Energy Saving with ICT
-- Green University of Tokyo Project --

Kaoru YOSHIDA, Ph.D
Social System Research Division
Mitsubishi Research Institute, Inc., Japan
E-mail : kaoru@mri.co.jp

Hiroshi Esaki, Ph.D
Graduate School of Information Science and Technology,
The University of Tokyo, Japan
E-mail : hiroshi@wide.ad.jp

Abstract

Energy saving and the protection of environment for sustainable society is now global agenda, that we must achieve for the next generation and for our Earth. This activity around IT and ICT industry is called as "Green IT/ICT". Though the most of the Green IT/ICT would focus on the energy saving "of" IT/ICT equipments, we are focusing on the energy saving "by" IT/ICT technologies. The real target is not the energy saving, but is to establish ubiquitous digital sensor and actuator network environment and to encourage the technical innovation/revolution or new applications using this network platform. This is the "end-to-end" model that the Internet has achieved.

In this presentation, the speaker gives the overview of R&D projects related with energy saving, e.g., Green University of Tokyo Project. The real goal of these projects is sharing any digital information over the globe to achieve higher efficiency on human and social activities and to establish the digital network infrastructure to achieve sustainable innovations.

Key words: *The Internet, Facility Management, Mieruka, Electric Consumption*

1. Background

Due to the current trend of tackling global warming, reducing electric consumption becomes one of the biggest topics in the industrial sector. Kyoto Protocol [1] has entered into force in 2005, and then Japan takes a responsibility to reduce green house gas by 6% compared to it in 1990.

In 2006, Hongo Campus of the University of Tokyo emitted huge volume of CO2, and therefore the energy saving is one of pressing issues to address for the university. Todai Sustainable Campus Project (TSCP) [2] has started its activity since 2008 to reduce CO2 emission at the campus and to realize a sustainable society in the world. The Green University of Tokyo (GUT) project has started its activity since June 2008 complying with the TSCP.

The main role of the GUT project is to establish IT/ICT based facility management systems and to reduce electric consumption through optimized facility controls. Since the university consists of multidiscipline laboratories, there exist various technical challenges to overcome.

There exist various facility management systems that aim not only to manage facilities but also to reduce or optimize energy consumption, but most of previous approaches usually require proprietary systems to develop. Due to its proprietary, it is hard to adapt new features by ourselves or to inter-connect different systems. As a result, it is impossible to manage facilities in a building with a single facility management system.

Different from those previous works, the GUT project aims to deploy open facility management system based on open architecture specification. Providing an open and a standard protocol for facility managements, the project tries to be a referential model of facility managements for complexes.

2. Green University of Tokyo Project

2.1. Project Overview

The GUT project [3] has started its activities since June 2008 complying with the TSCP. The basic goal of the project is to show technical approaches of reducing CO2 emissions, more properly electric consumption. To achieve the energy saving, the scope of the project contains both "of" and "by" IT/ICT for the energy saving.

In detail, we, our project members, try to not only save electric consumption of IT/ICT equipments but also adapt IT/ICT technologies for more efficient and intelligent facility managements.

To demonstrate and validate our approaches, we set up an experimental field in the Faculty of Engineering Bld.2 (Eng. Bldg.2) and conduct various types of demonstration experiments there.

At the same time, since we do realize that compulsory energy-saving activities do not work well as our experiences, we recognize that there should be a way that all the people are willing to tackle the energy saving. So, through demonstrating energy-saving experiments we also try to model a scenario that make people tackle the energy saving.

Project members mainly consist of private companies, universities and organizations/associations and various types of companies participate in the project; some of them are giant electronic corporate, some of others focus on facility managements and some of the rest are trading companies. The project started with twenty-seven companies/organizations and now the number of participants becomes forty-one as of 1st September, 2009. Since the project has not been funded by public institutions such as government agencies or national institutes, the project activities are supported by participants' budgets.

2.2. Structure of GUT Project

To achieve two main objectives; (1) Saving energy "of" IT/ICT equipments and "by" IT/ICT technologies; (2) modeling a scenario that people can actively tackle for the energy saving, the project forms five technical working groups (WGs); Concept WG, Facility Control WG, Experiment WG, Mieruka (Making Visible) WG and Protocol Standard WG. Each WG plays an important role for managing our PDCA (plan-do-check-act) cycle as shown in Figure 1.

