

Network Platform for Next-Generation Data Centers

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A data center must be able to deploy information technology (IT) systems rapidly in the ever-changing business environment surrounding its customers. It must also be able to visualize the state of energy use by data-center facilities in response to Green IT initiatives and the need to reduce energy costs. To satisfy these requirements, Fujitsu has constructed two network platforms applicable to next-generation data centers at the new annex of its Tatebayashi System Center located in Gunma Prefecture in Japan. One is an optical network platform for customers using wide-area Ethernet technology, and the other is an environmental monitoring sensor network for data center management using ad hoc technology. This paper describes the objectives and actual effects of constructing and implementing them and touches upon future developments.

1. Introduction

A data center includes two types of networks: one used by customers and the other by management for monitoring and managing facilities such as air conditioning and electrical equipment. When an order is received from a customer for system expansion (more racks), a data center should be able to provide a network and facility environment to accommodate that expansion in a speedy manner. At the same time, the deployment of high-density information technology (IT) equipment such as blade servers has been accelerating in recent years, increasing the amount of generated heat. Cooling IT equipment efficiently under such conditions requires an environmental monitoring system that can measure not only the overall temperature of the server room but also the temperature and airflow velocity in the immediate vicinity of racks. Thus, a platform that can easily and quickly provide a network and facility environment in response to an increase in the number of racks is important for expediting the

necessary environment when the new request for measuring the temperature and airflow velocity in the immediate vicinity of racks.

Against the above background, an optical network platform using wide-area Ethernet technology and an environmental monitoring sensor network using ad hoc communications technology were constructed at the new annex of Fujitsu's Tatebayashi System Center located in Gunma Prefecture in Japan in fiscal year 2009 with the aim of speeding up the provision of network environments to customers. In this paper, we introduce the technology behind the optical network platform and the environmental monitoring sensor network, discuss its effectiveness and associated issues on the basis of knowledge gained from actual deployment in Fujitsu, and touch upon future developments.

2. Optical network platform

In Fujitsu's data centers, the past approach to making network connections for customer systems among server rooms and between each

server room and the monitoring room was to lay optical fiber separately for each customer system. Specifically, an optical connector box was installed in each server/monitoring room and a large quantity of optical fiber was laid beforehand between optical connector boxes, as shown in **Figure 1**. In addition, an optical media converter was installed on the customer's side and optical fiber was laid between it and the nearest optical connector box. The original building at the Tatebayashi System Center used several thousand optical fibers in this way. Extending the network by laying optical fiber separately for each customer in the above manner (separate wiring method) had the effect of physically separating the various customer networks, which dispelled any worries about crosstalk between those networks and eliminated the security risk. However, the separate wiring method suffers from several problems, as described below.

2.1 Problems with conventional separate wiring method

1) Provision time

As shown in Figure 1, optical fiber is laid between optical connector boxes beforehand, but each time a customer system is expanded, optical fiber must be drawn from the customer's racks to the nearest optical connector box. Optical fiber connector termination is usually done at

the manufacturing plant and it takes about two weeks to prepare optical fiber for laying. This hinders the speedy provision of network environments to customers.

2) Cost

Unlike unshielded twisted pair (UTP) cable, optical fiber requires advanced technologies to achieve interface connections (electro-optical signal conversion) and connections between optical fibers, which can easily drive up costs.¹⁾ In high-speed transmission over long distances, though, the cost of the optical fiber itself rises in proportion to transmission distance, so the cost of the interface section has little impact on the overall cost of laying optical fiber. On the other hand, when a large amount of optical fiber is laid in a confined space like a data center over short distances, the interface section cost impact is high, which drives up the total cost.

3) Usage efficiency

As described above, optical fiber is provided for each customer in the separate wiring method. Thus, every time a customer system is expanded, high-cost optical fiber is occupied by that customer, which makes for poor usage efficiency in terms of optical fiber facilities.

4) Monitoring

In the separate wiring method, customer-by-customer monitoring can detect faults in the optical media converter but not faults on the

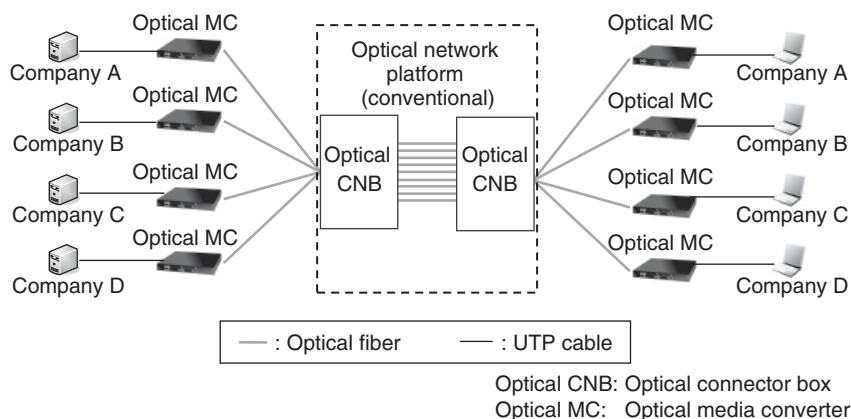


Figure 1
Conventional optical network platform.

optical-network-platform side in the data center.

