Registration Protocol for Health IoT Platform to Share the Use of Medical Devices

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Abstract

This paper proposes an open healthcare platform structure design and suggests an authenticated registration process that links to a mobile device to enable convenient registration and sharing of diverse types of medical devices and services. Furthermore, in order to verify the effectiveness of the proposed registration method, the paper introduces and implements a health IoT-based mobile application. This research was completed with the intent that the results will contribute to user authentication and platform development for IoT-based medical devices in the future

Keywords: Mobile heath, IoT Platform, Registration Protocol

1. Introduction

Today, there is an increasing interest in IoT (Internet of Things) due to explosive growth in the supply of mobile devices and related peripheral devices [1-3]. In particular, the aging population and an increase in number of patients with chronic illness are expected to foster a more active application of IoT-based health care services [4-8]

Although Google, Samsung and Apple are all currently making attempts to use their own mobile platform to build IoT platforms in order to increase demand for their smartphone products, their efforts face a fundamental limitation in terms of creating an open-source structure that is not dependent on particular devices or services [9-11]. Moreover, since the existing services developed by medical institutions work only on a particular platform, only the medical devices compatible with particular services can be used. However, the problem is that it does not foster the development of more competitive services to patients, thus forcing them to use services that are inconvenient.

Accordingly, this paper proposes a registration protocol that can be used to apply medical devices to an IoT-based healthcare platform. Moreover, since the identification of the ownership of medical data is made possible through the linking of mobile devices during the transmission of medical information obtained using medical devices to the platform, it is necessary to link medical devices, mobile devices and platform servers. The aim of this paper is to show how such a registration protocol can be designed and implemented.

This protocol enables the patient to share the weighing scale or blood pressure monitor in a public medical institution or a medical center. In addition, family can share the device such as glucose meter. However, access control to the device from someone is required because medical device deals with critical and privacy information.

2. Related Research

In order to monitor the health information, the U-health services have been used in the sensor network such as Bluetooth or Zigbee [12,13]. The network model for U-health has been changed to IoT network from sensor network [14,15]. The IoT network model for U-health is different from the sensor network in that all device and/or server have an independent function to send and receive information autonomously[16,17], while all information from the sensor is sent to the Healthcare server in the network model for u-Health as shown in Figure 1 [18].
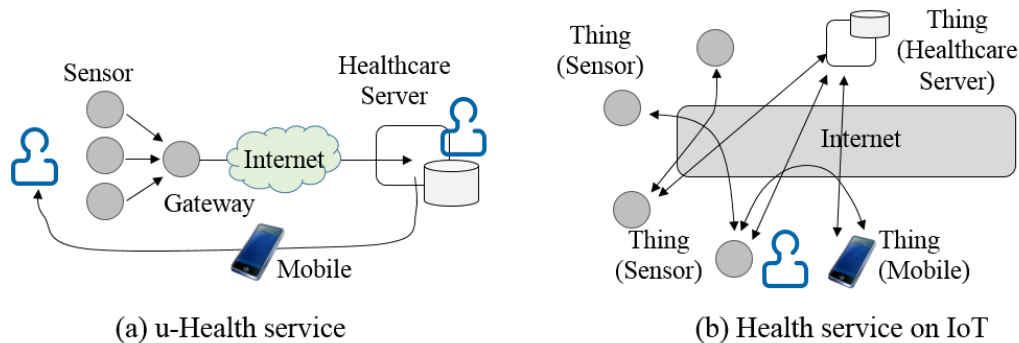
Figure 1. Two Different Network Model for U-health

One of the characteristics of an open healthcare service system is that all devices or services are designed in user-centered ways [19-22]. For example, suppose that a user purchases a medical device compatible with an open platform at a nearby convenience store. Then, the user could use a mobile device to register the medical device purchased in the platform, which enables him to search and select different healthcare services from different medical center [23-27]

Suppose that, as shown in Figure 2, members of a family or a social group share medical devices. Let's denote (f,a) to mean member "a" in group "f". The users (f,a), (f,b) and (f,c) share the same medical devices. The owner of the medical data is determined according to who binds to the mobile device when a medical device is used.

