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# M2M Solutions that Use IT for Energy Efficiency and Comfort in Offices

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*OVERVIEW: M2M communications, a field that has played an important role in the development of social infrastructure, makes extensive use of the Internet. Reflecting this trend, Hitachi has developed M2M solutions based on the Internet model specified in the IEEE 1888 international communication standard. The solutions feature seamless interconnectivity between infrastructure equipment and the services provided by ICT management systems; a database-centric architecture designed for use with web services; and superior flexibility, expandability, and speed. They also take advantage of this speed in the control of infrastructure equipment to contribute to the energy efficiency of buildings without compromising comfort. Similarly, the flexibility is utilized to minimize the need for new installations by facilitating the connection of existing equipment and other devices. An estimate of the cost savings achieved in buildings that adopt the solution indicates a payback period of three years.*

## INTRODUCTION

GROWTH in the market for machine-to-machine (M2M) communications since the late 1980s has been concentrated in particular niches such as the monitoring of infrastructure in commerce and industry.

Along with wider use of Internet technology in recent years, however, use of M2M technologies is expected to broaden to encompass applications that support public infrastructure. To achieve this, there is a need for solutions that, in addition to overcoming challenges such as improving productivity, are also designed for easy installation and future expansion.

This article presents an overview and gives examples of M2M solutions that focus on office productivity and on delivering both building energy efficiency and comfort.

## M2M SOLUTIONS

### Market Trend and Issues

Growth in the M2M market has been based on vertically integrated solutions designed for specific fields. Accordingly, the business model has focused on customization, bringing with it the associated problem of the high cost of adding and enhancing functionality.

Overcoming this problem will require a shift away from vertically integrated solutions toward horizontally integrated solutions that support interconnectivity.

This leads to the following three requirements:

(1) Use of an Internet model that supports interconnectivity and wide-area operation.

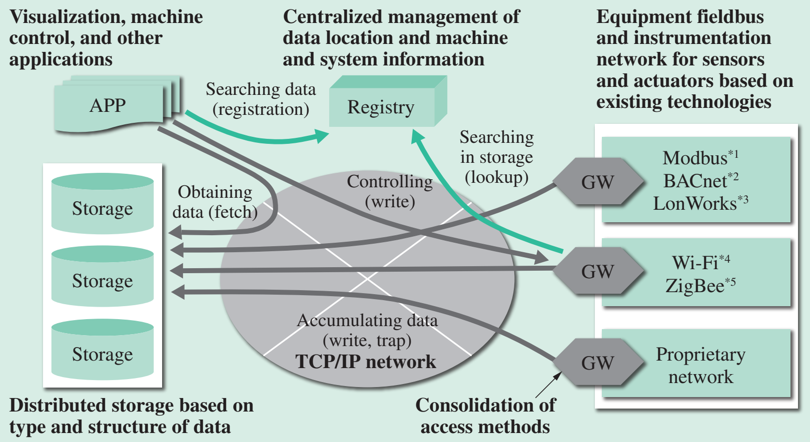
(2) Integration of standards and existing systems.

(3) Database-centric architecture with centralized management of information collected from sensors.

### Architecture and Features

To develop solutions that satisfy these requirements, Hitachi has adopted the IEEE 1888 international communication standard. IEEE 1888 was developed by the Green University of Tokyo Project(1) (GUTP), an industry-academia consortium, and formalized as an international standard in 2011. It standardizes multi-vendor interconnectivity between equipment and applications used in building energy management systems (BEMSs).

The IEEE 1888 standard defines four functions for the efficient collection and management of the large amounts and different types of information from sensors in ways that take account of equipment control. The “gateway” function is used to deal with differences between existing systems and




APP: application TCP/IP: Transmission Control Protocol/Internet Protocol GW: gateway
*1 Modbus is a trademark or registered trademark of Schneider Electric and/or such related companies.
*2 BACnet is a registered trademark of American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE).
*3 LonWorks is a trademark of Echelon Corporation registered in the United States and other countries.
*4 Wi-Fi is a trademark of Wi-Fi Alliance.
*5 ZigBee is a trademark for the ZigBee Alliance.

