Smart Parking System for Internet of Things

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***Abstract*—In this paper, we propose a smart parking system detecting and finding the parked location of a consumer's vehicle. Using ultrasonic and magnetic sensor, the proposed system detects vehicles in indoor and outdoor parking fields, accurately. Wireless sensor motes support a vehicle location service in parking lots using BLE.**

I. INTRODUCTION

Recently, IoT(Internet of Things) has studied in the various application fields of human living space [1], [2]. IoT is based on the smart sensors and the middleware for connecting between clients and terminal devices. It can provide the public with the interesting information about various things deployed in our surrounding environment. In particular, the smart parking system is one of the main projects for IoT [3].

In legacy parking management systems, only the administrator has information about the parking spaces occupied by vehicles. Since the existing parking system cannot use the active information exchanging, it did not provide useful parking information for drivers. To solve this problem, smart sensors and the middleware for handing them are needed.

The vehicle parking location service has been proposed on the using of RFID devices. In this service, the drivers have to receive an RFID tag on the entrance of parking lot. The tag provides the vehicle location service for drivers through the RFID reader of parking space. However, this approach is inconvenient because the driver must receive the RFID tag in the entrance. In addition, the cost for RFID tag is needed [4].

In this paper, we propose a new smart parking system to solve the problem of the exiting parking systems based on the wireless sensor network and Bluetooth of smartphone. The proposed system uses ultrasonic sensors for indoor parking lots and a magnetic sensor for outdoor parking lots. For the location service of parking vehicles, the Bluetooth and USIM ID are exploited. Based on the smartphone, the proposed system not only provides the convenience for consumers but also contributes to low implementation cost compared to the previous RFID tag method.

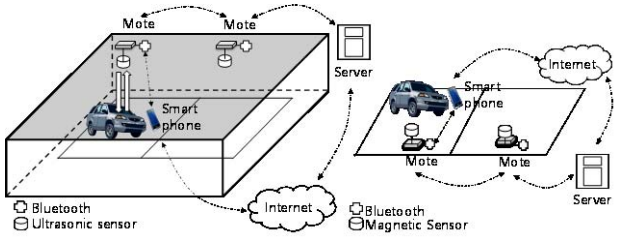

Fig. 1. Indoor and outdoor Parking System.

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II. SMART PARKING SYSTEM ARCHITECTURE

Fig. 1 shows the architecture of proposed indoor parking system and outdoor parking system. For the indoor parking system, a sensor mote with an ultrasonic sensor and Bluetooth communication module is installed on the ceiling of each parking slot. The sensor mote collects the data from ultrasonic sensor and communicates with the consumer smartphone as using BLE (Bluetooth Low Energy). It also sends mode ID and USIM (Universal Subscriber Identity Module) ID to server through Zigbee with gateway. In the outdoor parking system, the mote mounts the magnetic sensor module.

As shown in the Fig. 1, all motes collect the data about the state of parking slots. They receive the USIM ID of customer smartphone through Bluetooth communication. These data are used for the location service for parking vehicles. The server provides the Web service based on the received data. To get the parking service, the consumers exploit the Web browser or Apps software in their smartphone.

A. Hardware Architecture

The hardware of smart parking system is composed of the wireless sensor motes, gateway, and server. The sensor motes are deployed on the parking lot, which are monitoring the vehicle existence on each parking slot and are sharing with customer smartphone. The gateway is in charge for the data transmission to server. The sensor motes are constructed with MicaZ product involved in Atmega 128L MCU. We made the indoor motes with ultrasonic sensor and the outdoor motes included magnetic sensor. All motes have the BLE module.