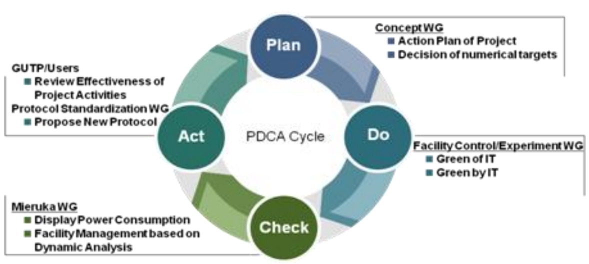


Figure 1 GUTP's PDCA Cycle

Here, the roles of Concept WG are to produce a model that makes people actively tackle for the energy saving and to enlighten people on the energy saving. Facility Control WG and Experiment WG actively conduct demonstration experiments in the Eng. Bldg. 2. Achievements of the WGs so far are to develop and deploy IT/ICT based facility measurement systems in the building. Mieruka WG mainly focuses on visualization (Mieruka) of data which Facility Control WG collects.

Protocol Standard WG was established relatively recent. The goal of Protocol Standard WG is to design / formulate a standard protocol for facility managements. Although there exist "standard" protocols for facility managements, those protocols have problems for the interoperability between them.

3. Energy Saving "by"/"of" ICT

In this section, we introduce our achievements so far. Especially, we focus on measurement systems of electric consumptions and Mieruka tools.

3.1. Protocol Design and Implementation

We design the protocol architecture so that the system has the feature of "Eco-System" [1]. With the author's understanding, the followings are some of required features for Eco-Systems;

(1) **Independency** of individuals and sub-systems
Each individual and sub-system must live or be operate-able by themselves, at least temporally.

(2) **Autonomous** operation of individuals and sub-systems
Each individual and sub-system can make their operational and governance rules by themselves.

(3) **Interaction** among individuals and sub-systems
Individual and sub-system have some level of interaction, e.g., cooperation and collaboration, with other individuals and sub-systems.

(4) **Adaptability** against the change of environment
Individual and sub-system can adapt themselves, according to the change of environment.

Also, we consider that the Internet architecture does not mean the particular protocol suites, such as existing TCP/IP. TCP/IP itself has experienced a lot of protocol modifications and functional enhancements, during the

[1] An Eco-System is a natural unit consisting of all plants, animals and micro-organisms in an area functioning together with all of the physical factors of the environment. Ecosystems can be permanent or temporary, in both spatial domain and in time domain. An Eco-System is a unit of interdependent organisms which share the same habitat. Eco-Systems usually form a number of food webs/chains, as the interaction among the independent organisms. In the area of economics, the Eco-System is defined as a business structure among related organizations (e.g., private companies), which form the cooperative and collaborative business activities to yield benefits and innovations for themselves.

deployment of global Internet system. We must recognize that the Internet architecture is the "logical" architecture framework, not the particular protocol sets nor routers and switches.

Therefore, we design the protocol architecture of the Green University of Tokyo system, so as to include the following five essential features of the Internet architecture. These are (1) autonomous, (2) distributed, (3) disconnected, (4) inter-domain, and (5) global, operation. The current Internet system has been challenged by the following three aspects; global, ubiquitous and mobility.

The followings are yet other design parameters for us.

(a) Impossible to accommodate earth with single technology
We have wide variety of technologies so as to connect the digital devices, especially in the field of facility networks. In order to maintain the continuous innovation of networking technology, we have to intentionally maintain the capability of alternativeness in the networking components. This feature, i.e., diversity and replace-ability, leads to the aspect of sustainability and adaptability in Eco-System.

(b) Investment and operation is always autonomous
Installation and operation of system by the single organization is neither scalable nor realistic. We have to design the system, which collaborates and cooperates to each other in a distributed and autonomous manner.

(c) We have large area where, even, wireless would be hard to use
Though we have a lot of nodes, which are connected to the network via wireless links, we will still have a lot of nodes and area, which could not be connected to the Internet. This will be true in facility networks, when we have mobile objects in the system.

