Cloud Computing for Software Development Environment

—In-house Deployment at Numazu Software Development Cloud Center—

● Yuji Arimura ● Masako Ito

In its development of middleware, Fujitsu has faced three problems: increasing server operation costs, server over/under-utilization, and increasing labor hours for development environment construction. To solve these problems, Fujitsu has been working since 2008 on moving its software development environment to a cloud platform at its Numazu Software Development Cloud Center. In addition to solving the above problems, this transition to a cloud environment is expected to reduce costs by 700 million yen annually from 2011. Converting to cloud computing within Fujitsu itself is also seen as a way to refine the cloud products and services that Fujitsu offers to its customers. This paper describes the background to converting to cloud-based software development, Fujitsu's approach to this conversion, the effects of cloud deployment, and the expansion of services as a result of using a cloud platform. It also introduces the Numazu Cloud Center tour, which conveys cloud computing know-how through face-to-face conversations with customers.

1. Introduction

The expansion of cloud computing began with public clouds such as those offered by Google and Amazon, which provide services over the Internet to the general public. Today, however, the industry is seeing rapid growth in private clouds created by companies to consolidate their information and communications technology resources in-house and use them more effectively.

Fujitsu provides its Global Cloud Platform to general users in the form of a public cloud. It also operates a private cloud at its Numazu Software Development Cloud Center (hereinafter Numazu Cloud Center) to provide software development environments to internal Fujitsu middleware developers.

This paper describes the background to converting to cloud computing at the Numazu Cloud Center, Fujitsu's approach to this conversion, and the effects of cloud computing on software development.

2. Introduction to Numazu Cloud Center

The predecessor to the Numazu Cloud Center was an in-house development center established in 1976 on the premises of the Fujitsu Numazu Complex for the benefit of Fujitsu's software developers. This development center currently provides development environments and related services to about 4500 software developers operating out of ten hubs in Japan and other countries.

Today, the Numazu Cloud Center targets only middleware developers. Since middleware products are positioned between the operating system (OS) and application software, their operation must be evaluated on a variety of platforms having different OS's, hardware configurations, etc. To support these evaluations, the Numazu Cloud Center operates a wide range of system configurations, from mainframes to open systems, and about 850 models of servers

manufactured by Fujitsu and other companies.

The Numazu Cloud Center also operates older equipment dating back to the mid-1980s to support long-term maintenance of middleware products and to provide a test environment for the products customers are still using.

3. Background to cloud conversion

Fujitsu's conversion of its middleware development environment to a cloud platform was prompted by three problems: increasing server operation costs, server over/under-utilization, and increasing labor hours for constructing development environments. These three problems are described below.

1) Increasing server operation costs

With the coming of the open-system era, a priority came to be placed on flexible configuration and ease of operation, and servers used for the development of middleware products came to be distributed among six hubs in Japan to meet this need. These servers were purchased by individual development departments, and developers in each department carried out a variety of management tasks such as patch creation and application, backup operation, fault and power-outage handling, inventory, and troubleshooting of middleware-related problems. These tasks required an average of 1.5 person-days per month per server, and, as the number of servers increased, the labor hours required of developers became overwhelming.

2) Server over/under-utilization

The procurement of servers for product development was based on peak demand during the testing phase of the product development process. This resulted in times of server over/under-utilization depending on the development schedule for each product.

3) Increasing labor hours for constructing development environment

Middleware products must be able to run on a platform that combines various types of hardware and OS's, but, with the recent appearance of 64-bit CPUs and virtualization software, the number of platforms for testing product operation has increased dramatically to about eight times that of FY2005 as of the time of this writing (**Figure 1**).

There is, however, a limit on the absolute number of servers that can be used for development purposes, and, because of this limit, the practice was to use one server while switching the platform environment (OS and middleware) to accommodate current testing requirements. As a result, the work of testing multiple platforms also involved the work of constructing environments, thereby adding to development labor hours.

