# *A Server-assisted Provisioning Method for Machine-to-Machine Gateway*

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***Abstract*— Machine-to-machine (M2M) communication with an M2M gateway is expected to spread rapidly with the penetration of smart devices and sensors. As increasing the number of connected devices leads to repetitive manual configuration on an M2M gateway, one of the key factors in M2M communication is ease in configuration for end-users. In this paper, a new server-assisted provisioning method for an M2M gateway is proposed in order to support end-users including novices. The method is implemented in a prototype system and the experimental results show that the method can reduce the number of operational steps by half and the operational time by 25% compared to the conventional manual provisioning method.**

***Keywords—Machine-to-Machine communication; Machine-to Machine networks; provisioning; management server; gateway***

## I. INTRODUCTION

Machine-to-machine (M2M) communication with a smartphone as a gateway is expected to spread rapidly with the penetration of smartphones and sensors. M2M communication is defined as automatic communication between connected devices such as sensors and actuators with little or no human intervention [1]. The increase in the number of connected devices is leading to repetitive manual provisioning on the gateway that is to ensure the connected devices interworking and interconnecting to networks. The provisioning is initial configuration to utilize the devices. Therefore, one of the key factors in M2M communication is ease in provisioning for end-users, especially for novices.

This paper proposes a new server-assisted provisioning method for a gateway in order to support end-users in initial configuration. The proposed provisioning method was implemented in a prototype system and experiments were performed in terms of the number of operational steps and the operational time to configure a gateway, compared to the conventional manual provisioning. In Section 2, we describe issues with the M2M system. In Section 3, we propose a new server-assisted provisioning method. In Section 4, we explain implementation of the method in a prototype system and evaluation of the operation to configure the M2M gateway.

## II. MACHINE-TO-MACHINE TECHNOLOGY

Figure 1 shows a case of the M2M system using the M2M gateway. M2M devices can connect to the M2M gateway using M2M area network protocol. The protocol varies such as Bluetooth [2], ANT+ [3], IEEE 802.15.4 [4] and so forth. A typical M2M gateway is supposed to be a smart device that is able to collect data from the M2M devices and transfer data to application servers through a mobile access network. The M2M service platform is defined as a platform implementing common service capabilities in standardization [5]. The end-user is required to perform the following four main configuration phases: (1) application installation phase to install application software on M2M gateway, (2) device association phase to configure network connection between the M2M devices and M2M gateways, (3) service specific setting phase to make application service-specific settings (e.g., registration of end-user's properties such as height and gender in the case of healthcare-related services), and (4) data acquisition phase. The first three phases are a series of provisioning process. C. Park presented a service configuration mechanism for smartphones with proposed middleware to support the end-user on configuration [6, 7]. The middleware has a function for identifying and obtaining application software of IEEE 802.15.4 based connected devices. However, the issues listed below remain:

- Issue 1: Operation of the M2M gateway to establish a M2M area network connection depends on the wireless protocol. A method that does not make end-users aware of the differences in the operational process is desired.
- Issue 2: The end-user needs to obtain appropriate application software among the huge number of application software stored in web servers, which typically requires the instruction manual of the M2M device in order to obtain information on how to obtain the software. End-user intervention must be alleviated.

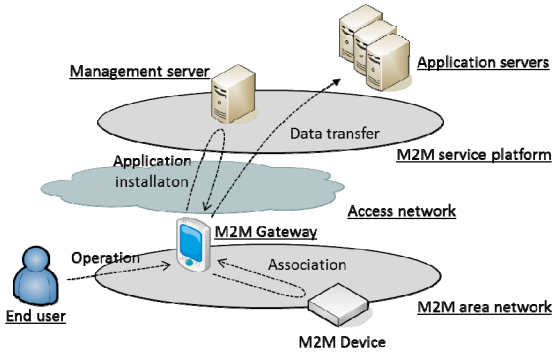


Fig. 1 Case of M2M system and proposed method

- Issue 3: The end-user needs to operate an M2M gateway with a complicated provisioning every time a new device joins the M2M area network. End-users have to take time as well as proceed certain operational steps. The operational step by the end-users must be minimized for their convenience.

