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Machine-To-Machine Communication as Key Enabler in Smart Metering Systems

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ABSTRACT: Machine-to-machine (M2M) communications is a topic that has recently attracted much attention. Smart utilities will include a lot of M2M connected devices. The industry defines M2M communication as the automated communication between remote entities and central management applications. It provides real-time monitoring and control without the need for human intervention. The most represented example in the M2M segment is smart metering management which is defined as using ICT (Information and Communications Technology) technologies in utilities. It is understood as using one system for measuring and collecting energy consumption and other data of two or more of the above-mentioned energy forms.

Diversity of end-user platforms makes the task of collected metering data dissemination very changeling. In this paper, we present a project, which goal was to develop proof of concept for smart metering based on existing M2M Service Enablement (M2M SE) Node developed in Ericsson. M2M Service Enablement is a platform that enables integration of telecom assets and device information with industry specific services and applications in a common user experience. Furthermore, a comparative analysis with the ETSI smart metering standards has also been made. Presented solution collects data from water, gas and electricity meters and stores the data in M2M SE node. Also, the solution is verified as a web application which provides data presentation of collected data to end user in graph form.

KEY WORDS

1. M2M communication 2. Smart Metering 3.Service Enablement

I. INTRODUCTION

M2M refers to technologies that allow both wireless and wired systems to communicate with other devices that have the same ability. M2M uses a device to capture an event, which is sent through the network to an application that translates captured event into meaningful information. M2M communication is the communication between two or more entities that do not necessarily need any direct human intervention. The goal of M2M services is to automate decision and communication processes Smart metering being the most represented example in M2M segment. The same system is used for measuring and collecting energy consumption and other data of two or more energy forms. Smart Metering represents the cornerstone of future smart grids. It provides a range of applications using an infrastructure comprising networked meters, communication networks, data collection and management system.

According to European Energy efficiency action plan individual meters shall be implemented that accurately reflect the end customer's actual energy consumption and provide information on actual time of use [6]. Billing shall be based on actual energy consumption and shall be performed frequently enough to enable customers to regulate their own energy consumption. Usually, a smart meter is considered for registration of electricity and gas use, however water consumption registration is also a possibility.

In this paper we present an alternative approach in energy consumption metering by using smart meters and the M2M Service Enablement Node. The solution allows for different meter data readings to be stored into the M2M SE Node, and then graphically displayed through a web application. The presented approach is additionally validated through a simple system used for energy consumption metering.