2.2 Requirements of next-generation optical network platform

To solve the above problems, the network platform in a next-generation data center should meet the following requirements.

- 1) The number of optical fibers must be reduced as much as possible by consolidating multiple users on the same optical fiber.
- 2) High reliability with no mixing of communications among customers must be provided even with network consolidation.
- 3) The network platform must be capable of autonomous monitoring.
- 4) It must be possible to set, as needed, the communication band provided to customers.
- 5) It must be possible to provide a customer with a network environment quickly.

With these in mind, Fujitsu turned to wide-area Ethernet technology for the construction of the new annex. The provision of wide-area Ethernet services by communication carriers has been expanding in recent years. In these services, multiple users are consolidated on one physical line in layer 2 and the security problems associated with circuit consolidation that have traditionally been of concern are solved through technical means. Furthermore, since a single

physical network is shared by multiple users in these services, the number of optical fibers is decreased.

The Tatebayashi System Center has deployed Fujitsu’s high-quality FLASHWAVE5000 series transmission equipment to implement wide-area Ethernet technology. This equipment, which has received high marks from communication carriers, is designed for reliability throughout the network. It is also capable of bandwidth control and autonomous monitoring. Moreover, it can be connected to customer equipment by UTP cable, which means that cable preparation time can be greatly shortened, which speeds up network provision to customers.

2.3 Effects of next-generation optical network platform introduction

Tatebayashi System Center has deployed FLASHWAVE5740 and FLASHWAVE5531 layer-2 switches designed for wide-area Ethernet services as an optical network platform. This equipment has a fault rate a few tenths of that of ordinary layer-2 switches, so it provides highly reliability operation (comparison conducted by Fujitsu). On the basis of the network configuration diagram of Tatebayashi System Center shown in **Figure 2**, the effects obtained by introducing this optical network platform into

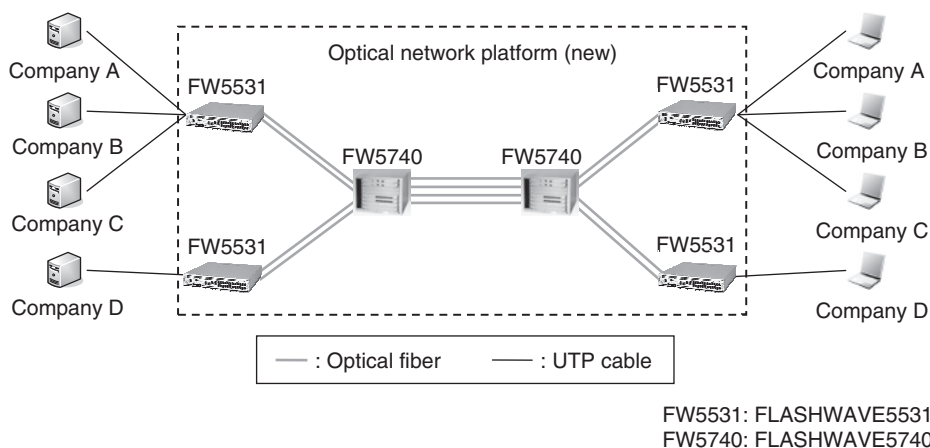


Figure 2
Next-generation optical network platform.

the data center are described below.

1) Rapid network environment provision

Unlike in the conventional system, there is no need to prepare optical fiber or an optical media converter every time a customer system is introduced. As shown in Figure 2, the customer only needs to prepare UTP cable to connect to the optical network platform. As a result, the data-center operations department only needs to make virtual local area network settings to quickly provide the customer with a network environment spanning several server rooms. Work that previously took two weeks to perform can now be completed in one day.

2) Significant decrease in optical fiber amount

As the new annex was built next to the original building, it was essential to provide network connections between the two buildings. If we assume 200 customer systems, then making these connections by the conventional separate wiring method described above would have required the laying of 200 optical-fiber cables (400 cores) between the buildings. In contrast, the new optical network platform provides these connections using only four optical-fiber cables (eight cores) including redundant optical fiber (as depicted in Figure 2 between the FW5740 equipment), which reduces the quantity of optical fiber to one-fiftieth.

3) Advanced circuit management functions

The new optical network platform has advanced circuit management functions including communications-band management and priority control that provide customer systems with a minimum bandwidth guarantee. Customers can therefore receive appropriate bandwidth for their needs, which, in combination with circuit consolidation, raises the utilization efficiency of optical fiber facilities.