*Fig. 1—Architecture of IEEE 1888.*
*The storage, gateway, and application functions provide the write, fetch, and trap communication protocols and the registry function provides registration and lookup.*

communication protocols, and to make sensor data available on the Internet. The large quantity of sensor data collected via the gateway is then stored on the Internet for long-term archiving (the "storage" function). "Applications" are used to visualize data and for processing, analysis, and control. The "registry" manages the distributed components of the system such as gateways, storage, and applications (see Fig. 1).

Intended for systems that handle time-series data, IEEE 1888 uses a simple protocol based on the reading and writing of time-stamped data using extensible markup language (XML) and the simple object access protocol (SOAP). Its features include high development productivity, ease of data administration and use, suitability for multi-vendor applications, and the flexibility for use in large systems.

## Use at Hitachi Omori 2nd Building

Hitachi Information & Telecommunication Engineering, Ltd. initiated a proof-of-concept (PoC) experiment to test the M2M solution on one of its own buildings in 2012(2). In July of the same year, Hitachi also started full commercial operation of an energy efficiency system for air conditioning control and data visualization at its Hitachi Omori 2nd Building (O2 Building) in the Shinagawa district of Tokyo.

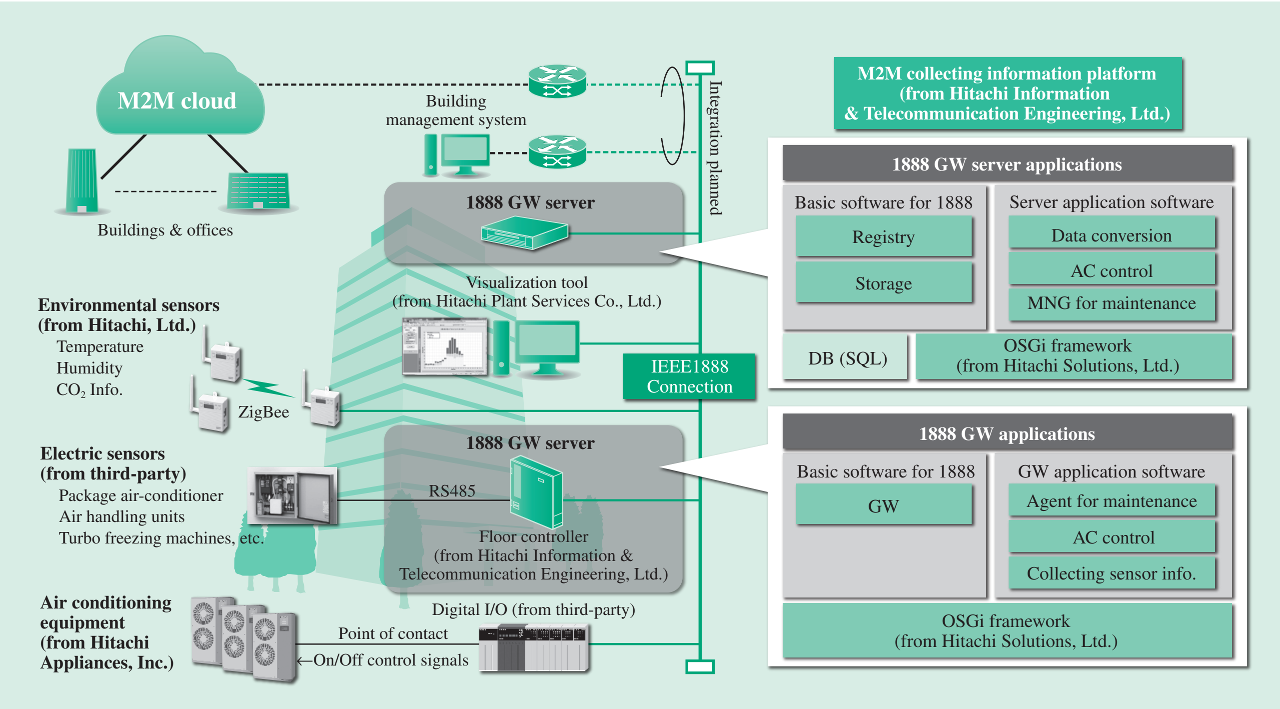
One of the concerns when installing an energy efficiency system is that it might damage productivity by subjecting office staff to unpleasant levels of heat or cold. Accordingly, the objectives for the project included improving comfort levels inside the building as well as cutting energy costs. The project also set a return on investment target of three years to assess the system installation costs.

