Optimization of IT Load and Facility Energy in Data Centers

● Kunio Fukumoto ● Nobuyuki Tamura ● Hideki Ishibashi

While the convenience of data centers is attracting attention and demand for them is increasing, the amount of energy they consume has been increasing. This is because they use an increased amount of electricity and require greater air-conditioning to cool server rooms due to the increased load of the IT devices installed there. To reduce such energy consumption, there are needs for energy-saving measures and the ratio of facility energy to IT load of server rooms needs to be optimized. Aiming to implement these measures, Fujitsu has developed an energy-saving operation management system and introduced it in the new annex of the Tatebayashi System Center, located in Gunma Prefecture in Japan. The purpose is to conduct detailed monitoring (visualization) on electric power, temperature and wind velocity in relation to IT load, and thereby computerize efficient methods of operation to optimize facility energy. This paper presents the characteristic functions of and future outlook for this energy-saving operation management system.

1. Introduction

Along with the diffusion of ASPs, SaaS and Cloud computing, there has been a growing demand for data centers.

The amount of energy consumed at data centers is increasing as this demand grows, which has made it necessary to take energy-saving measures at data centers.

As one such measure, the facility energy (such as electric power for air conditioning) with reference to the IT load[note)] (including servers) in the server area needs to be optimized. To do this requires detailed monitoring (visualization) on the temperature, wind velocity and electric power conditions for each rack and computerization of efficient methods of operation to optimize facility energy.

note) The IT load means the amount of energy consumed by servers and network equipment in server rooms.

The energy-saving operation management system that has been constructed in the new annex of the Tatebayashi System Center, located in Gunma Prefecture in Japan, (hereafter "Tatebayashi new annex") supports energy-saving operations of the entire data center by meeting these requirements. It can visualize the usage of energy in the server area (temperature, wind velocity and electric power for each rack) and power-saving effect and has a function allowing facility operations to be continually improved.

This paper describes the characteristic functions of such energy-saving operation management systems and their future development.

2. System overview

At data centers, almost half of the total electric power is consumed by air-conditioning facilities, which are indispensable for safe operation of customer servers. With the existing data centers, however, more air than the servers require is supplied to maintain the temperature at certain levels and air-conditioning facilities consume unnecessarily large amounts of power. To reduce this waste, the energy-saving operation management system at the Tatebayashi new annex realized a system to allow optimized air conditioning operation by managing in real time the power usage for each customer rack and the temperature and airflow around the racks.

This energy-saving operation management system is also equipped with a number of features that support energy-saving operations. They include the provision of advice when a customer introduces a server on which a distribution board and breaker should be selected so that power can be supplied to the server and data center devices (such as UPSs) in an effective way.

To achieve these functions, the energy-saving operation management system is composed of subsystems for managing electric power and temperature (with the individual servers realized by SOA communications), a sensor network that collects information about the temperature, and wind velocity sensors and measuring units (provided by Fuji Electric Systems) for extracting information such as electric power values from the distribution board information.

3. System features

In the existing data centers, IT load and energy condition data are collected for each building and server room and the collected data are analyzed by data center operators for controlling the facility equipment. For this reason, it has been impossible to gain a detailed understanding of the state of each rack, and this has made it hard to control facility equipment in an optimized way.

To address this problem and reduce the power consumption of data centers, we strove to optimize the IT and energy loads of the server area as shown in **Figure 1**. We did this by collecting (monitoring) the electric power and environmental conditions of servers for analysis and evaluation, and used the results to improve the efficiency of the power and air-conditioning facilities.

The energy-saving operation management system can collect detailed information via a sensor network and data center operators' know-how, and thereby optimize facility operations.

