Demo: 6Lo-based LWM2M Smart Metering System for IoT

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***Abstract*—The purpose of smart grid is to construct new energy efficient services that measure and control residential electricity consumption in the real time. Nowadays, 6LoWPAN has emerged as a key network technology for Neighbor Area Network(NAN) and Home Area Network(HAN) in smart grid because it enables constrained smart meters to be globally connected to each other with low-power consumption. However, since those constrained smart meters operate on the low-data rate IEEE 802.15.4 mac protocol, the system for lightly measuring and controlling them should be required in smart grid. In this paper, we introduce a novel smart metering system for smart grid, which provides lightweight smart meter management mechanism using OMA lightweight M2M(LWM2M) standard and lightweight IPv6 communication using SNAIL: 6LoWPAN platform. In addition, by constructing web service for our system, anyone can easily analyze the electricity consumption for home appliances and control them with interoperability.**

I. Introduction

In order to solve a blackout issue and deteriorated power-grid, smart meter has been propagated rapidly around USA, EU and Japan. According to Pike Research [1], the cumulative number of installed smart meter, which was only 46 million units in 2008, is expected over 250 million units that is 18 % of the total power meter in 2015. Nowadays, a large number of smart meter companies have adopt 6LoWPAN as communication protocol for smart grid because it enables resource constrained smart meters to be globally connected to each other with low-power consumption. However since those constrained smart meters operate on low-data rate, and low-power IEEE 802.15.4 mac protocol. Therefore, the smart metering system needs to provide a simple, low-cost remote management, and service enablement mechanism, which embrace 6LoWPAN and fits for constrained smart meters due to its lightweightness.

In this paper, we propose a novel smart metering system for smart grid, which provides lightweight IPv6 communication using SNAIL: 6LoWPAN platform, and lightweight smart meter management mechanism using OMA lightweight M2M(LWM2M): standard of simple, low-cost remote management and service enablement mechanism for constrained devices. In addition, by developing web services for our system, anyone can easily analyze and control electricity consumption for home appliances through globally interoperable web interfaces.

II. 6Lo-based LWM2M Smart Metering System Architecture

In Figure 1, our smart metering system is composed of three components, such as a smart meter in HAN, a service provider server in , and a web service. Also each components

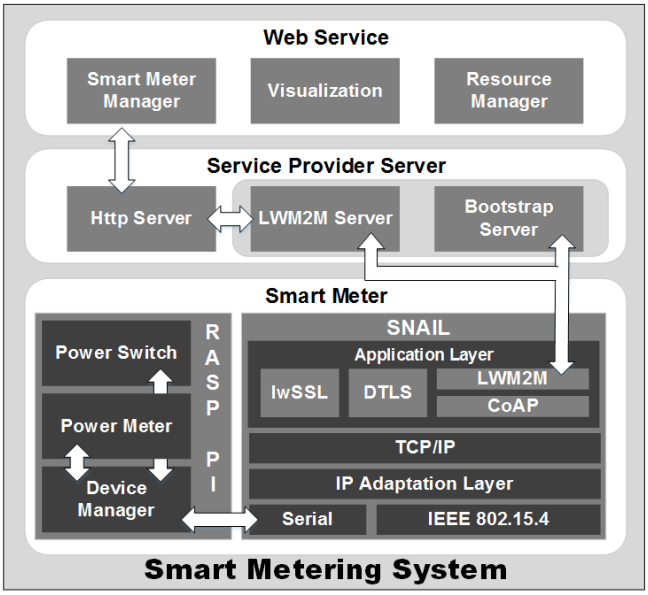

Fig. 1. LWM2M based smart metering overall system architecture.

are interconnected with each other through Internet based application protocol, such as HTTP, and Constrained Application Protocol(CoAP) based application protocol named LWM2M.

The Smart meter consists of raspberry pi and SNAIL, which is a 6LoWPAN platform. The Raspberry pi plays a role in calculating the electricity consumption by using collected raw data from a power metering sensor(pololu ACS7xx). It also provides APIs for serial communication to obtain the electricity consumption and control the smart meter on a device manager. The SNAIL provides current IoT connectivity standards such as 6Lo, RPL, CoAP, and DTLS, as well as LWM2M for exchanging collected the electricity consumption with a LWM2M server [2].

The Service provider server consists of a LWM2M bootstrap server, a LWM2M server, and a HTTP server. The LWM2M bootstrap server plays a role in offering bootstrap information to a LWM2M client to register endpoint resources. The LWM2M server produces operation massages, named ”Read”, ”Create”, ”Delete”, ”Write”, ”Write Attributes”, and ”Discover”, to manage the LWM2M client. The HTTP server provides a LWM2M app with accessibility to smart meters for collecting and controlling them through web interfaces.