Figure 2 shows the overview of protocol architecture in the GUT system, developed in our real office in downtown Tokyo, Japan. The design principle is; (1) common database, i.e., database centric, (2) accommodating various types of field-buses and sub-systems and (3) common APIs for database system and field-buses from applications. So as to accommodate various types of field-buses and sub-systems, we adopt (a) the XML routing among these heterogeneous sub-systems as a common communication protocol, (b) pub-sub system (as a DTN capability) and (c) IP technology in the backbone area. By the introduction of XML routing, we can accommodate various types of field-buses and sub-systems, while preserving the capability of smooth migration to IP-based sub-systems in the future. Also, the introduction of DTN capability is very important and critical for the system, so as to improve the operational robustness in the system.

Figure 3 shows the concrete system diagram of our GUT system. The left-bottom square is the system originally installed in the building. We have added the gateways to connect with the common bus among the sub-systems, such as HVAC or lightening system. Through the common bus, multiple common database systems are installed and operated, autonomously and independently. Also, the multiple application software is installed and operated, autonomously and independently, as well. With this system configuration, we can provide the environment where the sub-systems can cooperate and collaborate to each other. In other words, the legacy system was enough stupid and expensive to deny the cooperation and collaboration among the sub-systems, since the sub-systems are isolated by their own proprietary technologies. By the introduction of common protocol, we can provide the opportunity of cooperation and collaboration for these sub-systems, even though they use their own proprietary technologies. Actually, by the introduction of this platform, participating players and components start to consider the new applications and richer applications, with small or less cost, compared with the legacy facility system.

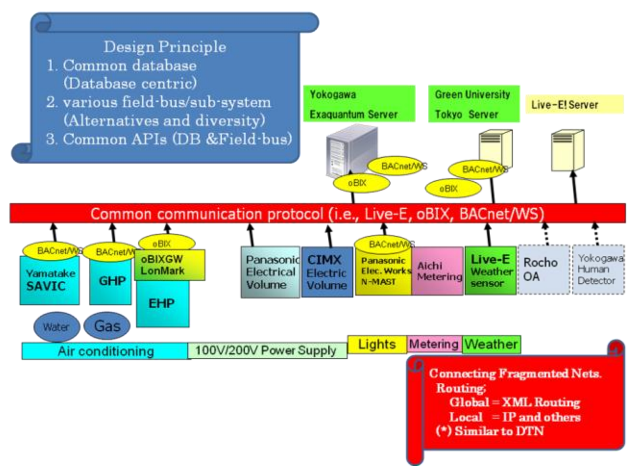


Figure 2 Protocol Overview of GUTP System

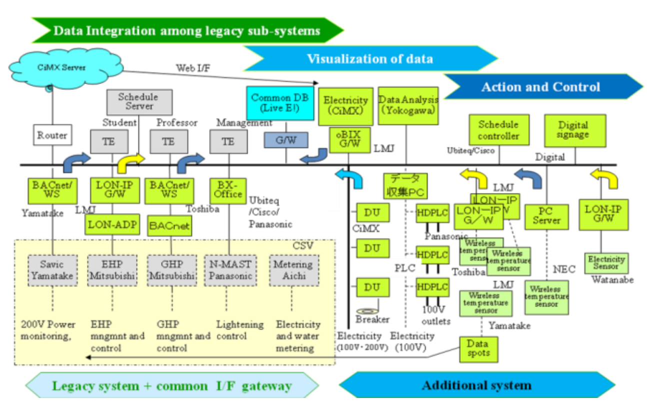


Figure 3 System Overview of GUTP

3.2. Developing Measurement Systems

First of all, to save the energy, it is necessary to find out where there is room for the improvement. Since utilizing the IT/ICT technologies for the energy saving is one of the important objectives of the project, the project also applies the IT/ICT technologies to the electric consumption monitoring.

But there were three issues to develop the IT/ICT based electric consumption monitoring system inside the Eng. Bldg.2 as follows; (1) the building had already been in the operational phase when the project started in June 2008: (2) the power monitoring system in the building was not designed to utilize the IT/ICT system: (3) due to the conventional facility management scheme, power lines were managed by equipments/sub-systems not by facilities/users.

As a result, it was hard for users such as faculties, officers and students to realize how they really use electronic equipments and emit greenhouse gases.

