicle has dual communication interfaces. Wi-Fi Direct network consists of group owner and group client. One interface is set to group owner and another interface is set to group client. Through the connection between the interfaces, vehicles make a series of networks. If there are many group owners, the vehicle must select the group owner in consideration of the distance, wireless signal strength, relative speed and direction. In addition, each vehicle should not form the cycle through a proper connection.

2.2 Rapid network formation methods

2.2.1 Fixed channel Allocation with constant Search Technique (FAST)

FAST is a way to simplify the device discovering process through the usage of a fixed channel and continues searching. In conventional method, the way of the device searching uses a number of channels and random delay. It is based on probability; the two devices may take a long time to search for each other. It is one of the reasons why the traditional searching mechanism is not suitable for vehicular environment. Reducing the time to searching devices is very important to communicate each other, because the vehicles are driving on the road at high speed. So, FAST is designed to optimize searching the target device. Each device determines an agreed single channel, and it searches the channel without the random delay.

2.2.2 Preparation for gRoup formation in vehicular Environment (PRE)

PRE is a method to reduce a group formation time and group owner selection time, and to form a pre-group. By
fixing the role of each interface, the predetermined interface is possible to form a pre-group. In conventional method, there is a process of determining group owner with negotiation before creating the group. In the negotiation process, there are a lot of communications in order to exchange information with each other. Unlike traditional methods, the proposed method can accommodate clients immediately. In terms of group formation time, it is obvious that PRE is more efficient than the traditional method.

3 Performance evaluation

In the section, we evaluate the performance for device discovery time and group formation time using open source hardware: Raspberry Pi Model B. The evaluation was performed with two devices based on Debian wheezy OS. And a wpa_supplicant [3] was used; it is IEEE 802.11x supplicant for implementation of FAST and PRE methods. Proposed methods were evaluated with default IEEE 802.11n setting of wpa_supplicant without channel scanning method and group formation order.

We performed evaluation of device discovery time with records of the 100 experiments based on UNIX time. Fig. 2 shows the cumulative delay of device discovery. Since FAST method is better than conventional one, a time difference is growing increasingly.

We also evaluate the group formation time with 50 records with actual measurement through the experiments. Fig. 3 shows the result of evaluation for PRE method. Similarly, the time difference is growing because average delay of PRE is shorter than average delay of conventional method.

We calculate the average of these evaluations at the Table 1. Average discovery time of FAST was much shorter than conventional method, and average formation time of PRE was shortening than conventional method about 1.42 seconds.

<table>
<thead>
<tr>
<th>Method</th>
<th>Avg. discovery time</th>
<th>Avg. formation time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional</td>
<td>3.06s</td>
<td>5.06s</td>
</tr>
<tr>
<td>FAST</td>
<td>0.14s</td>
<td>-</td>
</tr>
<tr>
<td>PRE</td>
<td>-</td>
<td>3.64s</td>
</tr>
</tbody>
</table>

4 Conclusions

In this paper, we have carried out the design and implementation of the vehicular network platform using the Wi-Fi Direct devices. The platform is designed to use a specific network formation method, FAST and PRE. FAST is rapid device discovery method, and PRE is the early group formation method by forming a group in the preceding time.

We evaluate both methods through open source hardware. Through the results, we confirmed that the device discovery time is reduced 2.92 seconds when using the FAST, and group formation time is reduced 1.42 seconds when with PRE method.

The rapid network formation of our platform provides variety of services in vehicular environment. We have a plan to expand the research to combining our platform with cellular networks.

5 Acknowledgement

This work was supported by the Center for Integrated Smart Sensors funded by the Ministry of Science, ICT & Future Planning as Global Frontier Project (CISS-2011-0031863), Corresponding author: Yunju Baek (yunju@pusan.ac.kr)

6 References