Such a service offers convenient flexibility to users in terms of being able to change their services when they want. For example, even when using the same medical device, (f,a) can choose C medical center while (f,c) can use D medical center. For such services to work, healthcare devices and mobile devices must be linked to enable user authentication. It is the platform manager that provides this function

The platform manager must enable healthcare service registration and provide service directory [28-30]. Also, it must enable registration of healthcare devices provide a directory for healthcare devices and implement membership, device and service authentication. It must also enable mutual authentication between devices and services. Among these functions, this paper proposes an authentication method that links mobile devices to a healthcare device platform registration
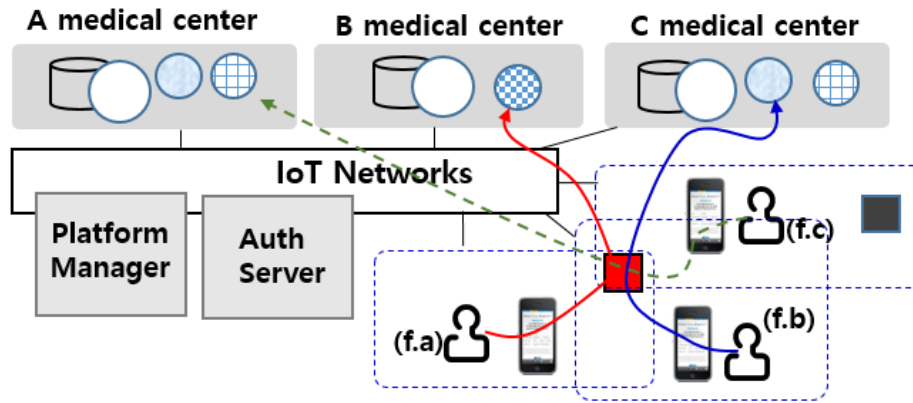
Figure 2. IoT Infrastructure for Healthcare and Its Services

3. Platform Architecture

In this paper, medical device and mobile device are defined in the hierarchical structure shown in Figure 3 and Figure 4. The hardware layer of the medical device is divided into medical sensors, network facility, and open hardware platform such as Arduino [31,32] or Raspberry pi [33]. The middleware layer of medical device supports an embedded operating system and provides more intelligent services
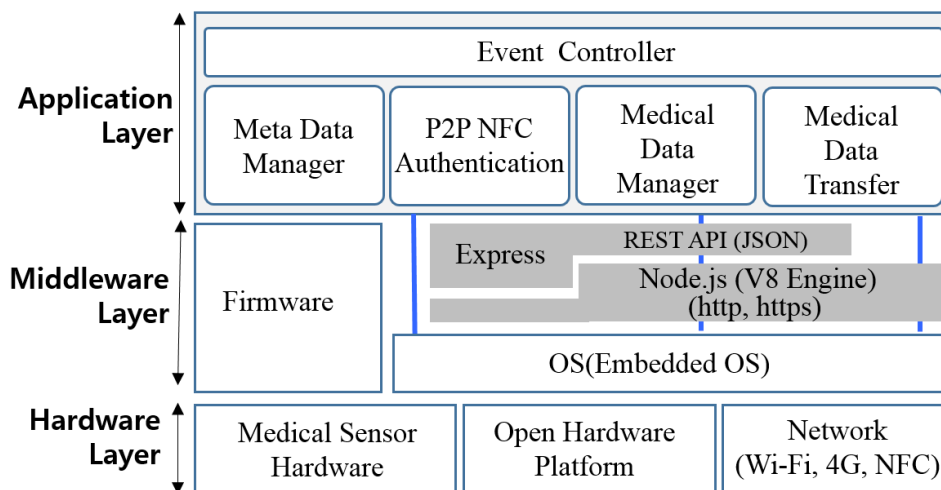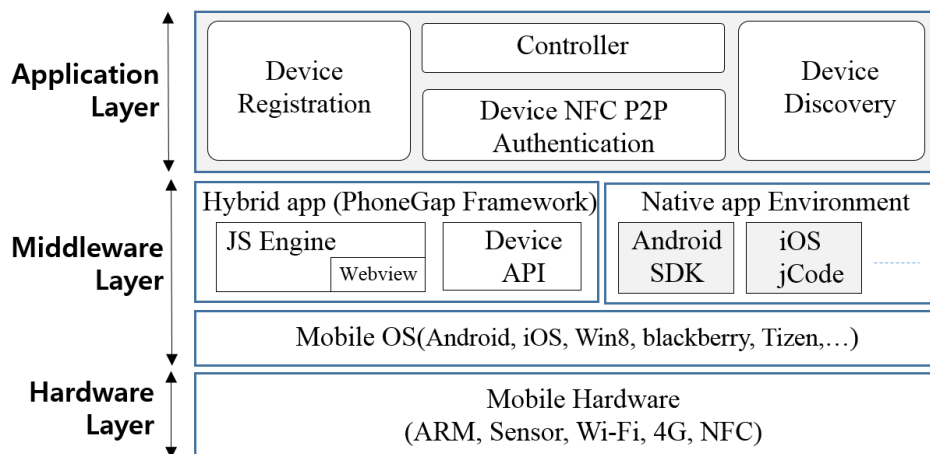

