Demo: Implementation of cooperative bus location system with BLE devices and smartphones

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Abstract—This paper demonstrates a new cooperative bus location system with BLE (Bluetooth Low Energy) devices and smartphones. Our idea has extended common participatory sensing systems to realize more practical sensing systems because common participatory sensing mechanisms require a participants’ operation to measure some values. Our proposed system consists of a BLE devices on a bus, smartphone applications on a participants’ smartphone, and a cloud service. The BLE device has a GPS (Global Positioning System) receiver and a communication function based on the BLE specification. The BLE device also activates a neighbor smartphone application by transmitting a special beacon message. Hence, the smartphone application can work and obtain the bus location from BLE device even if it was a suspended status. Additionally, it also uploads the bus location to the cloud service automatically. As a result, the proposed system can collect a bus location from BLE devices through smartphones automatically. The demonstration shows a prototype system based on the proposed idea for a bus location system.

I. INTRODUCTION

Bus location system has been attracted attention to make commercial bus services more effective and useful. A core mechanism of bus location systems is realtime tracking of location of each bus because a bus location usually depends on traffic conditions. However, traditional bus location system is difficult to employ for typical bus companies because installment of special equipped devices and communication charge are expensive [1]. Therefore, bus companies require a reasonable cost bus location system that is easily installed and inexpensively maintained.

A participatory sensing is a recent new idea to collect information by public-owned devices. However, typical public-owned devices such as smartphones support a low-power operation mechanism to extend its operating time by reducing consumed power. Therefore, almost all participatory sensing methods require participants to operate own device to obtain information. As a result, a participatory sensing is not suitable for commercial services because information acquisition ratio depends on participants’ decisions [3].

This paper propose a new cooperative bus location system with BLE devices and smartphones. The proposed system employs an extended participatory sensing systems to realize more practical sensing systems. Our proposed system consists of a BLE (Bluetooth Low Energy) devices, smartphone applications, and a cloud service. The BLE device has a GPS (Global Positioning System) receiver and a communication function based on the BLE specification, and has been installed on a bus. The BLE device also activates a neighbor smartphone application by transmitting a special beacon message. Hence, the smartphone application can work and obtain the bus location from the BLE device even if it was a suspended status. Additionally, it also uploads the bus location to the cloud service automatically. As a result, the proposed system can collect a bus location from BLE devices through smartphones automatically. Additionally, the proposed system can be easily installed comparing to conventional bus location systems because the employed hardwares of a BLE device and a smartphone are inexpensive. The demonstration shows that our system can update a bus location without a participants’ operation and can share the bus location on the smartphone application.

II. COOPERATIVE BUS LOCATION SYSTEM

Fig. 1 shows the overview of the proposed cooperative bus location system. The system consists of three functions: BLE devices with GPS receiver for obtaining a location and for triggering a special smartphone application, the smartphone application for location sensing and location sharing, and cloud service for management and distributing uploaded location information.

The benefit of the system is that a bus company can collect bus location by using passengers’ or driver’s smartphone when passengers or driver install the sharing application for a bus location. Additionally, the system can reduce consumed power for bus location sensing by using beacon technologies such as iBeacon[4] and Eddystone[5]. Therefore, the proposed system can solve two big issues in participatory sensing: difficulty to install a special application in participants’ smartphone and increasing of consumed power for sensing in a background...
process. Additionally, it also provides an accurate bus location because the BLE device can receive GPS signal continuously.

Fig. 2 shows the signaling process in the proposed system. The BLE device is configured beforehand and installed on each bus. Therefore, it also broadcasts a beacon message periodically. The smartphone application obtains the information about BLE devices from the cloud service. The cloud service informs the UUID, major, and minor when we employ iBeacon. The application registers the informed UUID to the OS system. Then, the status of the application will move to suspend status. The OS system starts the application in the background process when it detects the beacon message including the registered UUID. The application sends a service scan request packet to BLE device when it detects the BLE advertisement packet. Then, the BLE device replies a service id and device name. The application connects to BLE device by sending a connection request, and obtains information about a bus location from a GPS receiver. Then, the application disconnects from BLE device. It also uploads the bus location information to the cloud service. It has a function of location sharing of each bus, a passenger can check a dedicated bus position.

III. IMPLEMENTATION

We have implemented the proposed system. We employ an Arduino based BLE board to develop the BLE device. The beacon device can broadcast an iBeacon message periodically. The specification of the GPS receiver complies with NMEA (National Marine Electronics Association) 0106 and WGS (World Geodetic System) 85. As a smartphone application, we have developed the special application for iOS. The application supports functions for downloading of bus location from the BLE device in background process and sharing of location of each bus. The application typically does not work in background status because iOS does not permit continuous background processing. Therefore, it does not consume energy even if it is installed on a smartphone. We employ iBeacon to activate the suspended application to operate in the background processing. The cloud service is implemented by the apache server and the MySQL server in the prototype. It manages the information about BLE devices, buses, routes, and location of each bus. Additionally, it also distributes the bus location to the smartphone application.

IV. CONCLUSION

This paper proposes a new cooperative bus location system between BLE devices and smartphones. The benefit of the proposed system is realizing a practical participatory sensing system and obtaining an accurate location by a GPS module. As a result, it is easy for bus companies to employ the proposed system because the installation and maintenance costs are inexpensive comparing to conventional bus systems. We have implemented the proposed system with Arduino based board with a GPS module, iOS application, and web service. The demonstration shows that the system can collect location information from the BLE device automatically, and can confirm the shared bus location on the map.

REFERENCES