Fujitsu's Efforts for Education and Research System

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Over the past several years, smartphones have become widely used and tablet PCs have emerged, and the result is that system environments have been reviewed considering countermeasures against disasters. Therefore, information and communications technology (ICT) environments surrounding us are changing. Such trends also have impacts on educational places. In particular, as ICT environments in universities, it is preferable to have systems that can be used more simply and more flexibly by users including students and teachers. Now, a virtual desktop system, which is less affected by the devices to be used, is attracting people's attention. However, considering that universities' usage environments differ from those of companies, there are some problems to solve such as those related to the system scale and license. The important task is to find a balance between provision of new values and cost reduction. This paper introduces the issues with the education and research system provided by Fujitsu and its efforts to improve them. In addition, the expected future trends are described.

1. Introduction

Japan is facing a decline in the overall population as well as the 18-year-old population and, for universities in Japan, improvement and enhancement of university education is a major challenge for survival. **Figure 1** shows the changes in the 18-year-old population, number of enrollees to institutions of higher education, advancement rate and other data.[1)]

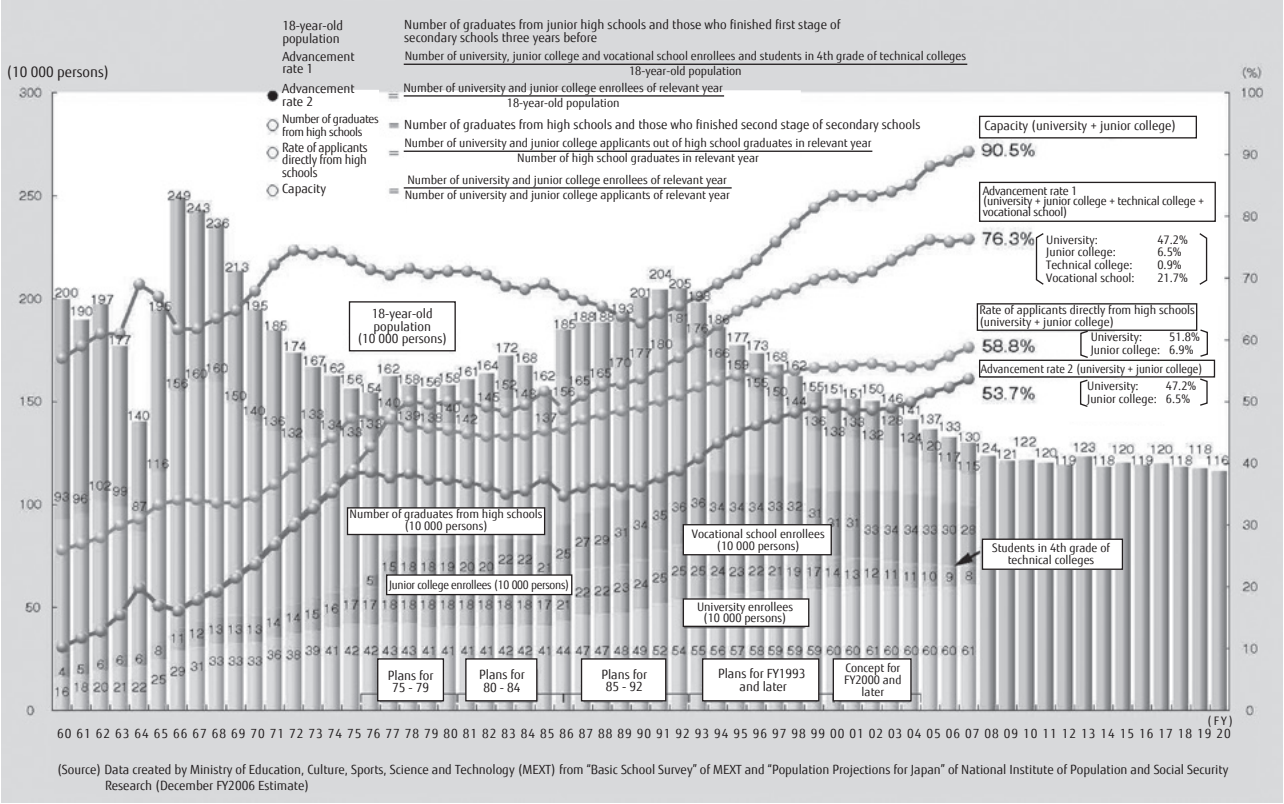
The following have been pointed out as overall situations relating to universities.