B. Software Architecture

TinyOS is used to control the Bluetooth module, a magnetic sensor, and an ultrasonic sensor [5]. Fig. 2 shows the software architecture for smart parking system. The mote installs PkSensorMote which controls an ultrasonic sensor and a magnetic sensor and transmits the collected data to the gateway. The BaseStation module is installed on the gateway. This module receives the data from the radio communication and sends them to the Parkinglot Monitor module on the Host PC. The Parkinglot Monitor module records the received data to the database and monitors the parking lot state on real-time. The smartphone application can communicate with sensor motes on parking lots by using Bluetooth. This application can

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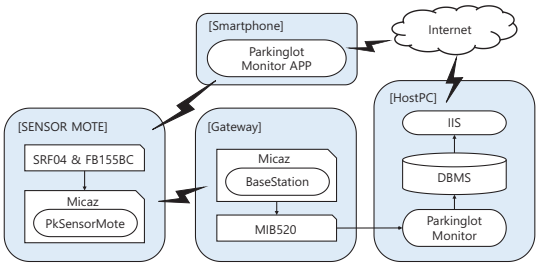

Fig. 2. Software Architecture.

transmit their USIM ID to the server and receives their vehicle location information from the database through the Internet.

III. Operations of Smart Parking System

A. Vehicle Identification and Location Recognition

To inform the vehicle parking location for users, firstly the available states of each slot in parking space are identified. The ultrasonic sensor emits the ultrasonic to the objectives and can measure the distance to them as using the echo waves [6]-[8]. We installed an ultrasonic sensor on the ceiling of a parking slot and measure the distance until the bottom. The distance between the ceiling and bottom is regarded as the basic distance value. If a vehicle occupies a parking slot, the new distance is measured between the ultrasonic sensors on ceiling and the vehicle hood. The difference of distances let us identify the existence of vehicle on the parking slot.

Since an ultrasonic sensor is very sensitive to the rain, snow, and dust, some problems are occurred in outdoor environment. Usually, vehicles are made up the parts over 100 involved in magnetic materials. Due to magnetic property in vehicles, the magnetic sensor can detect the movement of vehicles. The magnetic sensor in our sensor mote can measure the three axis of magnetic wave, so it can detect the vehicle entering into the parking slot with reliability [7, 8, 9].

To identify the vehicle of customer in the parking lot, we need the unique value to each customer. In this research, as the unique ID, the USIM ID of customer smartphone can be exploited. As the ID of USIM chip and the ID of sensor mote transmit to the server, the vehicle of each customer is identified.

To transmit the USIM ID to the sensor mote, we choose the BLE. In our research, to transmit the USIM ID without errors, we choose the sensor mote near to the customer's smartphone. To choose the best mote among the customer surrounding sensor motes, we exploit the RSSI(Received Signal Strength Indication) of BLE.

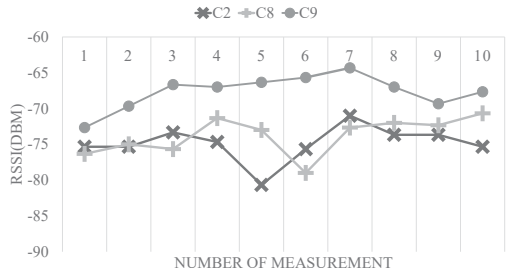

Fig. 3. RSSI measurement from 3 sensor motes.

Fig. 3 shows the RSSI values measured in three sensor motes, called as C2, C8, C9. They are installed on the ceiling of 2.6 meter height, and deployed with 2.3 meter interval each other. The test vehicle parks under the C9 mote. As shown as Fig. 3, we can find that the RSSI values form the C9 mote are higher than those of C2, C8 motes, because the vehicle is located close at the C9 mote.

B. Consumer Service Procedure

As the consumer parks the vehicle in the parking slot, the sensor mote detects the vehicle entering in its sensing area. Next, the consumer connects his/her smartphone to assigned sensor mote via BLE connection, and sends the USIM ID. If the consumer requests the location of vehicle using the smartphone, the smartphone sends its USIM ID to the server. The server can find the vehicle location in parking lot using USIM ID.

IV. Conclusion and Future Work

In this paper, the smart parking system was proposed on the Bluetooth communication between the smartphone and wireless sensor motes. It supported the identification of entering and leaving vehicles in parking slot and memorized the vehicle parking location. Since the smartphone is used, the customer has the convenient service for vehicle parking location. In our experiments, the proposed system had shown the accurate parking location service in parking lots. Compared to the previous method, the proposed system supported the low implementation cost.

For the future work, the more accurate RSSI measurement method will be studied, and the additional applications for smart parking space are developed, such as accident alarm, reservation for parking slot, and so on.

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