Prototype implementation of BLE based automated data collection scheme in agricultural measurement system

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***Abstract*—Field sensing systems for agricultural usages are a new trend to increase agricultural production due to the downward price trend of sensor devices. Recent systems employ short range wireless communication technologies such as WiFi, IEEE 802.15.4, Bluetooth etc. WiFi is a suitable solution when an existing network is available in a field, and IEEE 802.15.4 is employed in mesh networks. Bluetooth attracts attention in smartphone sensing because it is suitable to reduce power consumption in mobile devices. Smartphone sensing is a new data collection scheme. Smartphone sensing application usually consumes energy to collect data continuously because it runs as a background process. Therefore, users request smart data collection scheme to reduce excessive consumption of energy and to avoid the conscious operation of the application. This paper develops Bluetooth Low Energy (BLE) based automated data collection scheme in agricultural measurement system. The developed scheme utilizes a smartphone to realize automated measurement information collection from sensor devices. The demonstrations show the special BLE based sensor device, a data collection application, and a browsing application.**

I. Introduction

Due to downward price trend of sensor devices, field sensing systems for agricultural usages are a new trend to increase agricultural production [1]. Conventional sensing systems typically use cellular networks or mesh networks to collect measurement information. Especially, recent systems employ short range wireless communication technologies such as WiFi, IEEE 802.15.4, Bluetooth etc [2], [3]. WiFi is a suitable solution when an existing network is available in a field. On the contrary, typical field infrastructure does not supply electricity and network connection. Additionally, a lot of base stations are required to provide a network connection to a large field area because WiFi devices support one-hop communication.

Recently, smartphone sensing draws attention as a new data collection scheme [4]. Smartphone sensing application usually consumes energy to collect data continuously because it runs as a background process. Additionally, iOS does not permit typical applications to work as a background process to reduce power consumption. Therefore, users are suffered from excessive consumption of energy due to the background operation of the application or conscious operation of the application to collect data. Due to these reasons, typical farmers may not accept the installation of the application.

This paper develops Bluetooth Low Energy (BLE) based automated data collection scheme in agricultural measurement system. BLE is an optimized standard to realize a short range communication with low power consumption. Therefore, it is adequate to develop sensor devices with long-life operation. The developed scheme utilizes a smartphone to collect measurement information from the sensor devices. Therefore, the authors also develop a special application to collect measurement information through BLE communication. The advantage of the scheme is an automated data collection. The demonstration shows that the special application can collect measurement information from the sensor device, and can transfer to the cloud storage automatically without any user's operation.

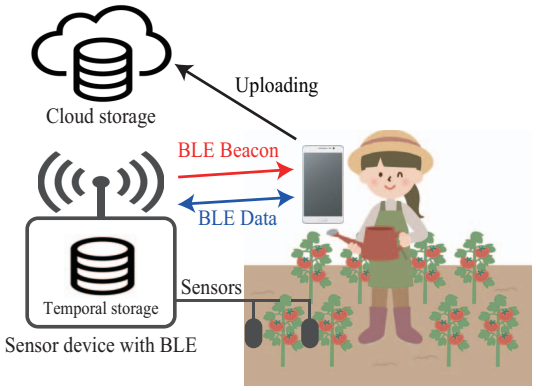

Fig. 1. Automated data collection scheme.

II. Automated data collection scheme

Fig. 1 shows the overview of the developed system. The system consists of the sensor device with the BLE function, the smartphone application, and the cloud storage. The proposed idea can be applied for any smartphone OSs such as Android OSs. The prototype implementation focuses on iOS that is suitable to reduce power consumption.

Fig. 2 shows the signaling process of the developed scheme. The fundamental idea of the proposed scheme is utilizing a beacon technology that informs a notification to a specific application. The proposed idea uses a Universally Unique Identifier (UUID) to identify the field sensing service in smartphone OSs, and uses a combination of a major value and a minor value as a sensor ID. Additionally, it also uses a service UUID to recognize the typical BLE communication service.

