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Design of Smart Energy Monitoring System for Green IT Life

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Abstract**—**This paper describes the smart energy monitoring system with a wireless sensor network for monitoring of electrical usage in smart house. Proposed system is composed of wireless plugs and energy control wallpad server. The wireless plug integrates an AC power socket, a relay to switch the socket ON/OFF, a Hall effect sensor to sense current of load appliance and a Kmote. The Kmote is a wireless communication interface based on TinyOS. We evaluated wireless plug in a laboratory, analyzed and presented energy consumption data from electrical appliances for 3 months in home.

Keywords**—**smart house, energy monitoring, wireless plug, wireless sensor network, current consumption.

I. Introduction

IN a world of highly developed countries and emerging economics, energy supply plays a major role. In a modern household, hardly any device runs without electricity. Understanding household energy usage in-home is vital for the planning of energy consumption and conservation. Household are an important group when addressing energy conservation. Many researchers pointed out that changing life style is important to reduce the energy consumption.

The traditional electric meter, used by electricity companies for accounting is the electromechanical induction watt-hour meter. Its robust technical design is in use for over a century but is not capable of more than measuring the accumulated amount of consumed energy. A disadvantage is that either an employee, sent by the energy company or the customer himself has to read the meter manually which implies costs and administration effort [1].

Smart meter is a very general term for a more advanced metering device, which provides more detailed information on consumption to the customer and is mostly able to communicate with the electricity supplier via some network for the purpose of accounting, billing and monitoring. Capabilities range from simple display a meter, which gives a user feedback on current and past consumption, to high-tech meters which are capable of interacting with home automation systems and for instance are able to switch on a device when the supplier indicates cheap energy prices.

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For example, Google PowerMeter is an on-line service that interacts with consumer's local smart meters via vendor or utility company. Load data is sent from a smart meter to the energy supplier, who forwards data to Google's data store by implementing and invoking the Google Data API. Google provides a uniform user interface to all customers including processed and analyzed data. This technology leads to vendor independent information processing and allows integration of multiple devices [2], [3].

This paper presents the architecture, design, and evaluation of smart energy monitoring system, a wireless plugs for gathering electricity usage and controlling AC in a smart house environment.

II. System Overview

The overall design of the smart energy monitoring system is shown in Fig. 1. The design we have made divides the system three parts. The three pieces of this decomposition are the wireless plugs, the base module, and the energy control wallpad.

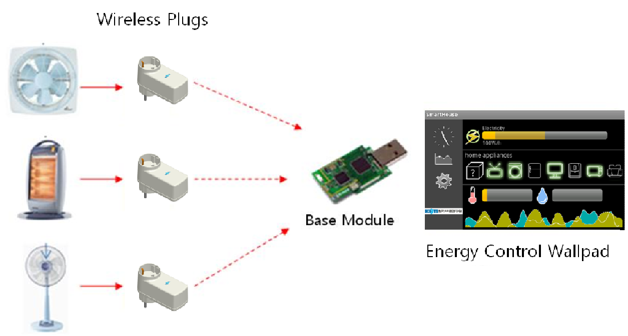


Fig. 1 System overview

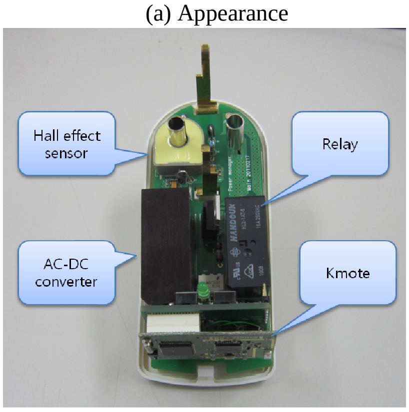
A. Wireless Plugs

An essential component of wireless plug is the device that performs the energy measurement and control. This device consists of four components – Hall effect sensor, AD/DC power supply, microcontroller with radio, and relay as shown in Fig. 2.

To obtain real, reactive, and apparent power measurements, a dedicated IC is usually used to perform the necessary analog-digital conversions. In this paper, we use the Hall effect sensor to convert current to voltage. These devices use the Hall effect to measure current and can be either clamp-on (non-contacting) or in-line. Inline Hall effect sensors intercept the AC current and couple it with an internally calibrated Hall effect element. This approach is compact and precise. More importantly, the high voltage AC input is electrically isolated from the low voltage output inside the in-line Hall effect sensor.

