Sensor Gateway Using Arduino via Google Cloud and IEEE 802.15.4e

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***Abstract*—In this paper, we described a sensor gateway for using in a hierarchical network architecture. We propose a gateway architecture termed "Light-Weight Gateway", which provides multiple interfaces to IEEE 802.15.4e called Zigbee and IEEE 802.11 called Wi-Fi, for supporting Google cloud client. For this, we used Arduino as wireless sensor gateway on Google cloud messaging service. It is possible to expose its functionality as an Internet of Things (IoT) node. The Arduino receives sensor information and sends it to the network through Google cloud using Wi-Fi module.**

Keywords-Arduino;Sensor Gateway;Google Cloud Messaging Service;IEEE 802.15.4e;Wireless Seneor Network.

I. INTRODUCTION

A Wireless Sensor Network (WSN) is a network consisting of distributed devices that provide sensing features such as industrial gas problems, pipe vibration, noise, motion, etc. Nowadays, WSN systems are developed more and more intelligently. [1]. The Future WSN aims to integrate heterogeneous communication technologies in order to substantially contribute to asserting the concept of IoT. The low cost of sensor technology has eased the proliferation of WSN in many applications, such as real-time monitoring, bio technology, and smart factories [2].

In this paper, we propose a scheme of wireless communication system. This low-cost, small-sized system can collect real-time environmental values, such as gas pressure, stink, noise, humidity and temperature data remotely. Figure 1 shows the overall system architecture.

II. RELATED RESEARCHES

In this section, we introduce google cloud messaging service.

A. Google Cloud Messaging Service

Google provides a service called Firebase Cloud Messaging(FCM), which we can be used to send data to the user's device from app server and even receive messages from the devices to our servers through the same connection [3][4]. Figure 1 shows entities in the FCM. It also shows the scenario of FCM client registration and data sending. FCM consists of three parts, FCM client, app server and connection server. Some IDs and tokens used in different stages are described as follows. First, we have to apply an API key from Google, and then get a Sender ID. Registration ID is then issued from the FCM app server to the FCM application that allows it to receive messages. If the FCM device wants to join push group, it sends Sender ID to FCM server and Registration ID to the app server for identifying each device and registering to receive messages for FCM application. When app server wants to push messages, it sends its own API Key and user's Registration ID to FCM server, and then sends messages to FCM server. There are two types of messages in FCM. One is the send-to-sync message, and the other is the message with payload. The send-to-sync message is a light message used in notifying the app on mobile device to update information. On the other hand, the payload message is able to contain up to 4 KB, and is often used to exchange instant messages. The proposed push notification adopts both of two types.

We implemented the cloud messaging system based on FCM service. It consists of four major components: sensor gateway, FCM client as a smart phone application, app server and mongo database as shown in Figure 1.

III. IMPLEMENTATION

In this section, we introduce light weight gateway and proposed architecture.

A. Light Weight Gateway

Arduino is an open-source hardware platform. The Arduino Uno is a microcontroller board based on the ATmega328p-pu [5]. The Arduino does not have built-in Wi-Fi and 802.15.4e connectivity. Instead, it is added by connecting Wi-Fi and ZigBee module. Modules are connected to the Arduino using a serial port or an API mode. Also, wireless capabilities are added by forwarding any data received from the 802.15.4e network to the Google cloud and forwarding received Google cloud to the 802.15.4e

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network, respectively. Figure 2 shows the proposed Arduino gateway.

B. Proposed Architecture

The main ingredient for any IoT based operation is a sensor gateway and app server [6]. The centralized sensor gateway acts as the heart of all the IoT rooted operation. In this paper, the app server is used for data storage, sensor feedback and control [7]. A virtual connection between the app server and FCM client devices include sensor gateway that needs to be created. There are several ways to make an Internet connection form, which we have used FCM. Figure 3 shows the proposed system architecture.