Since the O2 Building has multiple air conditioning units, rather than replace these with energy-efficient models, the upgrade involved fitting information and communication technology (ICT) to the existing systems to provide information on energy use and environmental conditions and to allow integrated management.

## System Configuration

Fig. 2 shows the overall system configuration. In addition to the use of Hitachi products, existing building systems were used wherever possible.

Temperature, humidity, and carbon dioxide ($CO_2$) density measurements transmitted via ZigBee wireless systems (an environmental sensor network system manufactured by Hitachi, Ltd.) installed on each floor, and energy use information from meters installed on the air conditioners, were collected on a 1888 gateway server [a Hitachi personal computer (PC) server] via 1888 gateways (floor controllers manufactured by Hitachi Information & Telecommunication Engineering, Ltd.) and analyzed using a data visualization tool from Hitachi Plant Services Co., Ltd. The analysis results were then used as the basis for on/off control of air conditioners manufactured by Hitachi Appliances, Inc., which was performed via digital input/output (I/O) modules by an air conditioning




M2M: machine to machine $CO_2$: carbon dioxide I/O: input and output DB (SQL): database (structured query language) VM: virtual machine
AC: air conditioning MNG: manager

*Fig. 2—Configuration of Energy Efficiency System for O2 Building and 1888 GW Software.*
*The installation cost was kept to a minimum by using existing products and minimizing customization, with new applications only being developed for the 1888 GW server and 1888 GWs.*

control application on the 1888 gateway server. The O2 Building project included the installation of 188 sensors, with a total of 896 measurement points. Collecting environmental data with the sensors and measuring points helped to achieve great degrees of comfort inside the O2 Building.

The M2M data collection platform was an IEEE 1888 component developed by Hitachi Information & Telecommunication Engineering, Ltd. and ran on the 1888 gateway server and 1888 gateways. The management platform was an OSGi[*6] framework from Hitachi Solutions, Ltd.

## DEVELOPMENT TECHNIQUES

### Energy Efficiency Control Techniques

The O2 Building has both a central building air conditioning system, installed at the time of construction, and a number of standalone air conditioners that were retrofitted at later times as required. While the central air conditioning system included a control system for energy-efficient operation, control of the standalone air conditioners was largely left to users, with only a subset of functions being controlled from the central operation room.

Accordingly, when considering scenarios for how to reduce energy costs, the focus was on control of these standalone air conditioners rather than on the central system. Since the central system is less energy efficient than the standalone systems, energy costs were successfully reduced and the building-wide air conditioning efficiency was enhanced by making more use of the standalone systems and less use of the central system (see Fig. 3).

The specific scenario involved reducing energy use by changing the cooling water temperature and air blower settings for the central system while using the standalone systems to make up for any resulting deterioration in the indoor environment. In addition to this compensatory role, intermittent operation of the standalone systems based on environmental information was also used to reduce their energy use.

The operation also utilized the availability of energy and environmental data to identify waste and take appropriate countermeasures. An operational committee comprising the facility administrator, operators, and human resources and accounting staff was established to work through the plan, do, check,

*6 OSGi is a trademark or a registered trademark of the OSGi Alliance in the United States, other countries, or both.