The sensor network module is implemented from a commercial product (Intech co., Kmote-B) which is a clone of Telosb platform, including a microcontroller (Texas Instruments co., MSP430, 8MHz), an IEEE802.15.4 compliant RF transceiver chip (Texas Instruments co., CC2420) [4-6].

(a) Appearance



(b) Configuration
Fig. 2 Wireless plug

B. Energy Control Wallpad

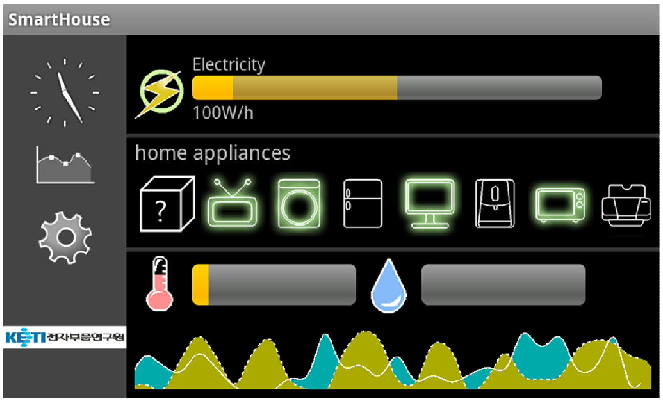
The role of the energy control wallpad is to store packets from the wireless plug to a database as show in Fig. 3. We choose a small size embedded board for easy development of client program and convenient management of the in-house monitoring system.

The wireless plug reads the packet from base module and writes it with additional information into the MySQL database. The UI program is implemented under the Android platform.

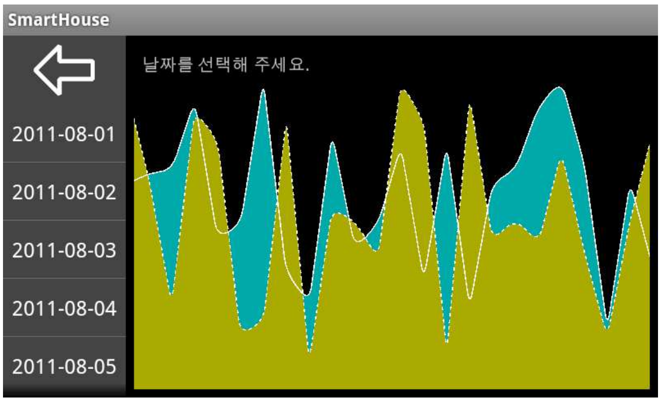
(a) Energy control wallpad

(b) Base module (Kmote)
Fig. 3 Energy control wallpad

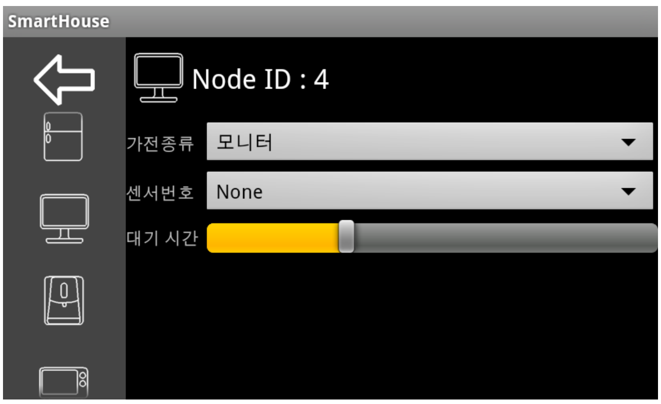
Fig. 4 is the energy control wallpad UI on the Android platform.



(a) Energy control main UI



(b) Energy usage history UI



(c) Appliance setting UI
Fig. 4 Energy control wallpad UI

III. Experiments

Fig. 5 illustrates the experimental measurement set-up. The wireless plug measures the current per 1 second, and transmits the wireless data to the energy control wallpad per 5 seconds. We measure the current consumption and electric power. It was based on the result of saved data in the energy control wallpad.