Most FCM systems use an external app server to send notifications via the Google cloud. In this paper, we proposed a modified FCM registration about sensor gateway. Therefore, sensor gateway stores the FCM client registration ids. So, sensor gateway can send a sensing data to the FCM client individually.

IV. RESULT

Figure 4 shows the registration sequence. Figure 4(a) is the FCM sequence and 4(b) is the proposed system sequence. Proposed sequence is more complex than FCM sequence. FCM client registration request is occurred twice in proposed sequence. This means that proposed sequence is too complex in the registration sequence. But this sequence is not important in entire FCM sequence, because registration is not being occurred frequently.

Figure 5 shows the push message sequence. Figures 5(a) and 5(b) show FCM sequence and proposed system sequence. FCM sequence is more complex than the proposed sequence. The sensor gateway for push message sequence is used in the proposed sequence. This means that proposed sequence reduced the step of the request data and user account. Since push message sequence is occurring more frequently, it is more efficient than FCM sequence.

Figure 6 shows time complexity graph of Big-O. Figure 6(a) is the registration sequence and 6(b) is the push message sequence. The graph of $y=O(n)$ shows the FCM sequence and $y=O(n^2)$ shows the proposed sequence in Figure 6(a). As shown in the graph, the proposed registration sequence is more complex than FCM sequence. The graph of $y=O(n^{2n})$ shows the proposed sequence and $y=(On^n)$ shows the FCM sequence in Figure 6(b). As shown in the graph, the FCM sequence is more complex than proposed sequence.

V. CONCLUSION

In this paper, we have described how to compose Arduino by adding an 802.15.4e and FCM client function, in order to use it as a sensor gateway. We also modified the registration sequence on Google cloud, and showed efficient push message sequence. We have described all of the necessary steps to make a registration sequence. In addition, we have described the design and implementation of Arduino sensor gateway, which can be used for WSN. To demonstrate the applicability of our system, we have presented two representative scenarios of use cases that illustrate how our infrastructure can be used.

Our future work includes the implementation of additional applications, which is smart phone application and web data visualization system.

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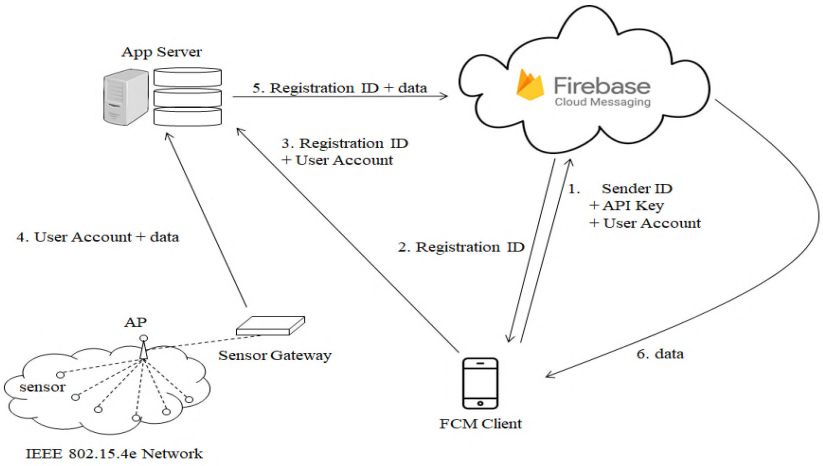