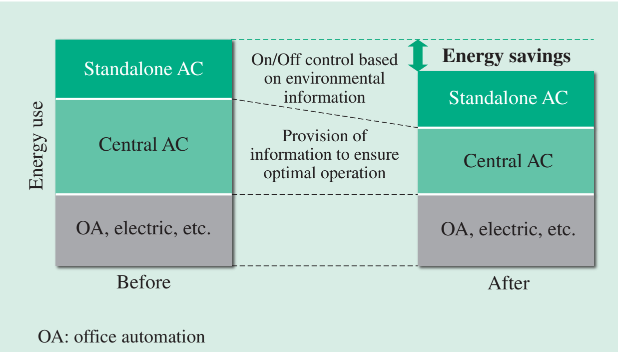



*Fig. 3—Energy Saving Scenario for O2 Building.*
*Energy use by the central air conditioning system was reduced through measures such as changing the cooling water and air blower temperature settings and through intermittent operation of the air conditioners. The increased energy use resulting from more frequent use of the standalone air conditioning systems was minimized by using intermittent operation based on environmental information collected by the system.*

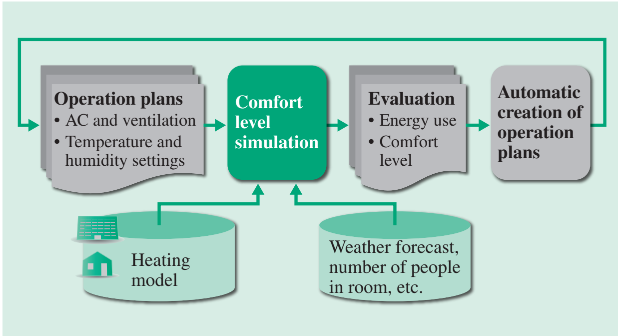



*Fig. 4—Comfort Control Algorithm.*
*A rough operation plan is generated the day before based on the forecasted external air temperature. The plan is then updated at 30-minute intervals during the day based on actual environmental information.*

and act (PDCA) cycle of formulating an operating plan (plan), implementing it (do), checking the outcomes (check), and revising the operation (act).

### Techniques for Improving Environment

Using the temperature sensors on each floor to calculate and display average floor temperatures demonstrated that significant temperature differences existed. To address this issue, the settings on the central system were adjusted to minimize these differences.

### Techniques for Controlling for Comfort

While BEMSs are intended to deliver major benefits through the well-balanced control of air conditioning systems, being designed to deliver both energy savings and a better environment, the initial installation costs are high. As a result, they are mainly installed in large new buildings(3) rather than in existing buildings.

To install a BEMS in an existing building such as the O2 Building, Yokohama Research Laboratory, Hitachi, Ltd. and Hitachi Information & Telecommunication Engineering, Ltd. represented the procedures for combining energy efficiency with comfort in the form of a knowledge-base and used this to develop comfort control algorithms that feature both lightweight and a wide range of applications(4) (see Fig. 4).

This uses the following framework:

(1) Prepare a range of operation plan options for the building.
(2) Use a comfort level simulator to predict the outcome of each operation plan.
(3) Evaluate the operation plans and select the best plan that combines comfort and energy savings.
(4) Implement the selected plan in the building.

This succeeded in producing an air conditioning operation plan that combines comfort and energy efficiency by using procedures for predicting power consumption and comfort level changes that require a minimal amount of mathematical operations.

## EVALUATION AND RESULT OF ADOPTING THE SYSTEM

### Ability to Combine Energy Efficiency and Comfort

The energy savings from installing the system in this building, which includes both central and standalone air conditioning systems, are anticipated to be up to 14%.

Moreover, providing information on average floor temperatures reduced the floor-to-floor temperature differences from 3.5°C to 2.3°C, and reduced the maximum average room temperature from 27.5°C to 26.9°C. The improvement in comfort during working hours was also demonstrated in terms of the temperature-humidity index (an indicator of room comfort level) (see Fig. 5).

### Ease of Installation

Hitachi succeeded in reducing the cost of equipment by adopting IEEE 1888 to facilitate interoperation with existing systems and the continued use of existing communication standards and equipment. Since installation primarily involves information technology (IT) equipment, it can be completed without interfering with business operations in the building.