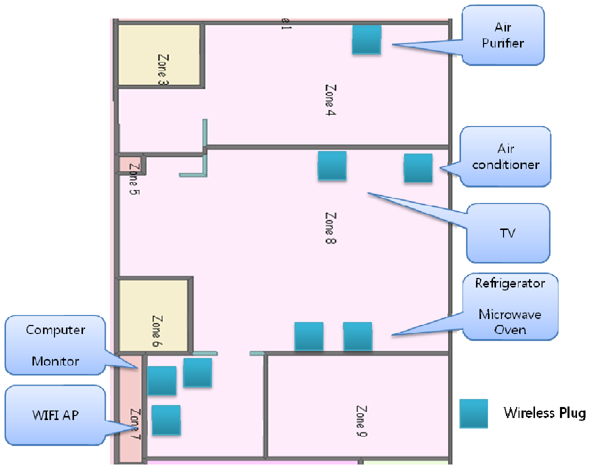
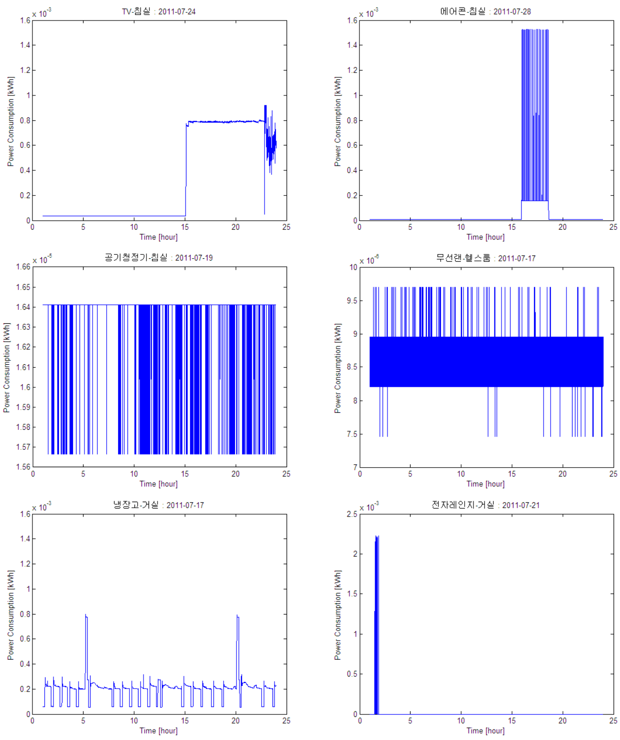


Fig. 5 Floor plan

Fig. 6 are power consumption traces from electrical appliances under measurement (TV, air conditioner, air purifier, WIFI AP, refrigerator, microwave oven, computer, monitor).



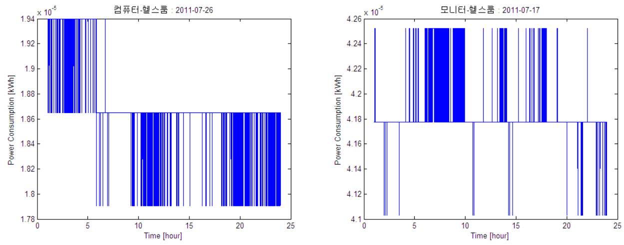


Fig. 6 Power consumption traces of appliances

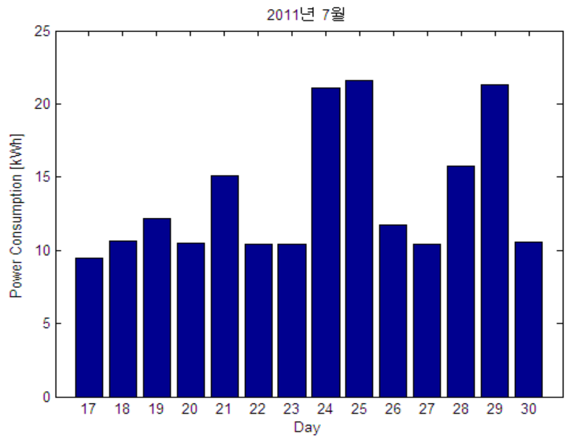


Fig. 7 Total power consumption

The energy control wallpad program can be converted into a smart phone apps using RF-to-Bluetooth dongle as show in Fig. 8. The smart phone is based on android platform.

Fig. 8 Smartphone application

IV. Conclusion

In this paper we describe smart energy monitoring system using wireless plug which we have developed. The developed monitoring system is composed of the wireless power outlet, which named wireless plug, and the energy control wallpad. The wireless plug integrates AC power receptacle and wireless sensor node into a power socket to switch the power ON/OFF and to measure the power consumption of plugged appliances. The energy control wallpad stores the received signals into the database. The experiment results show the adaptability and feasibility of the energy consumption data.

Future research may integrate into the end devices to allow them to be tasked with more sophisticated data processing and generation.

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[5] Texas Instruments, http://www.ti.com /
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