The change in the labor hours needed to build a product, construct a test environment, and test the product is shown in **Figure 2** for the

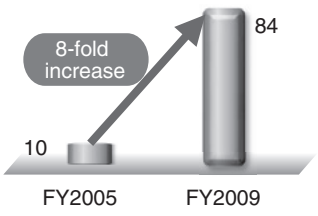

Figure 1
Increase in number of test platforms.

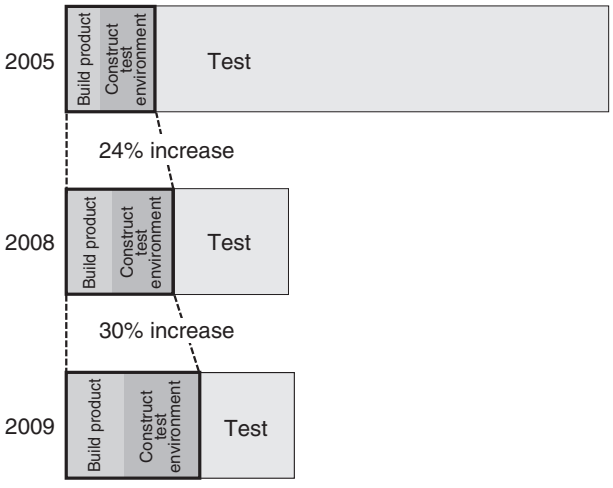

Figure 2
Increase in labor hours for build/test.

2005–2009 period. Here, "building a product" consists of a series of steps from constructing a product-building environment and compiling program source files to creating a CD image of the product. While the labor hours needed for testing decreased during this period due to advances in automated testing, those needed for product building and constructing a test environment increased by 24% from 2005 to 2008 and again by 30% from 2008 to 2009. In short, the number of labor hours required for constructing a development environment, that is, an environment for building a product and one for testing it, is trending upward.

4. Road to cloud conversion

For the three-year period beginning in FY2008, the Numazu Cloud Center undertook a conversion to a cloud-based software development environment in three steps (**Figure 3**): consolidation and virtualization, standardization, and systemization. The following describes each of these steps in more detail.

4.1 Step 1: Consolidation and virtualization

Fujitsu established a plan to consolidate the servers and their operations-management tasks located at its various hubs at the Numazu Cloud Center beginning in FY2008, and, at the same time, to construct a virtual environment for migrating actual servers to virtual servers. This plan targeted 1800 servers for consolidation, but some were older servers that could be discarded once migration to the cloud environment to be prepared at the Numazu Cloud Center got underway. The total number of servers consequently dropped to 1000 by the end of FY2010.

Middleware developers can rent both actual machines and virtual machines in a cloud environment. This is because low-layer software-product tests involving, for example, drivers and cluster control cannot be run in a virtual environment. Incidentally, the current ratio of virtual machines to actual machines for server rental is 5:13. The scale of the virtual environment is expanding, however, increasing from 900 virtual machines in FY2008 to 2300 in FY2010.

Server consolidation at the Numazu Cloud Center means that developers have to use those servers remotely from their respective hubs, which generates new problems such as how to perform physical server operations and how to maintain adequate network response. These problems are being handled in the following way.

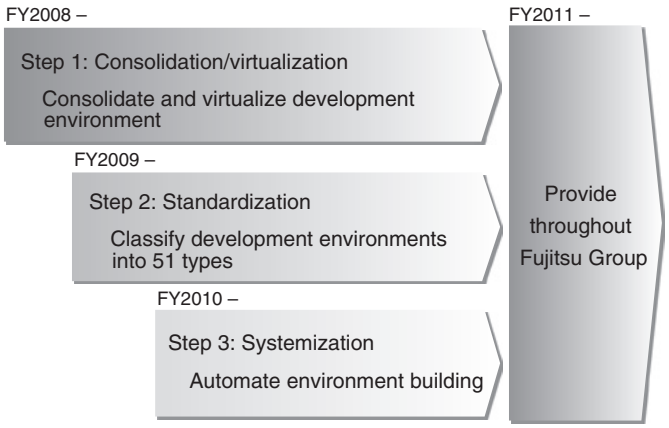

Figure 3
Steps in conversion to cloud-based software development environment at Numazu Cloud Center.