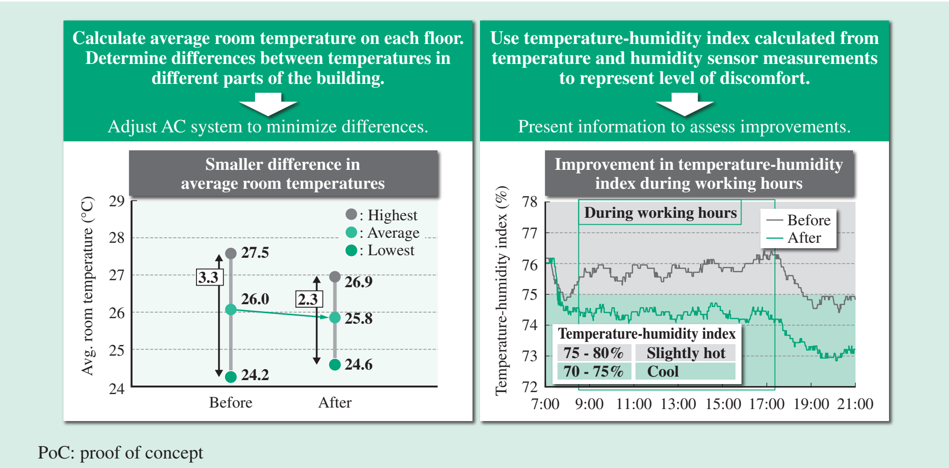



*Fig. 5—Improvement in Office Environment.*
*The PoC experiment successfully combined energy efficiency and comfort, and succeeded in reducing both the difference in average temperatures between workplaces and the level of discomfort in the workplace (as measured by the temperature-humidity index).*

As a result, installation was completed only two and a half months after receiving the order, with an anticipated investment payback period of only three years based on the energy savings described above.

### System Expandability

While the example described here involves installing the system in a single building, there is also potential for the centralized management of multiple sites over a wide area.

Specifically, Hitachi Systems, Ltd. has developed a cloud-based system that uses its own M2M network services(5). Hitachi Systems, Ltd. has demonstrated that the system can provide seamless centralized management of sites that are spread across the world by utilizing the Internet compatibility of IEEE 1888. The plan for the future is to expand the scope of integration with other Hitachi services and products in response to customer needs.

## CONCLUSIONS

This article has described work on a horizontally integrated M2M solution that uses IEEE 1888.

Its major feature is the flexibility to connect existing infrastructure and sensors together with ICT management systems that supply a variety of services. This is based on the use of an open Internet model with a wide range of applications, providing rapid system configuration and the expandability to progressively roll the system out to buildings at distant locations.

It also supports use of the combined analysis of different types of data to provide timely feedback control from a nearby location, as demonstrated in the proof-of-concept test of energy efficiency and comfort control.

Hitachi believes that its M2M solution can meet the needs of customers, not just in energy applications, but in any field where its flexibility, expandability, and speed will be of benefit.

## REFERENCES


(1) Green University of Tokyo Project, http://www.gutp.jp/en/
(2) Hitachi Information & Telecommunication Engineering, Ltd., News Release, “Commencement of Trial of Smart Office Combining Energy Efficiency and Comfort at Nakai Development Center of Hitachi Information & Telecommunication Engineering,” http://www.hitachi-ite.co.jp/news/2012/20120529.html in Japanese.
(3) Hitachi Plant Services Co., Ltd., Air Conditioning Energy Optimization Control System, http://www.hitachi-hps.co.jp/en/product_site/air_conditioning/products/savingenergy/ohsaver.html
(4) Hitachi, Ltd., “Role of Communications in Building Smart Cities, Case Study 3: Providing Comfort Everywhere,” http://www.hitachi.co.jp/products/smartcity/special/connecting/casestudies/case03.html in Japanese.
(5) Hitachi Systems, Ltd., M2M network service, http://www.hitachi-systems.com/solution/s0303/m2m/ in Japanese.

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