Figure 3. System Architecture of a Medical Device

Node.js is a java script engine that interprets and executes java script codes. It also has http and https protocol over TCP/IP. The http or https is robust and reliable to transmit data between medical device and mobile device. In particular, JSON(Java Script Object Notation) message is adequate to be easily understandable for exchanging information as well as a traffic load is smaller than a XML message. Therefore I introduce JSON as a message format.

In particular, using node.js for the IoT-based mobile web service software platform is not only superior in terms of cost effectiveness but also provides a standardized web protocol as a transmission protocol that facilitates more stable registration and termination of services in addition to safer transmission of medical data. Data transmitted among medical devices, mobile devices and the platform can be categorized in two types: metadata and the measured medical data.

The metadata is information that describes the specification of the device. For example, there are manufacturer name, model name, network address, MAC address, device identifier, user identifier, group identifier, authentication key, battery charging status, etc. In addition, the measured medical data means all data those measures from the any kind of medical device. For example, there are weights from weighing scale, height, BMI, access time, etc.

The mobile device plays a key role as a bridge between a medical device and a platform as well as a user interface of the medical device. The system architecture has three layers that are hardware layer, middleware layer, application layer. There are three methods to develop a mobile application in the middle layer, i.e. native app development, web app development and hybrid app development. As shown in Figure 4, the Phonegap framework is used to design and develop applications, taking into account the independence of a mobile platform. The framework is able to use java script codes and its skills which are same to medical device in the development method.


Figure 4. System Architecture of a Mobile Device

In application layer, Device Registration module is responsible for registering the device to the platform, while the Device NFC P2P Authentication module provides function to identify the user of the device by use of NFC[34] network. In addition, the Device Discovery module retrieves all the information on the registration list from the platform.