1) Introduction of remote operation equipment

As mentioned above, some of the consolidated servers at the Numazu Cloud Center are diverted for use as actual machines for rental purposes, but some of these do not support remote power ON and power OFF or remote BIOS setup. For these servers, Fujitsu has introduced power-supply management equipment[1] and remote server console switches (keyboard, video, mouse-type switches)[2] that are capable of turning power ON and OFF and configuring the BIOS over the network.

2) Network enhancements

The Numazu Cloud Center has deployed a dedicated network (wide-area Ethernet) that is independent from the in-house wide-area network (WAN) to shorten response time when accessing servers at the Numazu Cloud Center (**Figure 4**).

3) Remote installation services

The Numazu Cloud Center provides services that enable an OS to be remotely installed simply by selecting that OS without having to prepare a CD image of the OS for installation. These services include those for backing up and restoring systems (**Figure 5**).

The above measures have essentially eliminated the few disadvantages of consolidating servers at the Numazu Cloud Center.

4.2 Step 2: Standardization

Although "Step 1: Consolidation and virtualization" reduced the server management burden on developers, it increased the burden on operators at the Numazu Cloud Center. Fujitsu undertook to mitigate the operations management burden by unifying and simplifying operation procedures.

Analysis of the virtual development environments in FY2008 revealed 348 patterns, each representing a different combination of CPU number, memory size, disk capacity, and OS type

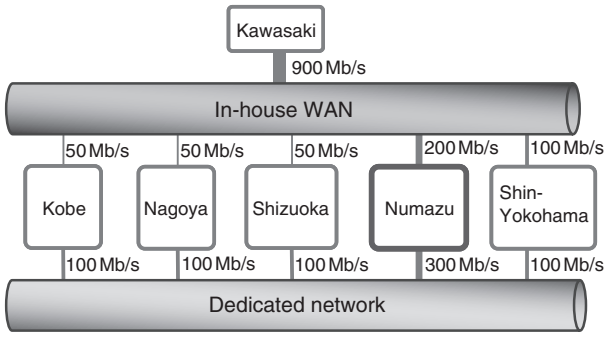

Figure 4
Dedicated network and in-house WAN.

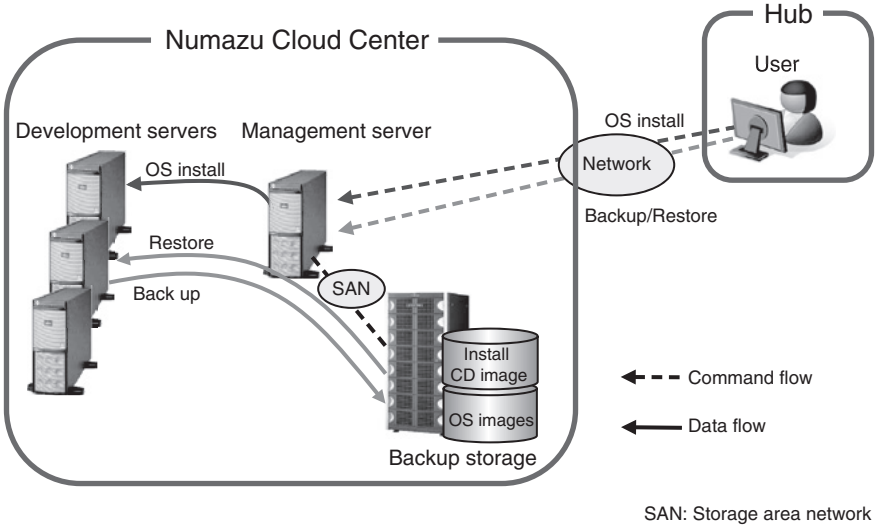

Figure 5
Remote installation services.

and generation. Since there were only slight differences in memory size and disk capacity, 51 development environments were defined for the more frequently used combinations of OS's and hardware specifications (e.g., 2 CPUs, 4 GB of memory, 30-GB hard disk). These 51 patterns consisted of 36 Windows patterns, 14 Linux patterns, and 1 Solaris pattern, which were converted into 51 virtual-server images in template form. This reduced the load of certain tasks like patching the OS's, thereby standardizing maintenance procedures and reducing the time required for carrying out the work of operations management.