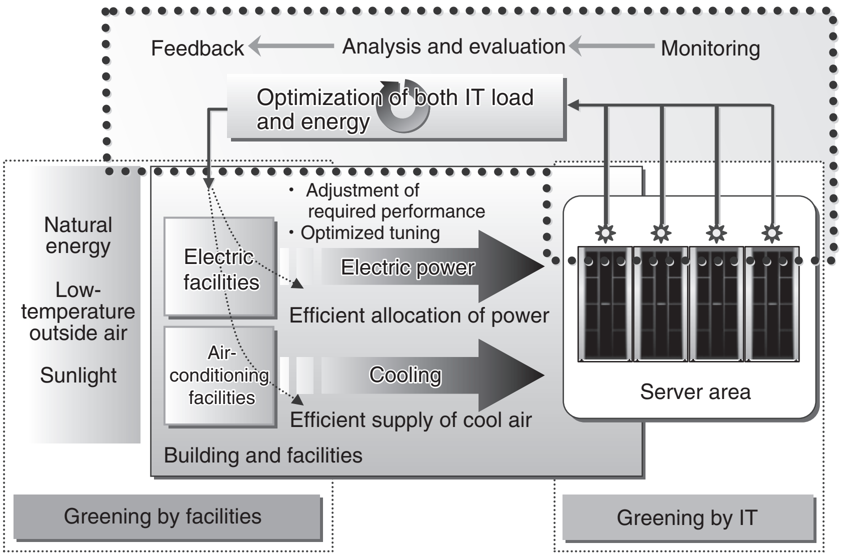

Figure 1
Flow of IT load and energy optimization.

Specifically, the IT load and facility energy of data centers are managed with two prominent subsystems.

3.1 Electric power subsystem (electric power facility optimization)

The electric power subsystem optimizes power distribution for IT load in the server area and has improved the power efficiency of IT devices. Specifically, a measuring unit is provided for each breaker of the distribution board that supplies electric power to IT devices. In this way, detailed electric energy for each IT device (rack by rack) is sensed and this allows the following functions to be provided:

1) Electric power capacity monitoring

The capacity of a UPS and distribution board is managed by gaining a detailed understanding of the rated and actual electric energy of each IT device. This allows the visualization of IT load in real time, which helps to prevent the breaker from being tripped when there is an increase in the amount of IT electric energy and also allows facility equipment to be optimized, added or removed.

2) Optimum distribution advising function

When operating the server area, an understanding of the surplus electric energy for efficient operation of facility equipment including UPSs and distribution boards is necessary in view of preventing electric power incidents and effectively utilizing equipment.

The electric power subsystem allows UPSs and distribution board devices to be more efficient and prevents incidents by automatically selecting the most appropriate distribution board based on the electric energy requirement of IT devices and by equilibrating the load allocation of each phase of three-phase power.

3) Optimum layout advising function

IT devices generate heat according to their power consumption and there is a close connection between the power consumption of IT devices and the temperature in the server area. For that reason, it is important to systematically arrange IT devices in accordance with the capacity of the air-conditioning facilities to appropriately control the temperature in the server area.

The electric power subsystem manages the rated electric energy of IT devices and analyzes surplus electric energy required when more IT devices are to be added. In this way, it helps the server area operators arrange IT devices.

3.2 Temperature subsystem (air conditioning optimization)

The temperature subsystem reduces the electric energy for data center operation by running air conditioners in accordance with the IT load to reduce the facility electric energy (facility energy). Specifically, temperature and wind velocity sensors are mounted on racks that house IT devices as shown in **Figure 2** to collect information by means of the environment monitoring sensor network. This allows temperature conditions to be sensed in detail and provides the following functions.

1) Rack temperature monitoring

In a server area, increasing the number of servers installed on a rack, an obstacle in the cool air supply path, or other factors may generate a partial temperature rise in and around the rack. To detect these local hot spots, multiple temperature sensors are installed

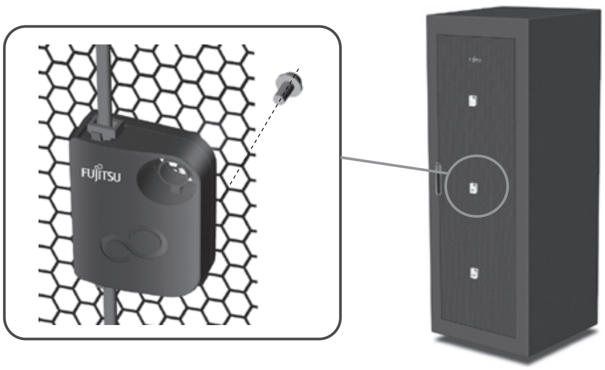

Figure 2
Installation of temperature and wind velocity sensor on rack.