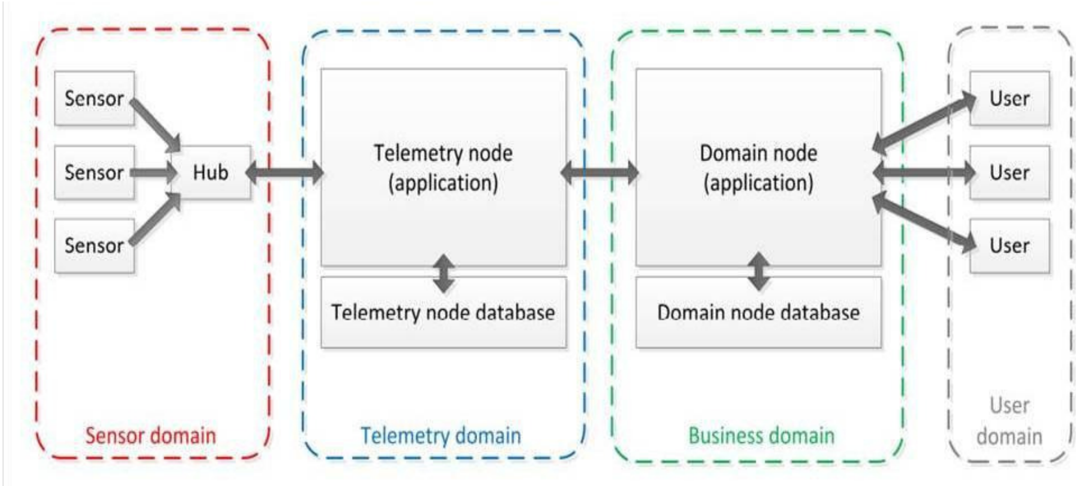

Fig 1 Domains in M2M system

II. M2M SERVICE ENABLEMENT IN SMART METERING SYSTEMS

Machine to Machine (M2M) communications is the communication between two or more entities that do not necessarily need any direct human intervention. M2M services intend to automate decision and communication processes [1]. M2M uses a device (such as sensor or meter) to capture an event (such as temperature, inventory level, etc.), which is relayed through a network (wireless, wired or hybrid) to an application, that translates the captured event into meaningful information [8]. There are four domains in M2M system as shown in Fig. 1.In sensor domain data is sent to a hub over wireless (for example GPRS) or wired network. Telemetry domain is responsible to retrieve data from a hub and store that data in telemetry node database. Also, telemetry domain is responsible to provide web services, so various applications can be developed to present data from sensor domain. Business domain is an application (for example web application) which presents data from telemetry node to end-users.

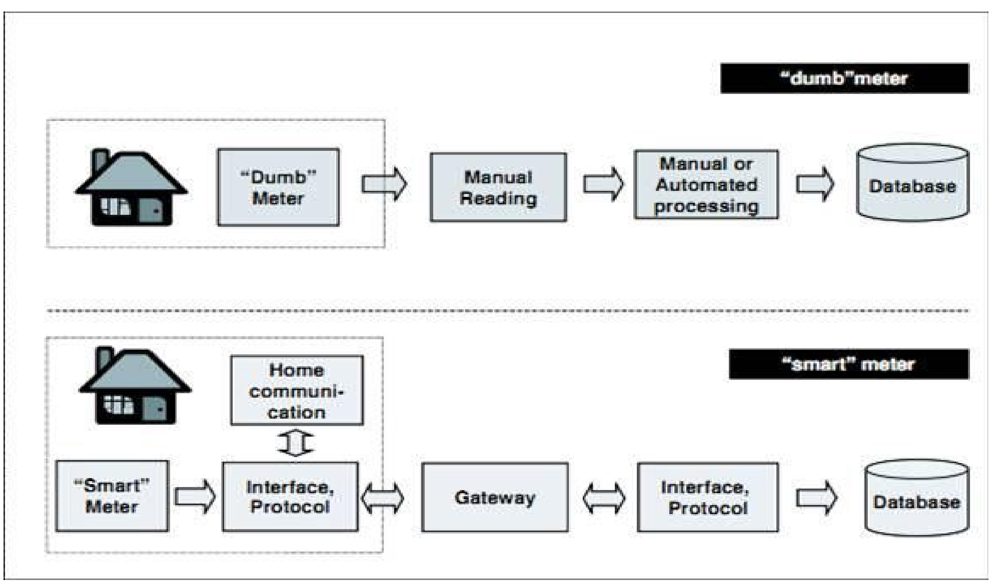

Fig 2 Difference between the conventional and the smart meter data process [2]

Smart metering generally involves the installation of an intelligent meter at residential customers and a regular reading, processing and feedback of consumption data to the customer [2]. Many advantages are attributed to smart metering, including lower metering cost, energy savings for residential customers, more reliability of supply, variable pricing schemes to attract new customers and easier detection of fraud. Additional benefits are foreseen in relation to distributed generation (DG). Smart meter can be used to separately measure electricity delivered by the DG to the grid and the smart metering communication infrastructure can be used to remotely control DG (e.g., in a virtual power plant concept). The differences of smart meters and classical “dumb” meters are shown in Fig. 2. The conclusion which can be drawn on the basis of all the mentioned smart metering characteristics is that in smart metering there is no need for any human intervention, sensor reading and data storing are done automatically [5].
Smart metering is a one of components towards transformation of smart cities.

III. SYSTEM ARCHITECTURE

A simple system has been developed as a proof of concept for the proposed solution, which consists of three main parts: the scheduler, the M2M SE node and the web application. The overall system architecture can be seen on figure 3.

Before the core of the system is described, a few things should be mentioned about the meters first. The meters that were used in this system are normal meters with optical cameras attached to them (meaning they are not real smart meters). Upon the user interaction, by pressing a button, a picture of the current consumption status is taken, and sent to a web server where it is parsed by optical character reader (OCR) software.

The scheduler part of the system periodically pulls the data from the web server with the OCR and parses the received data. Finally, scheduler stores data into the M2M Service Enablement Node. The scheduler also validates the received data, and if data isn’t valid (for example if an error occurred during the meter reading) it will not be transferred to the M2M SE Node. It is possible to set the time interval in which the scheduler will pull the data from the web server with the OCR program and transfer it to the M2M SE Node.