To monitor the electric consumption through the IT/ICT technologies, the project introduces various techniques and technologies. Some of monitoring technologies the project applies are described below;

(1) Standardized facility management protocol:

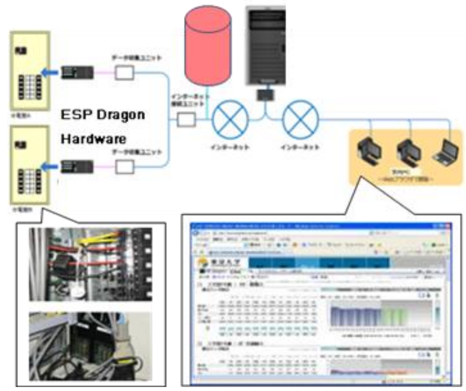
There exist standardized facility management protocol s such as BACnet[2]®/WS [4] and oBIX[3] [5]. In these days, many companies deploy their equipments so as to interpret those protocols, and those protocols are now available through the IT/ICT technologies. So, electric consumption of equipments can be collected through those protocols.

(2) Contactless sensor:

Cimx Corporation deploys and develops ESP Dragon® that can collect electric consumption through setting up proprietary hardware, contactless sensors, inside distribution boards. Data collected through contactless sensors are sent to a management server through the Internet and is visualized (Mieruka) there as shown in Figure 4.

2 A Data Communication Protocol for Building Automation and Control Networks; BACnet is a registered trademark of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).

3 OASIS Open Building Information eXchange Technical Committee;

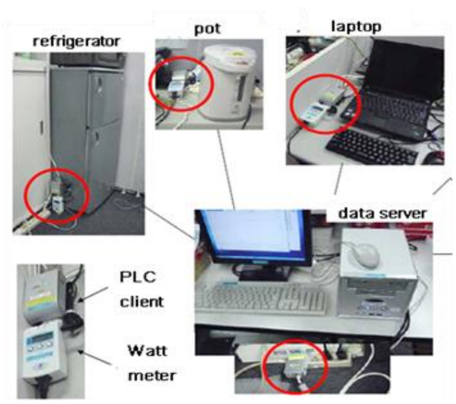


(Source: GUTP Experiment WG)

Figure 4 Contactless Sensor Monitoring

(3) HD-PLC (Power Line Communication):

Panasonic Corporation deploys an electric consumption monitoring module that works with the HD-PLC. The module is set between a socket and a plug, and then collected data is sent to the Internet through the HD-PLC (Figure 5).



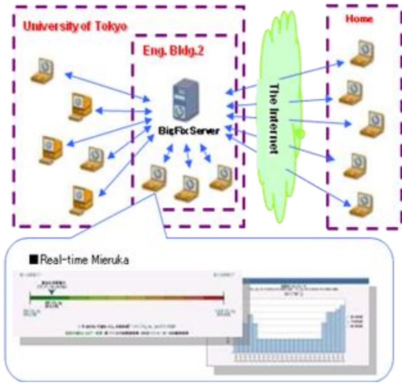
(Source: GUTP Experiment WG)

Figure 5 HD-PLC Power Monitoring

(4) Power Monitoring for PCs:

Mitsubishi Corporation introduces BigFix® to monitor electric consumption of PCs (desktop/laptop) and servers as shown in Figure 6. Different from the above system, we can measure electric consumption with the BigFix even when PCs are out of offices. This is useful, because especially laptop PCs are carried by people who move around in the building and therefore it is hard to trace a unique PC for the purpose of the power monitoring.

Leveraging these techniques/technologies, the project is now collecting more than 1,500 point data constantly, which include electronic, gas and water consumptions and facilities' status information (as of May 2009). All the collected data can be accessed through the standard protocol that the project is now design/formulat-ing.



(Source: GUTP Experiment WG)
Figure 6 Power Monitoring for PCs

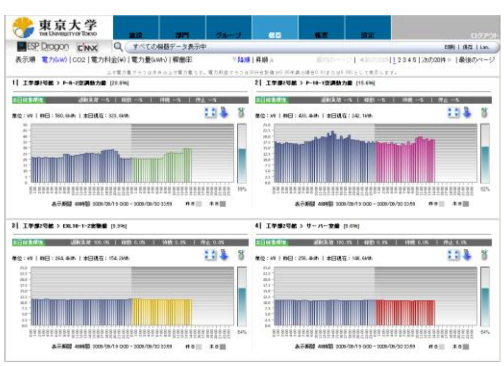
3.3. Implementing Mieruka for Collected Data

Even though collecting data, users do not make effective use of the data for the energy saving unless users can easily access to the data. Furthermore, the data should be not only accessible but also understandable for users. To provide the easily understandable data to users, the project recognizes that implementing Mieruka (making visible) should be one of the ways.