These issues could make the end-user, typically novices, reluctant to provision a smartphone in order to utilize the M2M services.

## III. SERVER-ASSISTED PROVISIONING METHOD

The proposed provisioning method illustrated in Fig.1 targets supporting provisioning in order to resolve the issues. The policies of the proposed method are described below:

- Policy 1: In order to solve Issue 1, gateway common software is implemented in a smartphone as pre-installed application software by a mobile operator. In particular, the M2M device replies with information to specify the device itself such as the model number and manufacturer. However, different wireless communication protocols have different service discovery protocols, different data models and attributes (e.g., the information of the device product model number is stored in the attribute "Model" in the case of Bluetooth and in the attribute "Model number" in ANT+). Hence, the gateway common software starts different service discovery protocols sequentially and treats this information from devices in a variety of wireless protocols as a unified information attribute of the device model number. Therefore, the end-user can ignore the differences in the wireless communication protocol.
- Policy 2: In order to address Issues 2 and 3, a gateway management server is introduced in the M2M service platform. The gateway management server has a database table that retains mappings between the M2M device and appropriate application software. When the gateway management server is requested, the gateway management server provides appropriate application software to the M2M gateway based on the M2M device information from the M2M gateway. It enables the end-user to obtain application software without knowing how to obtain the application software. As a result, the need for the end-user's intervention is eliminated.

We proposed this server-assisted method because of avoiding loaded processes. In particular, there are several hundreds of thousands kinds of application software for smartphones at present [8]. Mapping appropriate application software to a specified M2M device and searching the application software among the huge variety of application software is loaded processes for a smartphone, even though smartphone resources are increasing.

## IV. IMPLEMENTATION AND EVALUATION

### A. Implementation

The prototype system consists of a weight scale as the M2M device, a smartphone as the M2M gateway, an application server and a gateway management server which is a key component of the proposed method. We used two kinds of weight scales each with Bluetooth and ANT+ wireless technology. The M2M gateway was a smartphone with Android OS. It has Bluetooth and ANT+ communications protocol. In the smartphone, gateway common software was pre-installed in the form of Android application software. The prototype system is only for Android smartphones. The M2M gateway communicates with the gateway management server and the application server via the mobile access network (CDMA2000). Packet capture software is installed on the gateway management server in order to analyze the exchanged data packet between the smartphone and the gateway management server for evaluation.

Figure 2 shows the sequence of the proposed server-assisted provisioning method, when it is assumed that the end-user intends to connect a smartphone newly to the weight scale with Bluetooth. In this figure, the procedure expressed as [Step] indicates each operational step of the end-user's minimum operational process, which includes the operational steps except the operation on the weight scale and operation just for confirmation.