The M2M SE provides an interface for simple storing of data into the M2M SE Node and to easily fetch that data from the M2M SE Node. The interface for retrieving data from this node allows basic filtering options, e.g. time filtering (for example, filtering for data from a certain time interval), and device filtering, which in turn allows us to request data only from a certain device that was specified. The M2M SE Node also provides a possibility for user subscription [9].

The final part of the developed system is a web application which provides a simple user interface from which the user consumption can be checked. This web application offers a variety of different possibilities to visualize the consumption rates, e.g. the possibility to visualize the consumption of water through a single month in a single city [4]. Visualization options are provided for different time intervals (consumption through a year, month or day) and different consumer groups (all consumers in a region or a city or only for a single user).

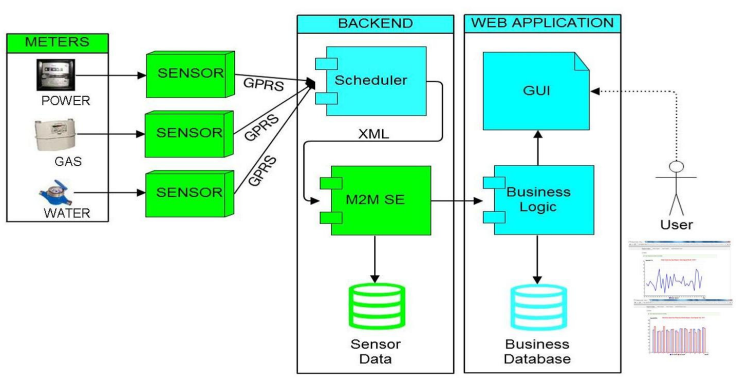

Fig 3 Smart Metering M2M System Architecture

IV. CONCEPT VALIDATION

The proof of concept system is able to collect data from four different meters: gas meter, water meter, single -phase electricity meter and three phase electricity meter. Aside from that, the system supports a two tariff system for the electricity meters. All the meters that were used by this system were classical meters with optical cameras attached to them. Those optical cameras take a photograph of the current meter state, and then send that photograph to a server where the number recognition and parsing takes place. The scheduler then periodically reads the meter data and stores it into the M2M SE Node.

Using those meters, the consumption for multiple users (around 30), during a time period of two years, was simulated. Each user had 6 meters (gas, water, single and three phase electricity meters, both of which had a two tariff system, which were treated as separate meters) and 4 readings a day were simulated for each user. The consumption data for all users was then stored into a single M2M SE Node. During the tests it was shown that the M2M SE Node was able to handle such an amount of data (totaling to more than thirty thousand entries) quite well, and that it fetched and filtered the stored data very efficiently.

As part of the proof of concept, several options for data visualization were developed within the web application. Figure 4 shows an example of a graphical display of electricity consumption through the months of a year (the first tariff is marked blue and the second tariff red). Figure 5, on the other hand shows the water consumption for the days of a month.

The developed system provides a wide variety of advantages when compared to classical meter reading. First of all, meter readings are much more frequent in such a system. The system can easily read the meter state several times in a week, or even day. Aside from that, such meter reading is much more reliable and less error prone. Even if the meter data is incorrectly read, such errors are much easier to find in such a system. All this provides the energy providers with much more control over energy consumption.

Energy providers aren't the only users of the system that benefit from its deployment. Ordinary consumers would have the ability to have a reliable insight into their energy expenditures. This would allow them to adjust their energy consumption on the basis of their past consumption. Later on, even more advanced options could be offered to the consumers. Some of them could be: prepaying for a certain amount of energy for a certain time period, paying the bills through the web application of the system or being warned when a certain amount of energy has been consumed. All things considered, such a system could provide many benefits to both, the providers and the consumers.

V. COMPARATIVE ANALYSIS OF SMART METERING STANDARDS BY ETSI WITH PROOF OF CONCEPT

During the solution development, a short comparative analysis between the developed system and the standards proposed by ETSI in [3] and [8] has been made. This comparison focused mostly on the use case scenarios that the system must satisfy in order for it to adhere to the standards that were proposed in [3] and [8].