In the project, some of member companies, such as Cimx Corporation, Panasonic Corporation, Ubiteq Inc. and Digital Electronics Corporation, address on Mieruka, and what they focus on are listed as follows;

(1) Display time-line trend of electric consumption:

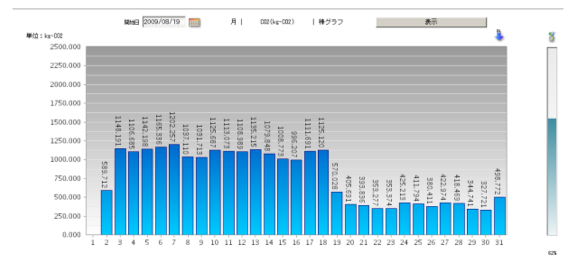
As shown in Figure 7, by displaying time-line trend of electric consumption such as daily, weekly or monthly, users can notice that how their usages differ in a one day from the one in another day. Also, by comparing the difference in daily variation, users can examine what kind of activities causes it. Therefore, users could know how they act next.



(Source: GUTP Experiment WG)
Figure 7 Time-line based Power Consumption

(2) Display effectiveness of the energy saving:

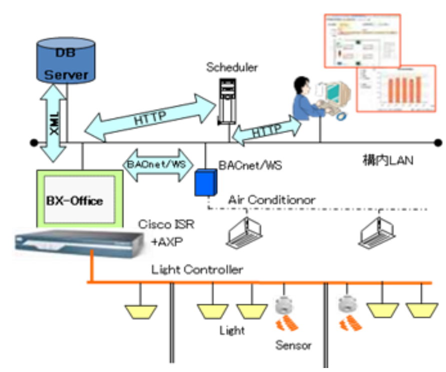
By displaying effectiveness of the energy saving makes, the project tries to show how each people's activity really contributes the energy saving. Some of the companies try to show how the activities can cut the cost or protect the environment through Mieruka (Figure 8). We believe this kind of approach is important to encourage people, since simple data display does not provide how people's activities contribute the energy saving.



(Source: GUTP Experiment WG)
Figure 8 CO2 Emission Display

(3) Dynamic Facility Management:

Ubiteq, Inc. and Cisco Systems develop BX-Office that controls facilities such as lights and air conditioners based on timetables of schoolrooms as shown in Figure 9. The basic idea of this system is to manage facilities based on their usage. Since especially classrooms are usually used along a timetable, it would become effective if facilities are managed based on it. And, since the BX-Office also works with motion sensors, facilities can be managed when people use them without a reservation.



(Source: GUTP Mieruka WG)
Figure 9 Dynamic Facility Management

We believe that showing the effectiveness encourages people and makes them tackle the energy saving more seriously. So, implementing Mieruka should be one of the optimal ways to show how people's daily approaches contribute the energy saving.

4. Conclusion

In this paper, as a practical project operation, we give the overview of the GUT project. We design the protocol architecture of the Green University of Tokyo system, so as to include the following five essential features of the Internet architecture. These are (1) autonomous, (2) distributed, (3) disconnected, (4) inter-domain, and (5) global, operation. Also the design principle of GUT system is; (1) common database, i.e., database centric, (2) accommodating various types of field-buses and sub-systems and (3) common APIs for database system and field-buses from applications. So as to accommodate various types of field-buses and sub-systems, we adopt (a) the XML routing among these heterogeneous sub-systems as a common communication protocol, (b) pub-sub system (as a DTN capability) and (c) IP technology in the backbone area. Based on the collaboration among academia and industry, a lot of and vide variety of components technologies are introduced in to the common platform and start the cooperation and collaboration.

References

1. Kyoto Protocol. [Online] http://unfccc.int/kyoto_protocol/items/2830.php.
2. **The University of Tokyo.** Outline of the Project. *TSCP Sustainable Campus Project.* [Online] http://www.tscp.u-tokyo.ac.jp/en/about.html.
3. **Green University of Tokyo Project.** [Online] http://www.gutp.jp.
4. **American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).** BACnet. [Online] http://www.bacnet.org/.
5. oBIX Open Building Information Xchange. [Online] http://www.obix.org/obix.htm