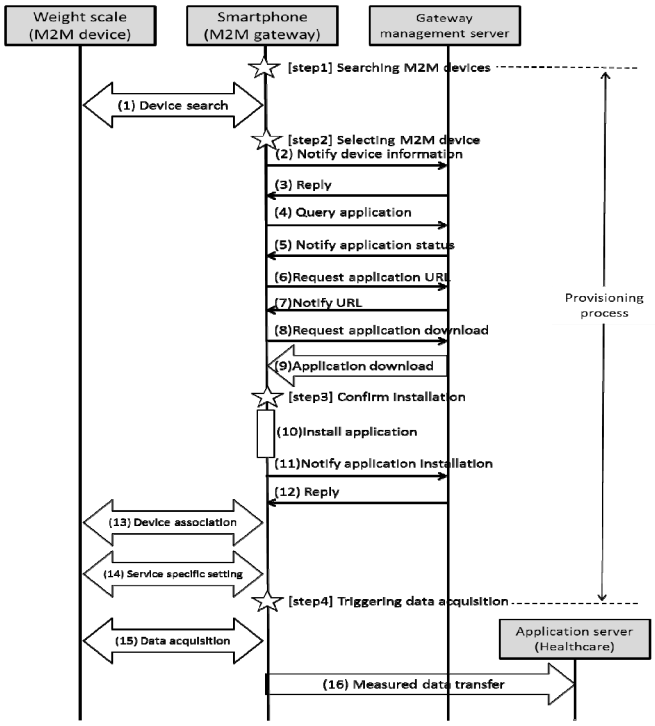


Fig. 2 Proposed sequences

When the end-user starts a device search (Fig. 2 [Step 1]), devices within the radio range of the smartphone are discovered. (Fig. 2 (1)) The end-user can select the device to configure the connection among the detected devices. (Fig. 2 [Step 2]) The smartphone notifies the gateway management server of information about the selected device and the Android application software that has already been installed (Fig. 2 (2) - (4)). The gateway management server receives the information, refers the database table and confirms whether dedicated application software has already been installed. (Fig. 2 (5)) If the smartphone has not installed dedicated application software, it requests the gateway management server to send

URL information to where the dedicated application software is stored. (Fig. 2 (6)) Referring to URL notification, the smartphone can download its application software. (Fig. 2 (7) – (9)) Through the installation confirmation screen (Fig. 2 [Step 3]), the application software is installed on the smartphone. (Fig. 2 (10)) The smartphone informs the gateway management server about the installed application status update. (Fig. 2 (11) and (12)) Finally, the association with the smartphone and weight scale is performed. (Fig. 2 (13) and (14)) The provisioning process is completed. The end-user proceeds the operation to acquire the measured data. (Fig. 2 [Step 4])

### *B. Evaluation*

We measured the number of operational steps and the operational time when the end-user operates the smartphone to configure connection with the weight scales. The experimental results in case of Bluetooth and ANT+ technology are summarized in Table 1.

In the case of the weight scale with Bluetooth, only 4 operational steps were needed to indicate the intention of the end-user as shown in Fig. 2. In contrast, the end-user is required 10 steps in total when there is no proposed provisioning method. It can be classified into 3 steps for associating via the wireless local area network between the smartphone and weight scale, 5 steps for installing the appropriate application software on a smartphone including searching the application software and 2 steps for acquiring the data. As a result, the proposed provisioning method reduces the number of operational steps to less than half compared to the conventional method. In case of the weight scale with ANT+, the proposed method reduces the operational steps from 7 steps to 4 steps.

The operational time was evaluated by using the weight scale with Bluetooth. It takes 48.9 sec in total to complete the provisioning process. The processes through Fig. 2 (2) and (9) as well as the processes through Fig. 2 (11) and (12) can be automated by the proposed provision method. Without the proposed provisioning method, the end-user is required to perform the following two additional processes: a series of processes to connect the wireless protocol and a series of processes to install the application software on the smartphone by the end-user's operation. It takes about 70.5 sec for a well-trained end-user to complete the provisioning process manually. Actually, the time is supposed to be much longer because the end-user usually has to check the installation instructions. This results show that the proposed method can shorten the provisioning process by approximately 25%.

TABLE 1 EXPERIMENTAL RESULTS

| M2M device | w/o proposed method | with proposed method |
|---|---|---|
| Weight scale with Bluetooth | | |
| number of operational steps (steps) | 10 | 4 |
| operational time (sec) | 70.5 | 48.9 |
| Weight scale with ANT+ | | |
| number of operational steps (steps) | 7 | 4 |
| operational time (sec) | 47.7 | 36.4 |

As above, the results show that the proposed system solves the issue of the provisioning in terms of the number of operational steps and operational time, compared with conventional manual provisioning.

## V. CONCLUSION

In order to support end-users in utilizing M2M communication for various kinds of devices, this paper proposes a new server-assisted provisioning method that avoids extra load on the M2M gateway. The proposed provisioning method was implemented in a prototype system. The experimental results show that the method can reduce the number of operational steps and operational time to configure the M2M gateway by half and 25% respectively, compared to the conventional process.

In future, we are planning to apply the prototype system to other devices and improve its performance. We will evaluate the performance in case of simultaneous multi-device provisioning because the number of M2M devices in use is expected to increase dramatically in the future.

## ACKNOWLEDGMENT

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