The conclusion that was reached is that the developed system does not satisfy the given standards, more specifically, it doesn't support some specifications required by the ETSI standard proposed in [3]. The main reason for this is the fact that the developed system does not use real smart meters for data reading, instead it reads data through optical cameras. One of the requirements for smart meters is to be able to periodically read the meter data and send it to the server, without any user action, which is not the case with optical cameras used in this system, because they needed user interaction for the meter reading to take place. Aside from that, this kind of meter reading, which was used by this system, does not support two-way communication, meaning it doesn't support communication from the supplier to the smart meter located at the users premise. The lack of two-way communication makes it impossible to support the more advanced use cases which require two-way communication between the operator and the meter, e.g. monitoring of supply quality, outages (electricity), network leakage detection (water) and identification of possible meter malfunction, etc.

Although this solution does not comply with the ETSI standards, it does have some advantages. Because the solution is very simple, it is easy to develop applications for such systems. Such a solution, where meters are augmented with optical cameras, is cheaper than solutions with real smart meters (prices for smart meters vary around 100 dollars, even for the cheaper meters).

On the other hand, some disadvantages, apart from the non-compliance with the standards, are that this solution requires user interaction for the readings to take place (this could probably be fixed if the cameras would have an option to automatically read the consumption data). Apart from that, the data which is received has to be interpreted with an OCR program, which could possibly interpret some of the data incorrectly. But if meter readings occur frequently enough, such errors should not pose a big problem, because they could be easily detected and the data marked as invalid or deleted.

Fig 4 Example of electricity consumption through months

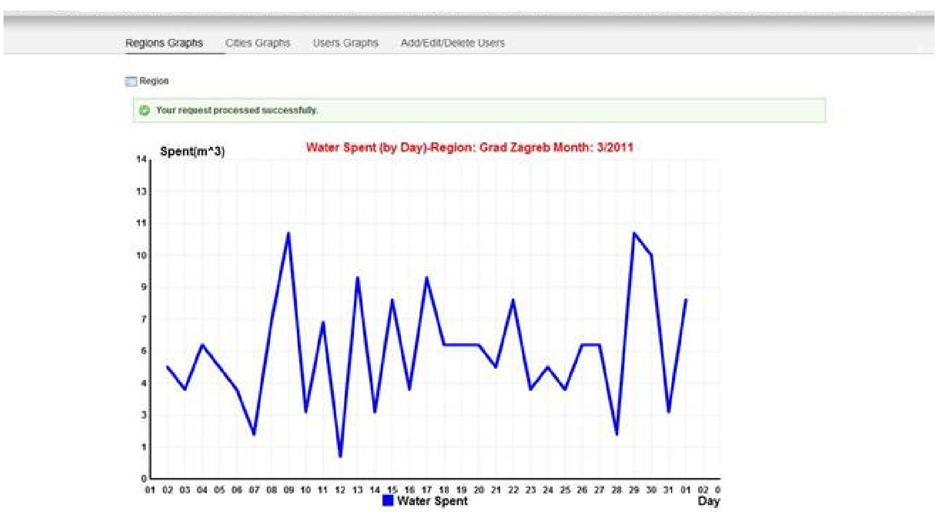

Fig 5 Example of water consumption through a month

VI. CONCLUSION AND FUTURE WORK

The presented system is able to collect data from gas, water and electrical meters with optical cameras using a scheduler which periodically pulls the data from a web service (OCR), stores the data in a single M2M SE node, and then display the data collected in the node. The data is displayed through a simple web application, which is used for retrieving the data from the M2M SE node, and displaying the data in graphical form. The data about consumption can be displayed in a number of different ways, for example, the user can display that data about consumption for all the years in which there is data about consumption or single year, single month, and even a single day. Furthermore, the data can be displayed for a single user, or a group of users located in the same region or city. This system can be further developed by integrating an algorithm, which could detect time intervals in which the energy consumption is high and then offer the users to consume resources in a different time interval, for lower prices, or other benefits. Aside from that, integration with an IPTV would enable users to view their consumption on an IPTV, and thus provides another possibility for the extension and further development of the system.

A comparative analysis between the developed system and the ETSI Use Case standards has also been made. Although many current real-world implementations take advantage of easier deployment of optical cameras attached to existing meters, and provide many benefits to providers and consumers, they do not conform entirely to the full set of smart metering standards.

ACKNOWLEDGEMENT

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