4. Registration Protocol for the Device to the Platform

For a user to provide his medical data to a medical service, they must first register a given medical device in the platform. The registration process can be divided into two stages: device registration in the initial stage and user registration to the device in the following stage. In order to register multiple users for a single device, you need a group ID (group-id), user ID (m-id) and device ID (d-id). Figure 5 defines a protocol used to register a device in the platform. The d-id is used as the identifier stored in the medical device, like a model number. The mobile phone number is used as the user ID because most users have their own phone. Moreover, the group id is given when you register the device on the platform.
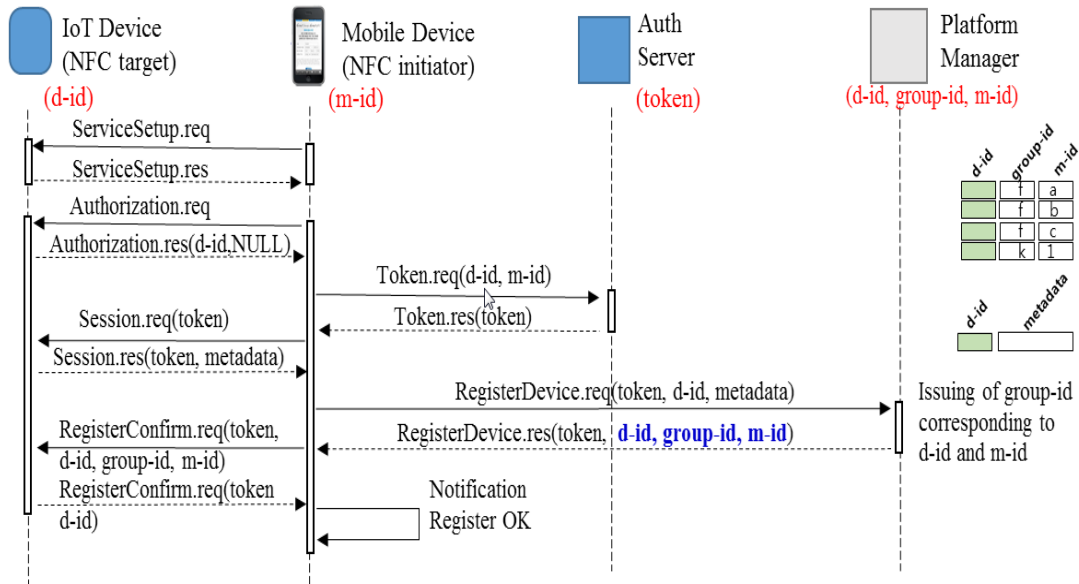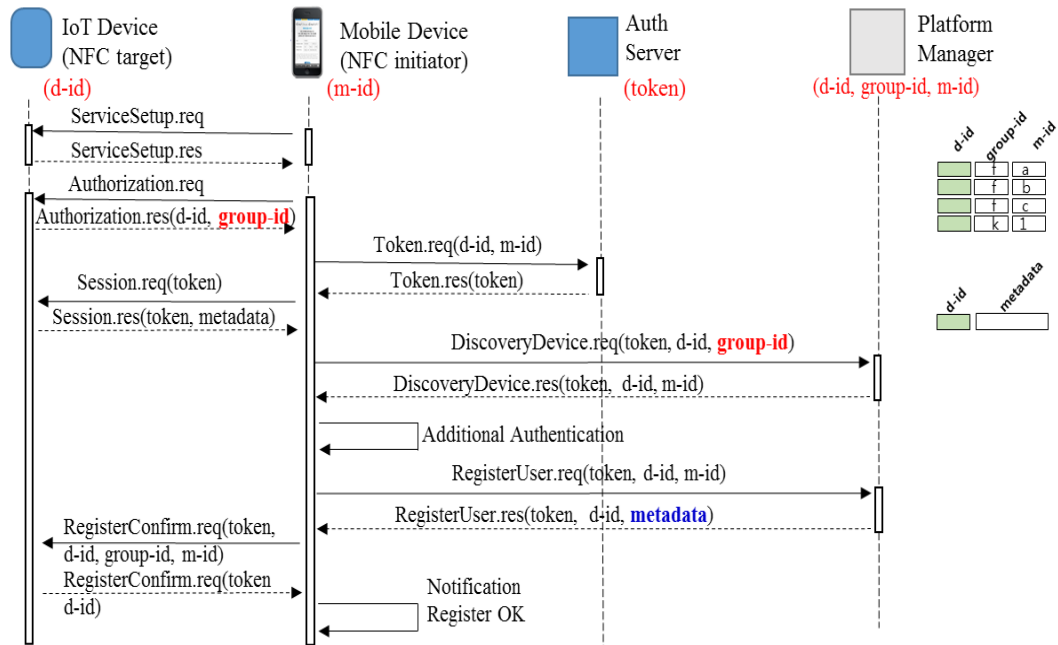
Figure 5. Device Registration to the Platform

In the initial registration process, a mobile device uses NFC to transmit Service Setup.req to synchronize the registration process. Then, the mobile device transmits Authorization.req to request d-id and group-id of medical device. If the device was registered in the platform before, it will have a group-id. On the other hand, if no group-id can be found, it will transmit NULL value. According to value of the transmitted NULL, the mobile device then decides whether to proceed with the registration process (a) or discovery process (b).

For mutual authentication, the mobile device uses d-id and m-id as an identifier to acquire token from the authentication server. Token provides effectiveness of service session. If mutual authentication between mobile devices becomes successful, the mobile device acquires meta-information about medical device, which it uses to send a registration request by transmitting RegisterDevice.req.