These 51 virtual-server images support 70% of all past cases. When a virtual environment not among these 51 types is needed, it is manually created either by the Numazu Cloud Center staff or a developer.

A developer who can use one of these standardized templates can begin using that development environment almost immediately knowing that recent patches have already been applied to the OS.

4.3 Step 3: Systemization

Some parts of Fujitsu's internal software development business are being increasingly taken up by offshore software development partners, and the number of requests from such partners for overnight provision of development environments has grown. Demand for servers such as for troubleshooting has grown within Japan as well. The manual deployment of such servers, however, cannot meet this demand, so a system that can automatically deploy servers on an on-demand basis is needed. It is also necessary to monitor the utilization of resources and availability conditions in a cloud environment so that insufficiencies can be forecast and resources can be added in a timely manner. Resources must also be used efficiently, and, to prevent users from monopolizing resources, those that are not being used must be aggressively released to maximize the benefits of resource sharing. At the Numazu Cloud Center, a system for monitoring resource usage in real time and for charging according to usage (metered charging) is essential.

To meet these needs, the Numazu Cloud Center has introduced new Fujitsu products as well as products from other companies as listed below.

1) Service catalog
   Systemwalker Service Catalog Manager V14g
2) Automated deployment
   Systemwalker Software Configuration Manager V14g
3) Automated operations
   Systemwalker Runbook Automation V14
4) Dynamic resource management
   ServerView Resource Orchestrator V2.2
5) Automated operations in a cloud environment
   BladeLogic Operations Manager (BMC Software)

These cloud products make it possible to automate virtual-guest rental and return and configuration updating and to provide these services in a self-service format. They enable the business of virtual-guest rental to be expanded without increasing the load on operators at the Numazu Cloud Center. As a result, we achieved a platform for expanding rental services on a large scale, and we can expect cross-line application to all group companies. Only five people are currently involved in virtual rental. Further expansion of rental services can be supported without increasing the number of people by introducing new cloud products and using them to create an enhanced platform for rental services.

5. Effects of cloud conversion

Fujitsu expects the conversion of its development environment to cloud computing to have a number of positive effects, like reducing costs through server consolidation, accelerating the development process through automatic construction of development environments, and reducing the environmental load through a

reduction in the number of physical servers.

1) Annual cost reduction of $9 million[note 1)]

In the three-year period beginning in FY2008, Fujitsu investment in the Numazu Cloud Center came to about $14 million in hardware (PRIMERGY, SPARC Enterprise, ETERNUS, etc.), software (VMware, Hyper-V, etc.), additional circuits, remote operation equipment, and other facilities.

At the same time, Fujitsu forecasts running costs to be reduced by about $9 million annually from FY2011 when cloud conversion is slated for completion. The factors behind this cost savings can be broken down into overall reduction in facility investment by centralizing, virtualizing, and sharing servers at the Numazu Cloud Center, more efficient use of office space by consolidating physical servers, and reduction in operations-related labor expenses by centralizing server operation at the Numazu Cloud Center.

A further cost reduction of about $2.5 million annually has been realized by terminating the lease on a building in the Tokyo-Yokohama area, which was made possible by relocating staff in conjunction with the server migration from that office space to the Numazu Cloud Center.

2) Balancing of server use

Now that servers that were formerly distributed among six Fujitsu hubs have been consolidated at one hub (Numazu Cloud Center), the peak period of server use differs between products and hubs. Fujitsu has therefore implemented a mechanism that can balance server utilization since all hubs are now sharing these servers.