Figure 1. Client Registration and Data Sending on FCM

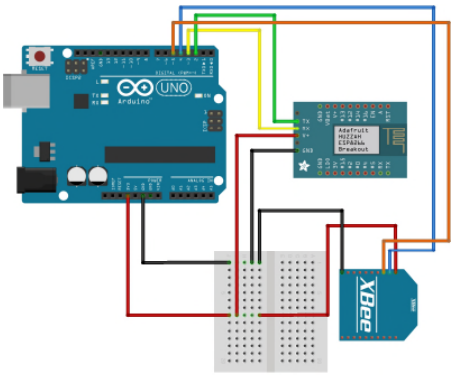

Figure 2. Proposed Sensor Gateway

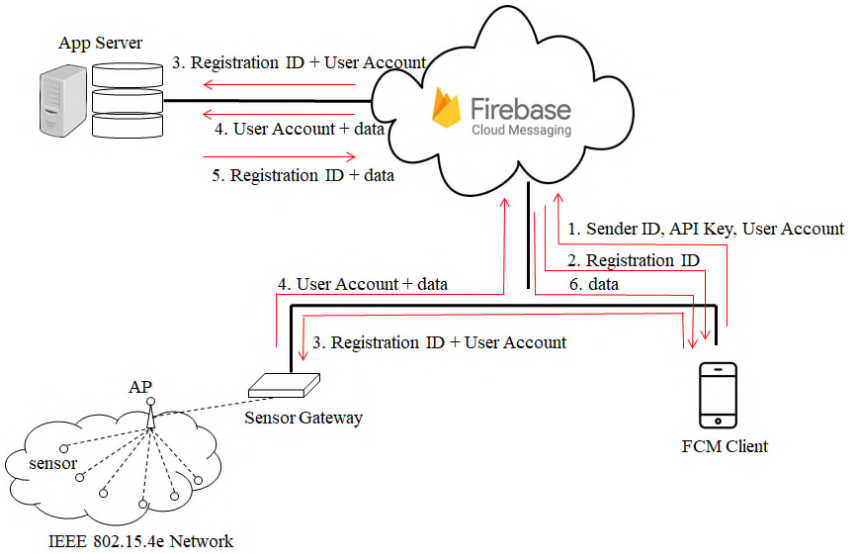

Figure 3. Proposed System Architecture

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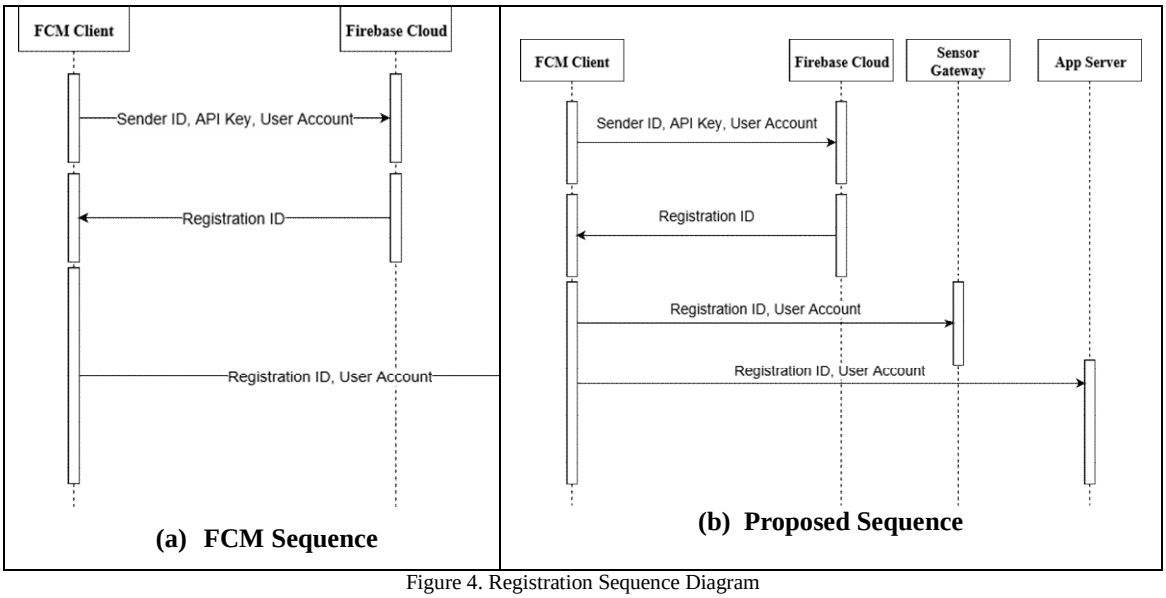