1) The rate of advancement to universities in Japan is 47.2%, which is not particularly high as compared with foreign countries.
2) The rates of acceptance of diverse student groups such as working adults, elderly persons and foreign students are low.
3) As social and industrial globalization is progressing rapidly, it is desirable for enterprises and educational establishments to help increase Japan's international competitiveness.

In these social situations, universities, which need to build a system of accepting diverse students and produce many human resources capable of contributing to society, are required to secure enrollees and provide high-quality education. In order to secure enrollees, universities are expected to provide various services that are appealing to students and, to that end, they need to improve their information and communications technology (ICT) environments. Such environments should be improved for the following reasons:

1) For solving various social issues, it is necessary to develop human resources capable of effectively utilizing ICT in ways that go across the borders of organizations.
2) The recent development of the Internet and cloud computing has allowed various types of information to be accumulated and distributed. What is desired is the development of human resources capable of creating new values by interconnecting between various devices and humans.

One ICT environment at universities is an education and research system. Universities must make it possible to apply ICT in areas such as classes using PCs, research making use of the Internet, and group learning, and provide services such as supporting communication between students and the community. To achieve this, universities must provide the latest system environment to users, with safety and



(Source) Data created by Ministry of Education, Culture, Sports, Science and Technology (MEXT) from "Basic School Survey" of MEXT and "Population Projections for Japan" of National Institute of Population and Social Security Research (December FY2006 Estimate)

(Original is in Japanese)

Figure 1
Changes in 18-year-old population, number of enrollees and rates of advancement to institutions of higher education, etc.[1)]

comfort ensured. In addition, universities are required to change the styles of classes, as in education not restricted by location, because of the popularization of smartphones, advent of tablet PCs and the Great East Japan Earthquake (that occurred in March 2011) and other impacts. However, such highly convenient and flexible system environments tend to generally require high costs. In the present situation, most universities are seeing a fall in the ratio of subsidies to operating expenses, and investment in ICT is inclined to decrease at universities. Recently, rather than owning hardware and software as assets, universities have come to have an increasing need for a pay-for-use system, in which hardware and software are used as a service, as required and when required. In reality, equipment for an education and research system is installed on a university's premises in many cases.

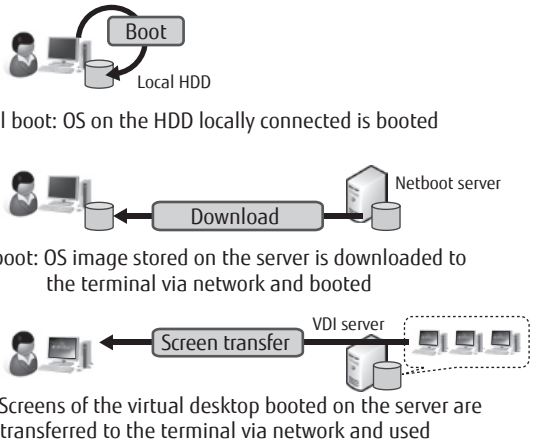
With such situation in the background, this paper describes Fujitsu's proposals for the type of education and research system that will be required in the future, based on the configuration of representative university PC environments.

2. Configurations of education and research systems

PC environments have been becoming diversified with the times and PC booting methods now include local boot, netboot and virtual desktop infrastructure (VDI) (**Figure 2**). Since the criteria for selecting from these methods may depend on OS types and user needs (such as use of Linux or Mac), a new method is not always adopted.