The web service consists of a smart meter manager, a visualization, and a resource manger. The smart meter manager supervises smart meters which is registered in the LWM2M server, when the bootstrap is established between the LWM2M client and the bootstrap server. The visualization uses ”Read”,

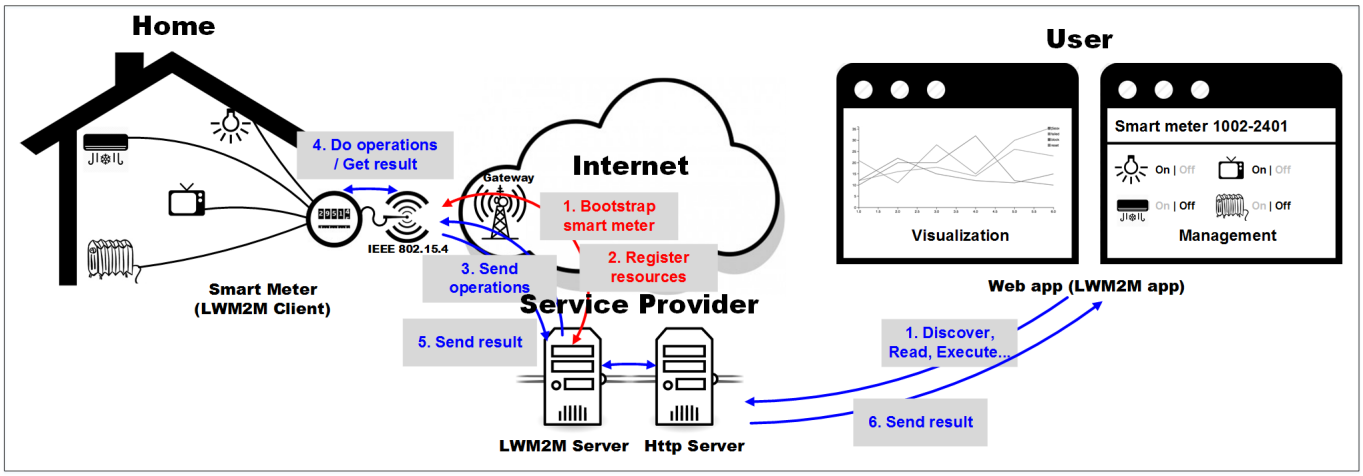

Fig. 2. LWM2M based smart metering system demonstration procedure.

Name	Object ID	Instance	Mandatory	Object URN
Smart Meter	7000	Single	Yes	Urn:oma:lwm2m:ext:7000

(a) Object definition.

ID	Name	OP.	Instances	Mandatory	Type	Units	Description
0	Voltage	Read	Multiple	Mandatory	Float	V	The current V of smart meter terminal.
1	Ampere	R	Multiple	Mandatory	Float	mA	The current mA of smart meter terminal.
2	Watt	R	Multiple	Mandatory	Float	kWh	The current kWh of smart meter terminal.
3	Power status	R	Single	Optional	String	-	The current power(not usage) status of smart meter.
4	Network status	R	Single	Optional	String	-	The current network status of smart meter.
5	Power switch	Execute	Multiple	Optional	Boolean	-	Switch smart meter terminal. (Turn on/off)
6	Power threshold	R, Write	Multiple	Optional	Float	kWh	Switch smart meter terminal, when kWh is over threshold.
7	Start-time	R, W	Multiple	Optional	Time	-	Reserve start time of sleep mode.
8	End-time	R, W	Multiple	Optional	Time	-	Reserve end time of sleep mode.

(b) Resource definition.

Fig. 3. LWM2M Definitions for Smart Meter (a)Object definition (b)Resource definition.

or ”Observe” operations to collect the electricity consumption from the LWM2M client and show it visually in the real-time. The resource manager uses ”Write”, ”Write attribute”, or ”Execute” operations to remotely switch home appliances.

Additionally, we newly define a LWM2M object and a resource ID for the smart meter to manage its components as described in Figure 3 by using Zigbee alliance’s Smart Energy Profile 2.0(SEP2.0): protocol standard of smart grid over IEEE 802.15.4 [3], and LWM2M technical specifiacation [4]. By using a DeviceInformation, a Demand Response Load Control(DRLC), and a Metering package in SEP 2.0, we derive voltage, ampere, Watt, power status, network status, and end-device controls for the smart meter.

III. Demonstration

In the demonstration, we will use three home appliances, smart meter prototype, SNAIL gateway, and MSI GS30 laptop. Three home appliances are respectively a light, a fan, and a laptop. The smart meter consists of a Raspberry pi and a CC2538 module, which is collecting and controlling the electricity usage of home appliances through SNAIL based LWM2M. The SNAIL gateway is 6Lo-gateway between the smart meter and the Internet. The MSI GS30 laptop plays a role in the LWM2M bootstrap server, the LWM2M server, the HTTP server, and a web app for showing web services. Demonstration procedure is following. When user installs the smart meter, it requests bootstrap information, and receives LWM2M server information from the bootstrap server. The Smart meter registers its resources to the LWM2M server after bootstrapping. When user execute a visualization, or a management service, the web app produces LWM2M operations, such as ”Discover”, ”Read”, ”Execute” and etc, to the HTTP server. The HTTP server forwards operations to the LWM2M server, then it sends operations to the smart meter. The smart meter communicates with the device manager through USB serial to collect the electricity consumption, or switch on/off home appliances. After complete operation, the smart meter returns the electricity consumption or the result of operations to the web app through LWM2M and HTTP protocols. Finally, the web app visualizes the electricity consumption, or current status of home appliances.

IV. Conclusion

This paper proposes the novel smart metering system that provides 6Lo based simple, low-cost remote smart meter management and service enablement mechanism to collect and control residential electricity consumption. In comparison with conventional smart meter, developers can easily be coding or porting their smart grid applications because of IP based system, and any user can easily analyze the electricity usage for home appliances by visualizing electricity consumption on the web. In addition, anyone can easily control home appliances by using SNAIL based LWM2M operations in order to save electricity consumption by using web interfaces.

Acknowledgement

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