3) Significant reduction in labor hours for development-environment construction

Developers have traditionally had to perform a wide range of tasks themselves to construct a development environment, from setting up the servers to installing the OS and applying to it the appropriate patches. This work could take several hours or even days to complete. Fujitsu efforts at standardizing our development environment patterns at the Numazu Cloud Center, however, have paid off as the work of constructing a development environment can now be done in minutes. Additionally, as developers no longer have to perform system backups or switching, they can devote their energies to actual development work.

4) Reduced environmental load

Fujitsu has reduced the number of physical servers in use by discarding older models that consume more power and by introducing a state-of-the-art virtual environment and migrating physical servers to virtual servers. The end result is a reduction in power consumption, which Fujitsu estimates to be equivalent to an annual reduction of about 1340 t of CO_2 emissions. This is one way that Fujitsu is helping to reduce the environmental load.

6. Service expansion through cloud conversion

The preceding sections described server consolidation and virtualization at the Numazu Cloud Center. The following introduces services that have become possible through this process of consolidation and virtualization.

6.1 One-stop automatic product building

The frequency of product building in software development is increasing as development styles change (such as the introduction of agile development processes like “test first”).

The Numazu Cloud Center provides an environment that makes the work of product building more efficient as well as a “build service” that automatically executes each job in the build process (**Figure 6**). The build service automatically executes a series of jobs such as the extraction of source files from the asset management server (checkout), the distribution

note 1) Dollar amounts were calculated using an exchange rate of $1 = ¥80.

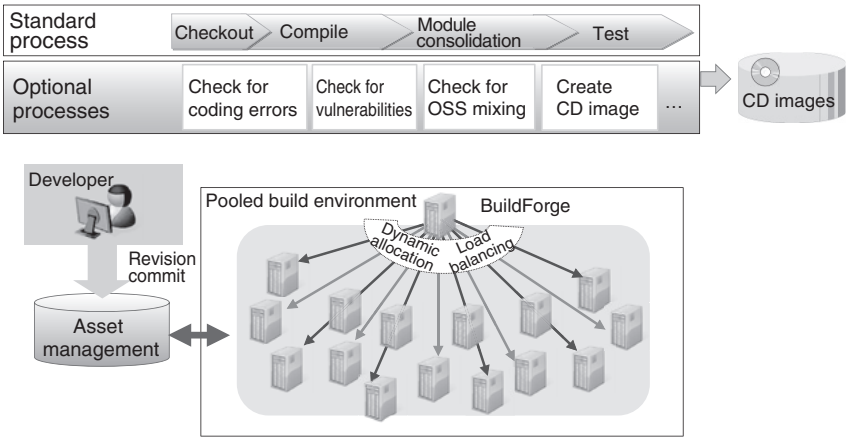

Figure 6
Build service.

of those source files to multiple servers, source compilation, module consolidation, and testing. The servers needed for job execution are automatically selected from the pool of servers in the build environment so as to meet the requirements in the building process. The build service also incorporates a variety of tools (such as checking for coding errors, checking for vulnerabilities, and checking for unexpected mixing of open-source-software [OSS] source code) that are specified and recommended in our internal rule books covering standard processes in Fujitsu middleware development. Up-to-date tools can therefore be used by developers at all times without maintenance. This build service was made possible by consolidating the development tools and various analysis tools at the Numazu Cloud Center through the creation of a cloud platform.

6.2 Disaster recovery

The Numazu Cloud Center stores all previously developed assets (source files and documents) of Fujitsu's middleware products. These assets consisted of about 60 million files (12 TB) as of July 2010.

This asset management system uses redundant, high-reliability hardware, monitors operations using operations management software, and deals with hardware and software faults. It also backs up any differences generated in developed assets to a remote sub-center (Toyama) on a daily basis. As a result, high-priority support operations for our middleware customers can be restarted within two hours even in the case of a total shutdown at the Numazu Cloud Center due to a major earthquake or other disaster. This is in keeping with a previously established business continuity management (BCM) policy (**Figure 7**).