For PC environments used in university classes, one of the above is selected as a representative configuration. Characteristic criteria include allowing for stress-free use even during simultaneous operation and, because of the large number of terminals, a system that makes it easy to manage them is required.

An important point will be how to propose a PC environment that is well-balanced in terms of



(a) Local boot: OS on the HDD locally connected is booted

(b) Netboot: OS image stored on the server is downloaded to the terminal via network and booted

(c) VDI: Screens of the virtual desktop booted on the server are transferred to the terminal via network and used

Figure 2
PC boot methods.

performance, management and cost, and this makes it necessary to have a good understanding of the characteristics of the respective methods.

The following gives a description of the methods.

1) Local boot

In this method, the OS and applications are installed on the local hard disk drive (HDD) of a physical terminal and used. Proposals based on this method are often made in combination with management software for centralized management of the environments of PCs that are installed in large numbers and maintenance of the environments.

Characteristically, there is not much conventional hardware dependency and the performance of the PC unit can be fully utilized in a stable manner.

2) Netboot

For terminal booting, an OS image stored on the server is downloaded to a physical terminal via a network and booted. The image stored on the server is downloaded each time and a mechanism of caching on the hard disk or other means is used to make the boot up faster.

One characteristic is that, because images can be collectively managed by the server, the OS images are easy to maintain.

3) VDI

In this method, only virtual desktop screens running on the virtual infrastructure of the server are transferred to a physical terminal and used. The PC environment runs on the server, which makes this method available on a thin client, low-spec PC or in a mobile environment.

This method is characteristically capable of realizing a PC environment independent of the place of use or the device used.

A detailed comparison of the solutions' functions is shown in **Table 1**.

3. Issues with proposals

3.1 Requirements of education and research system

When constructing an education and research system at a university, it is essential to consider the characteristics that are unique to universities as listed below, including use by an unspecified large number of students and simultaneous use in classes.

1) Simultaneous processing (boot, logon/logoff and application start-up) during a specified period of time (90-minute classes with a 10-minute recess in between) must function without any problems.
2) Users must be able to utilize a uniform environment and, at the time of booting, always use systems in a clean environment with the data used by the previous users cleared (environment refresh).
3) Applications requiring high specs, such as simulator, 3D and CAD applications, must operate without any problems.
4) Use of the latest (leading-edge) OSes and applications must be possible from the perspective of education.
5) PC maintenance takes place a few times a year to ensure users are provided with the latest PC environments. It must be possible to effectively manage the PCs in order to reduce system suspension periods.

In addition, there is an increasing need to be able to flexibly switch between different PC environments for different classes, prospective students' campus visits or Microsoft Office Specialist (MOS) examinations. Recently, based on the "bring your own device" (BYOD) concept, in which a PC environment can be used anywhere and anytime by means of a personal device, VDI has become a trend and is increasingly in demand.

3.2 Issues with VDI operation

This subsection presents issues with proposals that incorporate VDI as a latest trend. An environment,

Table 1
Comparison of solutions' functions.