Figure 4. Registration Sequence Diagram

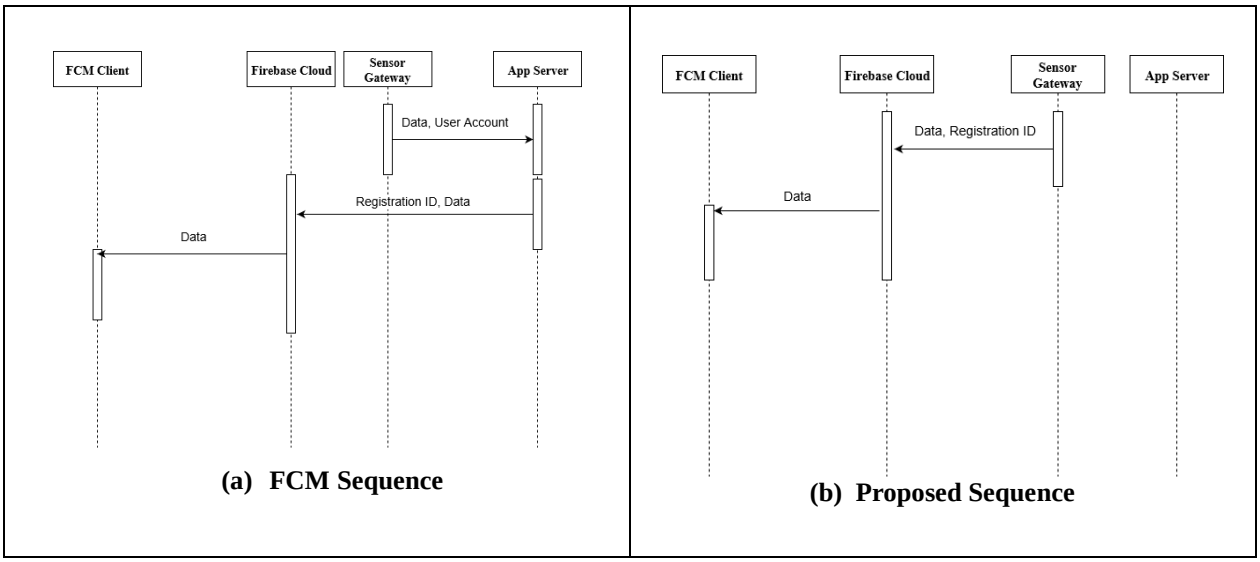

Figure 5. FCM Push Message Sequence Diagram

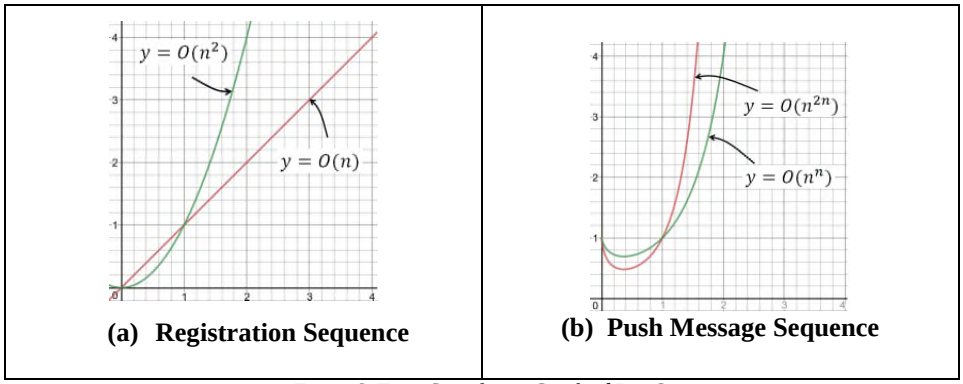

Figure 6. Time Complexity Graph of Big-O