Restarting development operations at the sub-center was previously difficult due to the scale and complicated configuration of the development environments. This is no longer a problem, however, since the development environment has been virtualized. At the Numazu Cloud Center, the management server used to manage the virtual-guest images and the storage storing those virtual guests are treated as a single set. A copy of this set is constructed at the sub-center so that mutual operation[note 2)] can be performed during normal periods. If, however, a disaster should strike the Numazu Cloud Center, all functions of the virtual-guest

note 2) Mutual operation: A virtual-guest rental service is normally operated at both Numazu and Toyama. If either should fail, operation of the service would continue at the site that was still up and running.

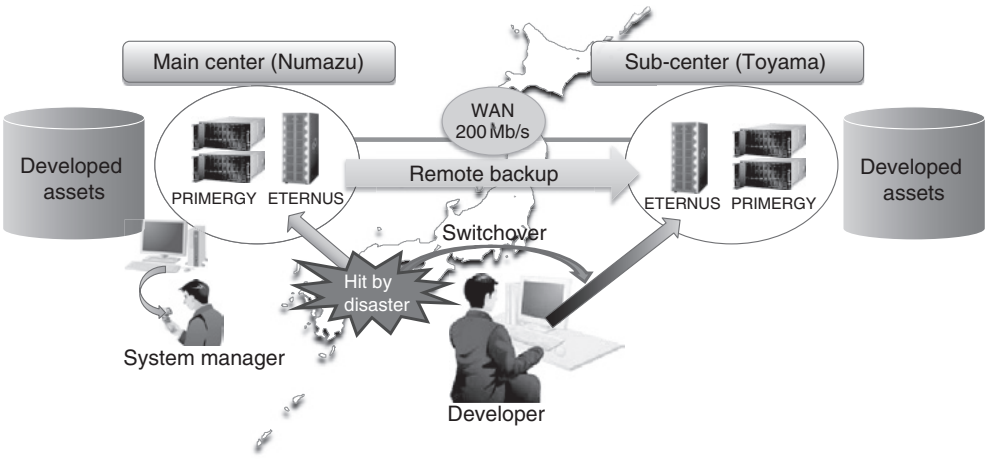

Figure 7
Disaster recovery.

renting service would be transferred to the sub-center so that essential operations could be restarted in accordance with the BCM policy. Although operations would be limited until services in the affected region were fully restored, critical development work and highly urgent maintenance work could be restarted in a relatively short time. This ability to continue development work following a disaster is possible due to the flexibility offered by the virtual operation and cloud environment accessible through the network.

6.3 Global software development environments

In addition to providing development environments that can be accessed from within the company, the Numazu Cloud Center also provides development environments that can be accessed from outside the company. These are being used by partner companies inside Japan and offshore offices in four countries (China, India, Australia, and Germany) and overseas partner companies. These externally accessed environments are in the Virtual Private Development Center (VPDC), which is physically separated from the in-house environments. It is equipped with secure-sockets-layer virtual-private-network (SSL-VPN) communication, multi-level authentication, resource access management, and other features that provide a secure access environment (**Figure 8**).

In the past, when development work was consigned to a partner company in Japan or when development was done jointly with an overseas offshore office or overseas partner companies, most of the development environment existed at the partner's location. It was consequently inevitable that information and materials needed for development would have to be transferred. Although this transfer of data was performed under an agreement concluded with the partner in accordance with various stipulations and regulations (export management, confidential information management, and personal information management), some situations would occur in which the risk of leaks due to handling errors could not be avoided.

Thus, for offshore development, the conversion of the server environment to a cloud made it possible to use a mail system in which users view the content of mail by logging onto a server from a thin client. In this way, information related not only to the development environment but also to the content of development-related mail could no longer be taken out of Japan. The risk of information accidently being leaked was therefore eliminated.