4) Autonomous monitoring of network platform

The new optical network platform is also equipped with an autonomous network-monitoring function that facilitates data-center monitoring. It can perform tasks like network-

wide anomaly detection and performance monitoring, which were difficult for the conventional network to handle, enabling the construction of a highly reliable network.

2.4 Introduction of mini-model

As described above, Fujitsu has introduced, for the first time, an optical network platform using wide-area Ethernet technology at one of its data centers. To provide each customer with a network environment in a quick and secure manner, we consider it important to accumulate operation know-how about optical fiber platforms. Accordingly, to improve and test operation technologies, we have prepared and implemented a mini-model equivalent to an actual equipment setup.

3. Environmental monitoring sensor network

The need for environmental monitoring that can measure the temperature and airflow velocity near server racks has been growing in recent years as a countermeasure to the high-density arrangement of servers and the accompanying problem of heat generation.

3.1 Problem treatment

In a data center where the number of customer racks is always increasing or decreasing, simply adding an environmental monitoring sensor network is costly from the operations viewpoint and also delays the start of network operations. The need has therefore been felt for an environmental monitoring sensor network that can hold down data-center costs and can be introduced quickly. In response to this need, it was decided to construct an environmental monitoring sensor network applying Fujitsu's "smart network technology" so that sensors could be added.

3.2 Application of smart network technology in data center

1) Simplified settings

Fujitsu's smart network technology is actually autonomous distributed network technology that automatically creates a network without having to make settings. It repairs itself in response to network faults and adapt to changes in the surrounding network environment.²⁾ With this technology, the addition of customer racks at the data center can be accommodated by simply plugging in as many environmental monitoring sensors as needed for the number of additional racks. A registration system using a barcode reader was chosen to keep track of sensor locations. In this system, a barcode sticker is attached to each environmental monitoring sensor and the encoded information

is read and uploaded to the system, enabling operations personnel to determine exactly where the sensor is installed.

2) Multipurpose use

As shown in **Figure 3**, Fujitsu's environmental monitoring sensor network consists of trunk nodes, relay nodes, and integrated temperature/airflow velocity sensors. At the Tatebayashi System Center, these environmental sensors are used alongside other types of sensors such as those for detecting lock/unlock signals for electrical rack locks and signals of power-supply equipment installed inside racks. These signals are also transmitted over the environmental monitoring sensor network. In other words, the environmental monitoring sensor network can be viewed as an integrated network platform for managing