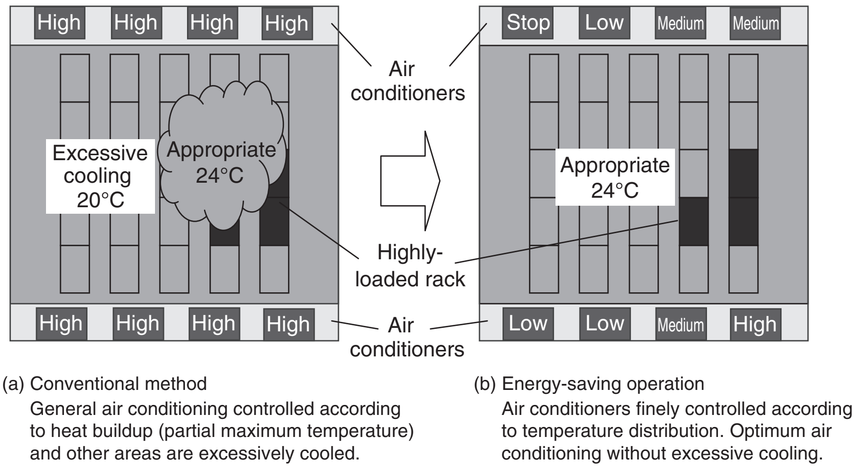

Figure 3
Efficient supply of cool air to rack.

on the rack to monitor the temperature of the cool air supplied to the rack. In addition, a temperature monitoring threshold is provided so that server area operators can visualize changes in temperature in real time. Thus, incidents that could be caused by a rise in temperature of IT devices can be prevented.

2) Optimum air conditioning advice

To maintain an appropriate temperature in the server area, there is a need for cool air to sufficiently discharge the heat generated by the individual IT devices. In conventional data centers, excessive amounts of cool air are supplied by increasing the output of the air conditioner as shown in **Figure 3 (a)**. However, this is an ineffective way to operate air conditioners and is a major factor in increasing the facility energy needed to maintain IT devices.

Accordingly, the temperature subsystem has wind velocity sensors installed on racks and floor grills to measure the amounts of cool air. In this way, it analyzes the amounts of cool air required by IT devices and supplied by air conditioners. In addition, temperature and wind-velocity sensors are installed under the ceiling to analyze the flow of cool air between the hot and cold aisles. This allows any excessive or insufficient operation of air conditioners and the flow of cool air to be indicated to the server area operators. This helps them optimally control the air conditioners without using excessive cooling as shown in **Figure 3 (b)**.

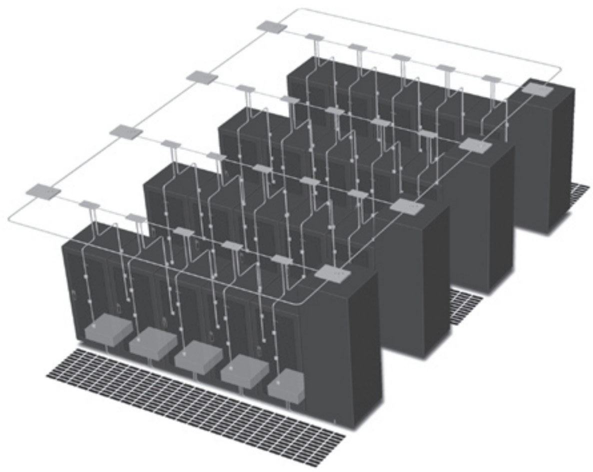

Figure 4
Sensor network created with ad-hoc network.

When the temperature and wind velocity sensors are installed in the temperature subsystem, they are interconnected by a wired sensor network so that they can efficiently gather information, and they use an ad-hoc network as shown in **Figure 4**. The application of ad-hoc technology enables the respective sensor devices to autonomously construct a network and the sensor installer can install the sensors without needing to know about the network configuration. In addition, using wired connections between sensors allows electric power to be supplied to those sensors via the network.

4. Two operation screens

The energy-saving operation management system provides two operation screens: a management screen for the construction of racks and distribution boards and detailed monitoring of power and temperature conditions in order to visualize the optimum operating conditions at the data center, and an integrated screen to give an at-a-glance view of the electric power conditions of IT devices and energy conditions of facility equipment in the server area.

4.1 Management screen

The management screen allows centralized management of the construction of IT devices and monitoring of IT device conditions and causes of incidents, which is work that data center operators perform every day via a Web screen.

1) Construction function

A function allowing operators to visualize the arrangement using a floor plan is provided when installing racks, distribution boards and temperature and wind velocity sensors, and when allocating power to racks in the server area.

2) Data display function

A function is provided for displaying the electric power and environmental information collected from the electric power and temperature subsystems for each layer and rack of the individual buildings to make graphs of the collected data and output them to files by the month, day and hour.

3) Alarm and event display function

Electric power and temperature capacity errors detected by the electric power and temperature subsystems and the work log for rack and distribution board construction are collected and maintained to centrally manage alarms and events.

4.2 Integrated screen

The integrated screen allows the data collected from the electric power and temperature subsystems to be analyzed and evaluated. It thus provides an overview of the data center operation status on a graph and floor plans, and this makes it easier to visualize the management know-how that has been built up by the data center operators.