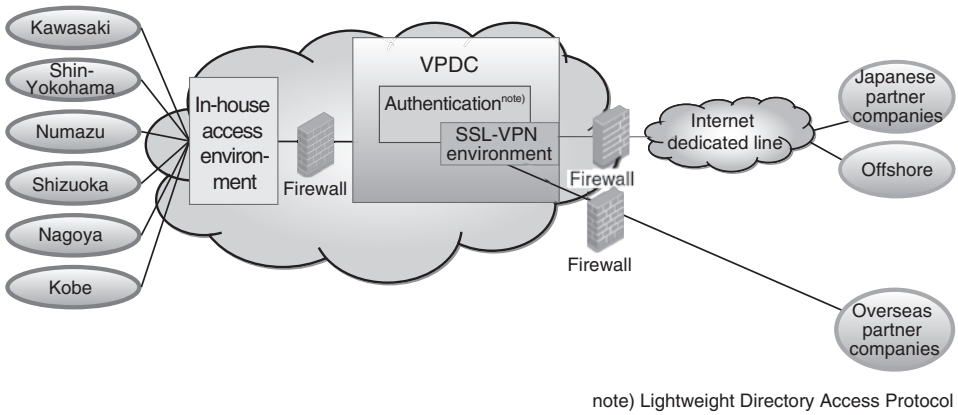

Figure 8
Global software development environment.

The VDPC also provides the same development tools as the in-house access environment, such as resource management, fault management, and project management in addition to development servers so that joint development can be performed as a unified process.

7. Numazu Cloud Center Tour

One role of the Numazu Cloud Center is to feed back know-how gained from deploying and using an actual cloud platform to the developers of Fujitsu's products and services. As a supplement to this role, Fujitsu provides the Numazu Cloud Center Tour inside the Numazu Complex to open the cloud site to the outside and disseminate know-how on converting to a cloud platform through face-to-face conversation with customers. This tour includes

- Introduction to the Numazu Complex
- Introduction to the Numazu Cloud Center
- Tour of the Numazu Cloud Center server room
- Meeting with on-site cloud-platform managers
- Demonstration of a real-time super-multi-point temperature measurement system (joint experiment with Fujitsu Laboratories).

It also includes a visit to the Ikeda Memorial Hall, which introduces Toshio Ikeda, who was a leader in the development of Fujitsu computers, and exhibits a variety of historical Fujitsu products such as the FACOM128B, the world's oldest computer still in operation.

The Numazu Cloud Center Tour publicizes actual Fujitsu practices and stimulates business discussions. It enables Fujitsu to hear what customers have to say so that their opinions and comments can be reflected in our middleware products and cloud services.

8. Conclusion

This paper introduced Fujitsu's conversion of its software development environment to cloud computing and the accompanying enhancement of services at the Numazu Software Development Cloud Center.

Fujitsu's conversion of middleware development to cloud computing has reduced server operation costs, balanced server use, and reduced the labor hours required to construct a development environment. In addition, the unifying of asset management (by deploying a developed asset management server and consolidating build servers) and the provision of diverse middleware development services such as the "build service" has improved resource access management, information management, and productivity in an external access environment,

all at the same time.

The result is not only improved middleware product development but also more efficient development of applications and embedded software.

Looking forward, Fujitsu plans to expand these services to configuration-management and fault-management systems in keeping with the plan to provide cloud-computing services to the entire Fujitsu Group.

References

1) Fujitsu Advanced Engineering: PMAN Model 100 (PW-PM1CL2). (in Japanese). *http://jp.fujitsu.com/group/fae/services/product/pman100/*
2) Fujitsu Component: KVM Switch (FW-D1008NP). *http://www.fcl.fujitsu.com/en/*

Yuji Arimura
Fujitsu Ltd.
Mr. Arimura is engaged in system development at the Numazu Software Development Cloud Center.

Masako Ito
Fujitsu Ltd.
Ms. Ito is engaged in service operations at the Numazu Software Development Cloud Center.