The platform server creates d-id and m-id to create and issue group-id. After the group-id is issued, a mutual binding of the medical device and user can occur. Also, within the token's expiration period, medical device, mobile device and platform server all maintain the same session. Figure 6 is a protocol used to register a user and the registered device in the platform. DiscoveryDevice.req is sent to the platform instead of RegisterDevice.req to discover device information registered in the platform.

The user can select the device to be registered by clicking one on the discovery list, and send RegisterUser.req to the platform. The registration is completed by sending group-id in RegisterConfirm.req to the device.

Figure 6. Device Registration to the Platform

Figure 7 is a Health IoT application that implements a mobile device registration process. Health Device is a menu used to register a device and Health Service is a menu that selects one of the registered services from the medical center.

For example, there are a lot of services like glucose monitoring services, weight management services, diabetes care services, etc. Many services from many centers are given to the platform, and qualities of services are different in every medical center. Therefore user can choice a services to check and manage health data for his/her health on the My Health menu.

In order to register a device on the application, user can push the Health Device and then push the Register button (plus sign) if it is the first time, as shown in Figure 7. When the mobile device approaches to a medical device, they communicate with each other by sending ServiceSetup.req.

As shown in Figure 7, user registration can be done by providing information by using discovery function if the device has not registered on the platform before. It means that the device may be shared to other users if a device is shown on the discovery list. This function is available to do service for unspecified users in public institution, as well as specified users in a closed group like a family

Figure 7. Mobile Application for a Device Registration

When a mobile device approaches to a device that has already registered on the platform, a message will be shown to a user, as shown in Figure 7. Finally, he can select one of three types of sharing, namely my group only, individual only, everybody. In the case of closed group like a family, my group only is a good choice, but the case of everybody is more suitable in a public institution. Otherwise, individual only can be selected. After confirmation, others can be used to share the device.
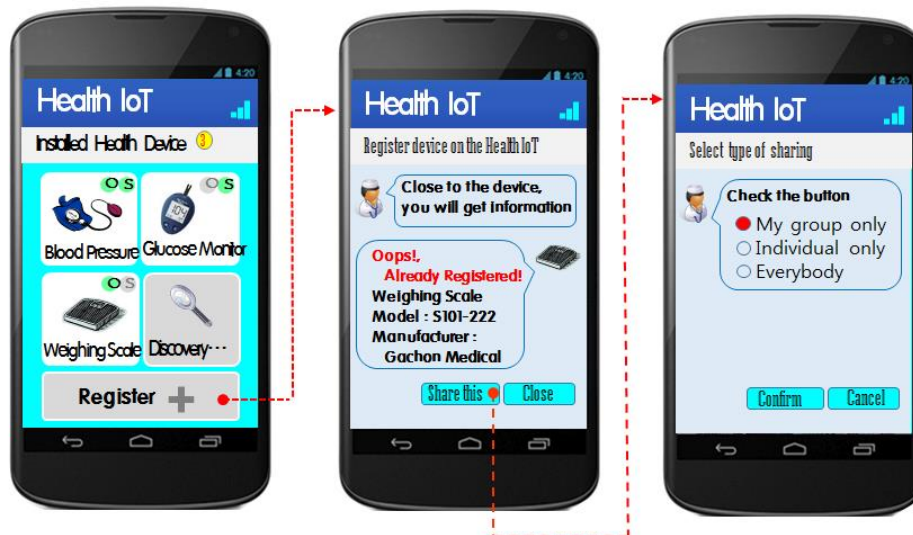
Figure 8. Mobile Application for a User Registration Using Discovery

Figure 9. Mobile Application for a User Registration Using Discovery

As shown in Figure 9, if user checks the glucose meter owned by James, all information about the device is retrieved. If approval is confirmed, the device is used on the service.

5. Conclusion

This paper designs and proposes a mobile device protocol that can be used to register a medical device in a healthcare platform. The protocol allows multiple users to share a medical device. Two protocols were proposed: a protocol used to register a medical device in the platform and a protocol used to register a user-member in the registered medical device. These protocols allow mobile device users to easily connect with one another to facilitate easy and convenient registration

The research area that requires further study is a real-time transmission protocol that accurately identifies the owner of the measured medical data in real-time and sends information (owner identity and measured data) to the platform when multiple users are registered to a single device.

Acknowledgement

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