Optimum Control of Electrical Power in IT Systems by ULP Networked Sensing Systems

Toshihiro Itoh, Jun Fujimoto and Ryutaro Maeda,
Research Center for Ubiquitous MEMS and Micro Engineering,
AIST,
Tsukuba, Japan

Tomoyuki Hata,
NEC Corporation,
Tokyo, Japan

Satoshi Itoh
Information Technology Research Institute,
AIST,
Tsukuba, JAPAN

SUMMARY

Energy demands has been increased dramatically for IT systems, such as personal computers and IDC (Internet data center). Ultra Low Power (ULP) Ubiquitous sensor is proposed to visualize the energy consumption of IT systems. Employing the visualized consumption maps, IDC control system is to be developed for minimizing energy consumption. Furthermore, social experiments are planned to establish the reduction method of all energy consumption for all IT systems including air conditioning facilities.

"Ubiquitous Sensor" group is developing maintenance-free wireless sensor nodes and sensor network system to monitor the power consumption of electrical devices, especially in information and communication technology (ICT) field. To realize ultra low power wireless sensor nodes with the average power consumption of approximately 1 μW, it has been developing the fabrication process of microcoil structures on the surface of wires with high permeability, which is used for the current transformer in the sensor nodes. The process, including a novel cylindrical lithography utilizing the precise synchronized motion of θ/X-direction with keeping small rotation eccentricity of the wire for projection exposure of coil pattern, has made it possible to form the coil pattern with the line width of less than 20 μm and turns of 200. Also, the monitoring network system has been developed using prototype wireless sensor nodes integrated with a conventional clamp-on type current transformer.

Grid group is developing the server management system to reduce the power consumption in data center. The management system obtains status of the servers (such as CPU load, memory usage and power consumption), and determines the assignment between virtual machines and physical servers to minimize total power consumption. In order to re-locate the virtual machine flexibly we developed the quick live migration named "Yabusame". Since existing live migration, such as Xen, kvm and VMware, uses the pre-copy type method, it takes dozens of seconds to move the virtual machine from a physical server to the other. However, our live migration "Yabusame" can move the virtual machine in one second, because we adopted the post-copy type method. The server management system using "Yabusame" can reduce the total power consumption while the system responses are kept high.

System experiment group aims at producing energy efficient data centers using modular design. The study was started by monitoring the energy consumption and temperature in some data centers for identifying the problem. The monitoring results show that the fluctuation range of the power consumption of IT equipment and the room temperature is not larger than expected in the existing data centers. It indicates that IT equipment wastes energy and it is improved by better operations such as server consolidation through virtualization. The monitoring results also indicate that energy for cooling seems too large. In addition to reducing energy consumption by improving the efficiency of cooling based on CFD modeling and simulations, a modular design that is suitable for heat removal by air ventilation is examined. In the modular approach, sensing and monitoring could be important for reliable operations. The reduction of energy consumption in data centers would be achieved by combining system operations and modular structure.

ECO-Design group's first study included in this project, presented assessment results of electricity consumption from ICT in future states based on "2025 ICT Society Scenarios". These results reveal that the total power consumption from ICT was over 49.2 TWh in 2008, which was around 5% of total electricity demand in Japan, 2008. Furthermore, we depicted a future ICT society based on scenario-planning and brainstorming methods, and estimated power consumption in 2025 utilizing these scenarios. The results suggest that power consumption from ICT reached to around 100 TWh in 2025, without considering technological progress. After this study, we began to examine the new technology of wireless sensor nodes and its application of power monitoring in many fields of society in order to make our previous study more concrete. We conducted many power-monitoring experiments in residential, commercial, and business areas, such as convenience stores, data-centers, restaurants and so on. We present the extent of our power monitoring experiments, using a new indicator which was calculated by multiplying the number of sensor nodes by monitored days. From this indicator, we conducted 33 thousands "sensor-day" experiments by the end of 2010. During these experiments, we gathered a total of around 17GB of electric current data. Through our field experiment in society, we discovered the factors required in order to widely spread smart meters.