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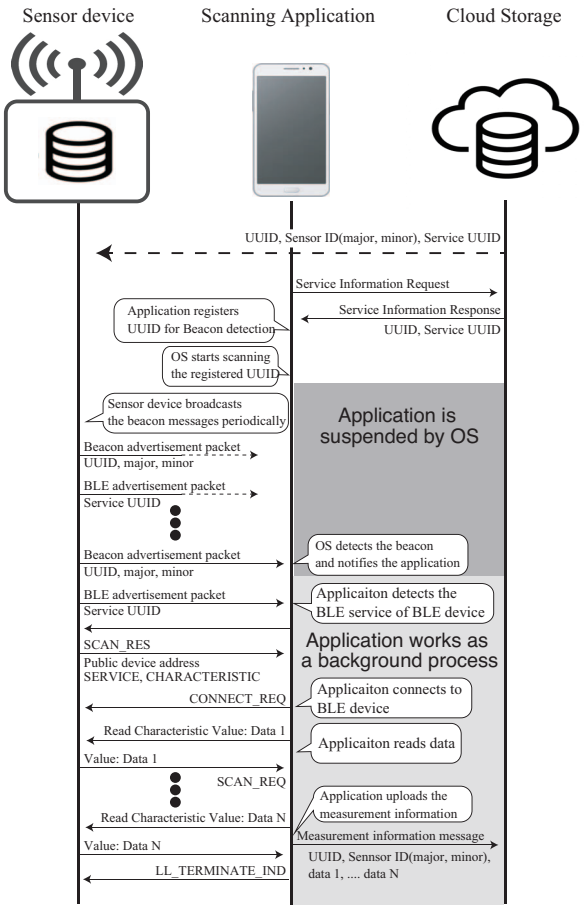

Fig. 2. Signaling process.

The sensor device transmits iBeacon messages periodically to activate the smartphone application because applications will be suspended by an energy management function in smartphone OSs. Then, the activated application tries to find the sensor device with the basic BLE communication function. For this purpose, the sensor device also transmits BLE advertisement packets periodically. The application collects measurement information from the sensor device when the BLE communication is established, and transfers the measurement information to the cloud storage.

III. Implementation

A. Sensor device

We have developed a sensor device with an ARM based microcomputer board. We employed Nordic Semiconductor nRF51822 System on Chip (SoC). The sensor device should store the configuration parameters such as the UUID for iBeacon, the major and minor values as the sensor ID, and the UUID for BLE communication. We have deployed an air pressure sensor (STMicroelectronics LPS331AP), and a temperature and humidity sensor (Boshe BME280).

B. iOS application

We have developed the prototype scanning application for iOS system. The scanning procedure for the sensor device starts when a smartphone exists near a sensor device. The application discovers services and characteristics of the GATT profiles after the establishment of connection between the sensor device and the application. Finally, it uploads the measurement data to the cloud storage though Hypertext Transfer Protocol (HTTP).

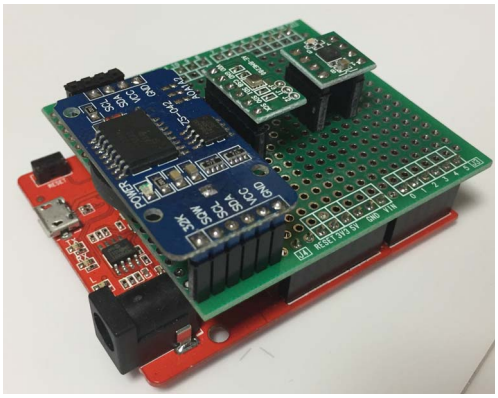

Fig. 3. Developed sensor device.

C. Cloud storage

The cloud storage has been developed as a PHP-based web application. We employed the Apache web server and mySQL database server as a fundamental services. The main functions are to manage each sensor devices, to store the uploaded measurement values, and to distribute measurement values.

IV. Conclusion

This paper has developed the BLE based automated data collection scheme in agricultural measurement system. The developed scheme utilized a smartphone to collect measurement information from sensor devices. The special smartphone application can collect measurement information from the sensor devices automatically when the smartphone exists near a sensor devices. The demonstration has shown that the automatic data collection scheme works well with the microcomputer for BLE and the smartphone application for iOS.

Acknowledgment

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