1) Data center energy condition display

Data center energy indicators include PUE, which shows the ratio of the IT device energy to facility equipment energy for maintaining the IT devices; and COP, which indicates the energy efficiency of air conditioners, providing important indicators of improved efficiency. The energy conditions of the data center are displayed by showing these indicators on meters. In addition, electric power supply from the special high voltage part, which is the source of electric power of the data center, to air conditioning equipment is shown as a tree. This allows operators to visualize the data center energy conditions and disclose information to customers.

2) Rack condition overview display

The electric power and temperature conditions of racks in the server area are indicated by using different colors and figures on floor plans. Thus, the system offers an overview of the operation status of IT devices in the server area, which provides data center operators with detailed information for each rack.

3) Optimum air conditioning state display

By means of the wind velocity sensors installed on the racks and floor grills in the server area, the amounts of cool air required by each row of racks and supplied by air conditioners are shown on meters. This allows operators to visualize the optimum state of air conditioner operation.

Figure 5 is an example of the integrated screen. In this way, the operation status of the

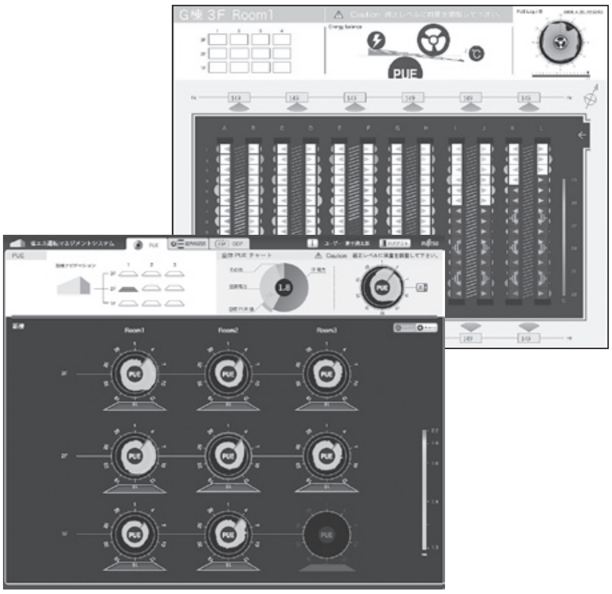

Figure 5
Integrated screen (PUE display and server area overhead view).

data center can be visualized.

5. Effect of system construction

The energy-saving operation management system at the Tatebayashi new annex has made it possible to manage and analyze the operating conditions of the data center. In the past, this was only possible on a rack-by-rack basis. This system has allowed centralized visualization by using the management and integrated screens and systematized know-how for data center operations management, which has been required for monitoring the operating conditions of the data center.

In addition, operational incidents resulting from increased rack temperature and lack of surplus energy can be promptly detected, which makes it easier to safely operate the data center.

At the Tatebayashi new annex, use of these energy-saving and optimization measures for facility equipment and a group of high-efficiency facilities has allowed the electric power used by facility equipment to be reduced by approximately 40 percent as compared with the existing centers.

6. Future challenges

We intend to utilize the energy-saving operation management system to address the following challenges in the future for even more efficient data center operations.

1) Automatic control of air conditioners

This system can automatically control air conditioners in the optimum way based on environmental data collected by temperature and wind velocity sensors, and also optimize the operating conditions of air conditioners for maintaining IT devices. This allows the electric power used by facility equipment to be further reduced.

2) Integrated management including status of servers in racks

Centralizing the management of the status of IT devices in racks and the electric power and temperature management of the energy-saving operation management system makes it easier to manage the data center in an integrated way, including the monitoring of customer servers.

7. Conclusion

The use of this energy-saving operation management system at data centers is a new experience for Fujitsu. We think that there is a need for continued operational verification and review to develop it into a system that offers a high energy-saving effect. We aim to offer automatic control in the future.

Furthermore, we intend to study the potential of this system, including expanding sales to other data centers and developing it into energy management systems for offices and factories that utilize the technologies of this system. In this way, it will help expand the environmental and energy-saving solution business as a state-of-the-art energy-saving operation management system.

Kunio Fukumoto
Fujitsu Ltd.
Mr. Fukumoto is engaged in designing facility management systems.

Hideki Ishibashi
Fujitsu Ltd.
Mr. Ishibashi is engaged in developing and designing custom-made systems for enterprises and other groups.

Nobuyuki Tamura
Fujitsu Ltd.
Mr. Tamura is engaged in developing software for security and network systems.