# Demo Abstract: PEAKSAVE: Energy Monitoring Service

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## Abstract

PEAKSAVE system is an energy monitoring service based on Wireless Sensor Networks (WSN). A smartphone is an important point of a system. Users can understand the energy consumption of each electric device and lighting in real time. Responsive energy monitoring service can help in reducing the waste of energy, especially in shaving electric load in a peak time.

## 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

PEAKSAVE is an energy monitoring service to reduce an energy usage and to shave a peak. In a short term, it aims to shave the energy consumption peak in summer and winter, when the peak is the highest. The system provides monitoring of the energy usage of a user in real time, and shows the total energy usage and reserve margin of the whole country. With information and alarm, this service encourages the user to reduce the energy usage at peak time. In a long term, it provides a service for the user to manage energy. Through PEAKSAVE service, the user can monitor the energy usage in pseudo real time. Therefore when an electric device is turned on or off, the user can immediately observe the change in the energy usage. The user can also set an alarm. If the total energy usage exceeds the limit set by the user, or if an energy bill is expected to surpass the preset amount, an alarm is sent to the user automatically so that the user can efficiently manage the energy usage.

## 2 Service

PEAKSAVE service provides diverse information in an integrated manner. Readings from smart meter, plug load data, temperature, humidity, and human presence data are gathered through WSN. The total energy usage and reserve margin of the entire nation is obtained through web service API provided by a government. As the major service of PEAKSAVE system, the current national reserve margin is provided, and the recent history of the energy usage of the user is analyzed and informed. Based on this information, the personal energy usage is compared to the pattern of the national energy usage, and its result is notified. After the rate of increase is analyzed, if needed, an alarm is sent to encourage the user to shave the peak. With 1Hz sampling rate, the system analyzes whether a light or an electric device is used, and its power consumption. A standby power is also analyzed and provided. At night or when there is no user, the energy usage is analyzed and the standby power is reported.

## 3 Architecture

PEAKSAVE is composed of mote, bridge, server, and smartphone. A mote senses data and sends it to a bridge. The bridge forwards data to a server through the Internet. The server processes data and sends the processed information to a smartphone. The smartphone displays the received information to a user. In reverse, the user can input a control command to the smartphone. Then the control command is relayed to the mote through the server and the bridge. Diverse sensors can be attached to the mote. Smart meter measures the electricity usage at power panel. The plug meter, which is called as S-Plug, not only measures the electricity usage, but also turns on or off the electric device attached to it. Temperature and humidity sensor, $CO_2$ sensor, and PIR sensor are made as a modular sensor board, called an Extension Board. As a mote, Kmote is used, which is a TelosB [3] clone. They all run TinyOS [2], and CTP [1] forms multi-hop collection routing, and forwards data to the bridge. The bridge receives data collected by CTP, and forwards it to the service gateway of PEAKSAVE server through WiFi. The bridge contains WiFi interface. In a single-hop communication, WiFi is less vulnerable to obstacles and has longer communication distance than IEEE802.15.4 radio, and provides stable communication. To minimize a shadow zone, we can relocate the bridge to a proper place and build a stable wireless network. To process and manage data, PEAKSAVE



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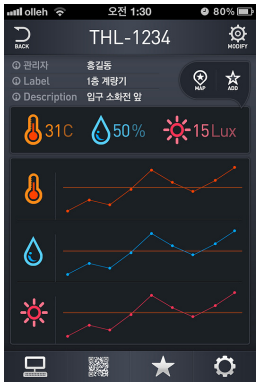


**Figure 1. Smartphone GUI example**


**Figure 2. Energy usage of a whole floor**

server is used. We used both Windows and Linux server. Between the server and the smartphone, there is a bandwidth limitation. Therefore, to minimize the amount of data to be transferred, only pre-processed data from the server is sent to the smartphone. Currently iPhone is supported. Figure 1 shows GUI in a smartphone. In this figure, environmental information is displayed: temperature, humidity, and ambient light. The user can see not only personal energy usage, but also the energy usage of the whole floor and the entire building, as in Figure 2. The total energy usage of the whole country is also displayed.

## 4 Experience in real deployment

PEAKSAVE is installed in Korea and Finland. The installation at a building in Finland, was a good opportunity to test a large-scale service spanning over multiple countries. In Finland, it is expected for a smart meter to be installed in over 80% of houses by 2013. This is a good environment to use energy monitoring service like PEAKSAVE. Depending on the situation of a site, the installation plan had to be adjusted. However, wireless network gracefully adapted. In an environment where wireless communication is limited, a wired bridge is used. In a place where WiFi is provided, a wireless bridge connected motes to the Internet. Not only by merely moving location of sensors, but also selecting a proper bridge, we could increase the end-to-end stability of the network. QR code is attached to a sensor, and is used to extract information about the sensor. It reduced the effort and increased the accuracy of the installation, and collaborators in Finland were very interested in it. The Figure 3 shows an installation work using QR code. In June 2012, 120 sensors of 5 types are installed in 4 separate places. Figure 4 shows smart meters installed. The data is sent to a server in Korea.

## 5 Discussion and Demo Scenario

The system operates well without any problem by the date of writing. PEAKSAVE will increase the scale of sensor, and we expect it will be happening soon. In displaying energy usage data to the user, how the data is processed affects by how much the user responds to the feedback and by how much the user actually comes to save the energy. Continuing research is needed on how to formulate and display data. Later a control loop will be added to further shave the peak

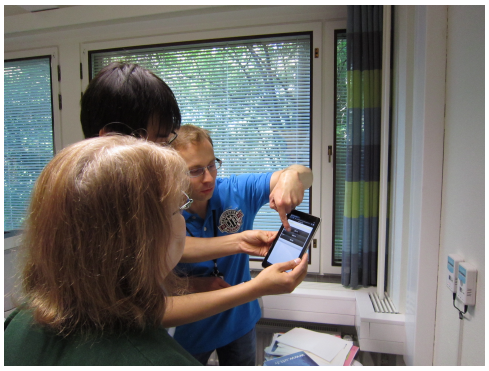

**Figure 3. QR code made an installation simple**


**Figure 4. Smart meters installed**

automatically. When interoperated with Demand Response (DR), PEAKSAVE will be more effective. As the amount of data increases, MySQL experienced a severe increase in a response time. The user experience with GUI became negative. Currently there are more than 100,000,000 records in a table. To process this big data, a proper database system will be needed, like Hadoop or OpenTSDB.

In a demo, smart meters, S-Plugs, and environment sensors will be demonstrated. With electric loads like light and dryer, the load data will be sent to a server in the Internet every second. Then the real-time data will be shown on a smart phone. The smart phone will also show the national reserve margin. S-Plug will be turned on or off remotely.

## 6 Acknowledgement

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