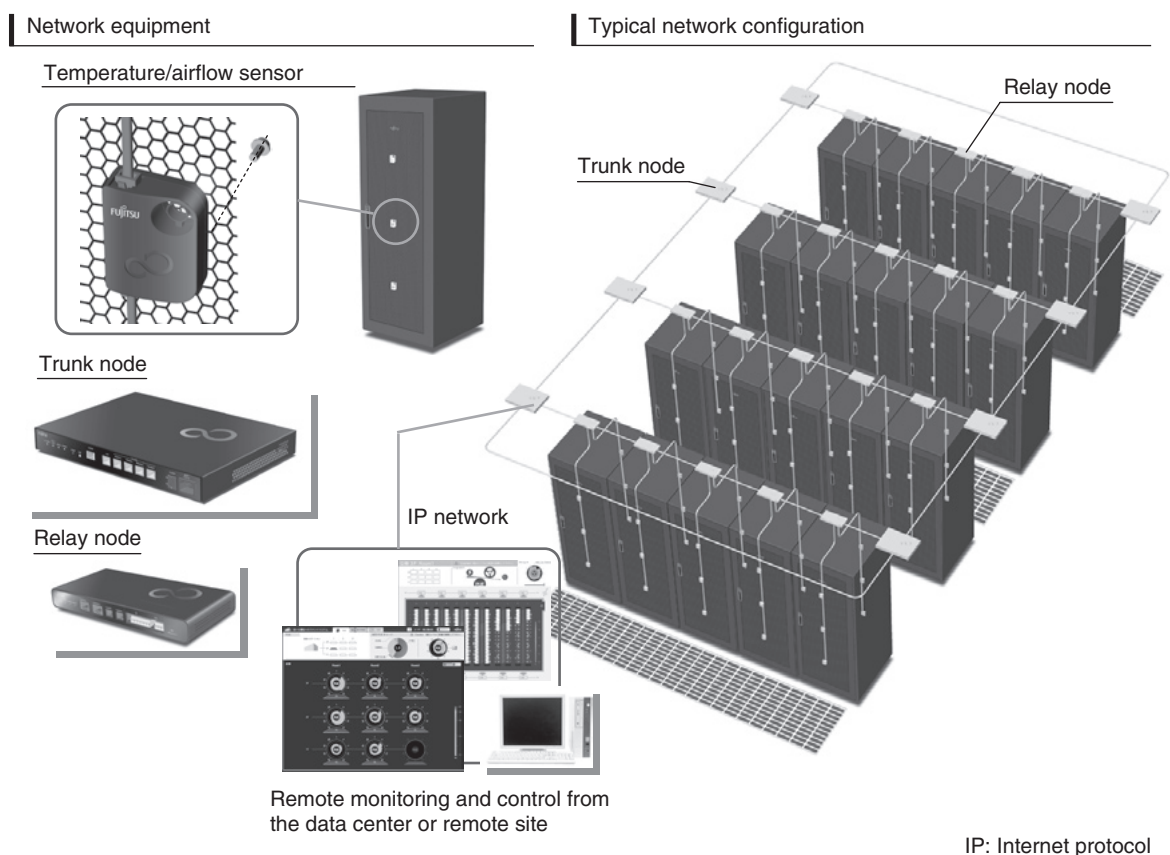


Figure 3
Environmental monitoring sensor network.

facilities in the vicinity of racks. This eliminates the need to separately install facility wiring for each and every purpose such as electrical-rack-lock sensing, so the implementation costs are consequently lower.

3) Redundancy

Smart network technology makes use of ad hoc techniques. In a network using such techniques, nodes can find optimal communication paths by monitoring adjacent nodes and collecting information from them about path quality. Then, in the event of a network or equipment fault, each node can autonomously select a detour path, thereby restoring and maintaining communications. In a similar manner, the environmental monitoring sensor network continues to function even when equipment is removed or installed. In a data center where equipment installation and removal is a common occurrence owing to an increase or decrease in the number of racks, this is an optimal system from the viewpoint of workability and maintainability.

4) Installation method

Equipment has been made as compact and light as possible. A trunk node has the form factor of a 1U switch, a relay node is no larger than a B4 notebook, and a temperature/airflow velocity sensor is about the size of a matchbox. In short, each piece of equipment has been reduced in size by eliminating all unnecessary elements. Such compact equipment leads to greater flexibility in installation location: equipment can be installed below the ceiling, under the floor, on racks, etc. Moreover, there is no need for special types of cables in network construction—ordinary cables and connectors such as those for local area network and telephone systems that can be easily prepared by installation personnel have been used for constructing the environmental monitoring sensor network.

3.3 Effects of environmental monitoring sensor network introduction

At the new annex, the use of this environmental monitoring sensor network enabled the installation of about 2000 temperature/airflow velocity sensors as the initial sensor group in a relatively short time. Furthermore, as the network is also being used as an integrated network platform for collecting and managing information about facilities in the vicinity of racks as described above, there is no need to construct independent networks for communicating contact signals from electrical rack locking devices and power-supply equipment. The end result is lower construction, installation, and material costs.

4. Operations system

The network platform deployed at the new annex is extremely important from the viewpoint of configuring customer systems. In a data center that aims to provide stable operation 24 hours a day and 365 days a year, this network platform is required to respond rapidly whenever a fault occurs. To this end, continuous monitoring is, of course, important, but a system that can respond quickly to an emergency is also essential. For this reason, Fujitsu has established a new operations system that merges the IT management center, which has extensive experience in monitoring and managing many customer systems, with the operation group of the data-center network platform.

In the future, we intend to operate a continuously evolving platform featuring the latest technologies while maintaining stable operation in the newly introduced network platform described here.

5. Future developments

The optical network platform using wide-area Ethernet technology that we presented in this paper is currently being used as a monitoring application targeting customer systems. In the

future, we plan to expand its application scope step by step while accumulating operation experience. For example, we can envision task-oriented network connections within the same customer system, network connections between different customer systems, and connections to Fujitsu-affiliated carrier networks.

Moreover, the environmental monitoring sensor network described here is expected to reduce implementation costs even further given its capability for adding and setting environmental sensors simply through the work of installation personnel without the aid of systems engineering. As a system that connects many and various types of sensors, this environmental monitoring sensor network constitutes a technology that could be applied to fields outside the world of data centers.

6. Conclusion

This paper used actual implementations to introduce an optical network platform using wide-area Ethernet technology and an environmental monitoring sensor network using

ad hoc communications technology as networks applicable to data centers.

The increase in IT equipment occupied by customers in recent years and the associated problems of securing installation space and operating and managing the equipment, not to mention its environmental impact, have driven up the demand for centralized data centers. While data centers must, of course, provide stable operation, speedy network provision and environmental considerations have also become increasingly important as well. Looking forward, Fujitsu is committed to introducing network systems applicable to data centers to promote the rapid implementation of customer systems and to respond flexibly to network changes.

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