Demo: Micro Energy Efficiency System Based on QR Code Mote

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Abstract

Micro Energy Efficiency System (MEES) provides energy saving while enabling each individual office in a large building to control heating, cooling, and electricity with its own policy. The usage of a decentralized independent control of each office, rather than a centralized one, is common in Korea. MEES provides measuring and controlling points at multiple granularities. An installation became easy and efficient using QR code, and the user configuration through an energy web portal further enhances the energy efficiency.

Categories and Subject Descriptors

C.3 [**Special-Purpose and Application-Based Systems**]: Real-Time and Embedded Systems

General Terms

Experimentation, Design

Keywords

Wireless Sensor Networks, Energy

1 Introduction

A building energy management system provides monitoring of and efficiency to the major energy usages like electricity, heating, cooling, and HVAC. Existing monitoring systems simply monitor the energy usage status of mostly indoor environment of a building, then control facility and electricity according to the collected information with a uniform policy. Most of newly built buildings adopt decentralized heating, cooling and HVAC systems, instead of centralized ones. In case of Korea, each individual office in a building has and operates its own electric heating and cooling system. There are multiple small companies in many of large office buildings: for example, there are 50 to 100 companies in a 20-story building. Each individual company runs its own heating, cooling, and HVAC system with its own policy. MEES provides energy saving where there are many individual entities with individual policies inside a single building, based on Wireless Sensor Networks (WSN) technology.

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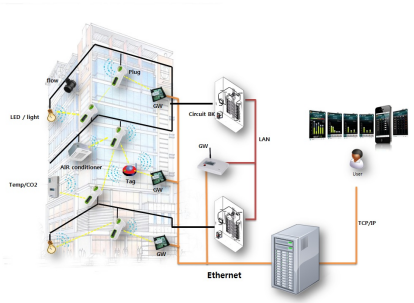

Figure 1. System structure

2 System Architecture

The energy efficiency system is composed of two parts: monitoring system of energy usage and controlling system of energy load. The system can also be divided into three parts in a different way: remotely controlled peak electricity meter, branch-level monitor in each floor, and monitoring plug for individual load in an office. The system structure is shown in Figure 1. In the system, peak electricity meter is critical, since it determines the energy cost. In Korea, electricity bill reflects the peak electricity usage, which is the highest value among average usages of each 15-minute interval. This peak electricity usage is measured by a peak electricity meter. To measure it as accurately as possible, multiple meters are installed in parallel, or additional equipments are used which reads count signals from meters of an electricity company. A branch-level monitor in each floor measures the electricity usage at floor-level. A monitoring plug monitors and controls individual electricity load connected to each power outlet.

2.1 Peak Electricity Meter

The peak electricity meter measures the peak electricity usage. It is composed of a sensor and a mote. The sensor gathers the output from the pulse counter of an existing meter. A new Advanced Metering Infrastructure (AMI) meter in a newly built building supports metering and networking, therefore it is easy to monitor the peak electricity usage. However, for an old AMI meter in existing buildings, electricity usage has to be calculated using the output interface of an existing AMI meter. Depending on the type of the meter, hall-effect sensor, pulse count sensor, or IR receiver sensor can be used. Electricity usage data, collected by sensors, are

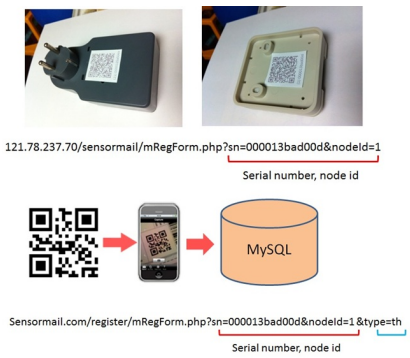

Figure 2. QR code based installation

transmitted wirelessly by a mote. A mote bridge, which is connected to Ethernet, forwards the data to a server.

2.2 Branch-level Monitor

The branch-level monitor in an existing building, also known as a circuit breaker, only provides branching and switching functionality. Moreover, the space in a panel is tight, so it is difficult to apply a new system. A remote branch-level monitor should provide monitoring and networking capabilities, and they require additional space. For an efficient installation, small and modularized equipments are needed. So far, Current Transducer (CT) sensors were connected to a server using wires to provide networking capability. However, wired CT sensors required much space, many wires made a panel messy, installation became complicated, and in an old building sometimes the whole branch-level monitor panel had to be entirely replaced with a new one. In some improved branch-level monitor, CT sensors are modularized and can be installed to each power line easily, and monitoring and networking capabilities are provided simply in an integrated manner.

2.3 Monitoring Plug

The monitoring plug uses Kmote and TinyOS [1], measures power up to 3520W, monitors electricity usage, and can turn on or off the power outlet. TinyOS provides multi-hop networking, so the plug can also work as a network backbone for environment sensors and location tags around it. For example, it can work as a router forwarding temperature data from a nearby sensor to a backend data server. The monitoring plug plays multiple roles, extends or integrates services. It enables diverse services and is open to new services in the future. It delivers more value with the same hardware configuration, compared to a single-purpose WSN system.

2.4 QR Code Based WSN Installation

A building energy monitoring system consists of large-scale wireless sensors which have different functionalities. Various environment sensors, electric metering sensors, branch-level electric sensors are network core components. These core components establish an energy monitoring network. In a 20-story building, over one hundred sub-networks will form a cluster. The main challenge comes from installation problems. Building operators should install these complex wirelessly networked sensors to a building without any physical connectivity indication. QR code based sensor installation gives an easy installation scheme to operators, as shown in Figure 2. Just a scan of a wireless sensor using a smart phone commits network registration and configuration.

3 Approaches for Energy Efficiency Business

MEES aims to collect an investment and to make a profit by saving the energy usage. To be considered as a proper investment in general, we set goals of 20% energy savings and breaking even in 5 years. After all, the cost of the system has to be designed to match the total savings in the energy cost of a building. The target building of the proposed system is an office building consisting of 50 to 100 individual offices. To achieve targeted energy saving and to have feasibility as a business, two major approaches are used. One is an energy web portal. The other is energy and environment monitoring.

3.1 Energy Web Portal for Office

Energy monitoring and efficiency service for 50 to 100 offices is performed on the portal web page. This web service is delivered to every office. In a conventional total whole-building energy web monitoring system, only the presentation of user energy consumption and trend were the main deliverables of the service, which was the only energy feedback to users. To improve the active energy efficiency system, our system uses micro web service. Every energy monitoring and controlling service networks are implemented based on the web service system, and all the network devices such as lighting, air-conditioner, power strip are accessible by a web interface. The web service can be accessed using a PC as well as a smart phone. Office users can arrange their own energy scenario through a web page.

3.2 Energy and Environment Monitoring

Temperature, humidity, occupancy, and user location information will be used for this energy efficiency system. In order to reduce the waste of energy, occupancy and user location tracking will be used. In addition to weather information, this human tracking will be a key point to eliminate improper energy consumption.

4 Demo System

Basic energy monitoring and presentation by a web browser and a smart phone will be demonstrated. It will include how to configure QR code based wireless sensors to the service by a smart phone. In addition, in a system-level demonstration, energy monitoring based on a sensor mail service will be on the live demonstration.

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6 References

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