		Local boot	Netboot	VDI
Representative product		Shunkai	Z!BootOS Citrix Provisioning Server Phantosys	VMware View Citrix XenDesktop Windows VDI
1. Convenience				
1	Client boot time	Poor Slower than other solutions. (May be improved with SSD)	Good Faster than local boot.	Good Faster than local boot.
2	Use environment	Poor Use from specified place and terminal	Poor Use from specified place and terminal	Excellent Can be used anywhere as long as a network environment is provided. Can also be used for BYOD and tablet devices.
3	Application	Good Can be used as long as the environment meets the operation requirements.	Relatively poor Software that locally has individual information may not run.	Poor Operating conditions are strict: • Software that uses a hardware key • Inability to play copyright-protected content • Lecture support software (Wingnet, etc.) • Multimedia, CAD or other software that requires a large bandwidth may cause the video to advance frame-by-frame.
4	Legacy OS	Poor Cannot be installed due to driver issues, etc.	Poor Cannot be installed due to driver issues, etc.	Good Can be used as long as an agent is available.
2. Scalability and potential				
1	External device	Good No limitations.	Good No limitations.	Poor May not be recognized. Devices other that USB devices are not guaranteed.
2	Addition of client	Poor Terminal with the same model number is necessary.	Poor Terminal with the same model number is necessary.	Excellent Clients can be readily added. There are no restrictions to the model of client.
3	Migration of client environment to cloud	Poor Migration to a cloud environment is not possible.	Relatively poor Delivery server can be migrated to a cloud environment but it is difficult to ensure the bandwidth in terms of cost.	Good Migration to a cloud environment is possible.
3. Maintainability				
1	Master image correction	Poor One terminal in one classroom must be occupied for template correction.	Poor One terminal in one classroom must be occupied for template correction.	Good Terminal does not need to be occupied because work takes place on the server.
2	Image deployment	Poor Closing of the classroom is required for image deployment.	Good No influence on use.	Poor HDD addition is required for efficient image deployment.
3	Client HDD failure	Poor Re-delivery of the image is required after HDD replacement.	Relatively poor HDD formatting is required after HDD replacement.	Excellent Thin client terminal is used and HDD failure does not occur.
4. Others				
1	Security	Poor Separate software must be purchased for restricting data takeout.	Poor Separate software must be purchased for restricting data takeout.	Good External device restrictions can be easily imposed and data takeout can be restricted.
2	Power consumption	Poor Client power consumption is high.	Poor Client power consumption is high.	Good Client power consumption is low.

no matter how it may improve the ease of making new services available, does not make sense if the change in the ICT education environment reduces the efficiency of classes from the viewpoints of instructors and students. Factors that cause such reduction include:

- Slow OS boot
- Start-up failure/slow running of applications
- Slow display of videos/images
- Terminal environment refresh taking too much time between classes

With VDI, the desktop environment is run on the server, which makes it very important to appropriately size the server system. While vendors that offer VDI products provide indices for sizing, commonly used indices do not suitably match the characteristics of universities and a use situation premised on an actual class must be reflected in sizing.

3.3 Solutions to issues with VDI operation

To address these issues, Fujitsu verified the operation of simultaneous processing tasks and applications in a verification environment premised on use in an actual class to derive the optimum system sizing in a classroom environment.

We calculated the indices of CPU and memory allocations and Input/Output Per Second (IOPS) peculiar to class use and optimized the required hardware resources, redundant array of independent disks (RAID) and VDI layout (load balancing) at the time of design.

For example, in order to run applications requiring high specs such as 3D graphics and CAD applications that are typically used in engineering faculties, we assume two to five times as much CPU and memory resource allocation as those for ordinary or open use. We also constantly consider the storage IOPS/RAID optimization and VDI layout in view of simultaneous logins at the start of a class and environment refresh for terminal reboot between classes.

For these reasons, VDI requires a system with large hardware sizing (high specs) of all the three configurations presented above, and this often leads to high adoption costs.

Fujitsu is working on optimizing VDI, which is increasingly in demand but poses issues in terms of costs, from the following viewpoints and makes proposals with hybrid configurations while taking into account the need for a good balance between cost and performance in some cases.

1) Integrate licenses of a university as a whole including the business system without confining licenses to the education and research system for overall optimization with a package license.
2) For products of other companies, share negotiation information and build a stronger alliance in order to always ensure the lowest price as the prime vendor.
3) Ensure high quality and reasonable prices of design, construction and testing for their provision by standardizing the design and test specifications.
4) In some cases, select hybrid proposals combining local boot, netboot and VDI according to the application.

3.4 Provision of new values

Up to now, this paper has described Fujitsu's efforts with the focus on how PC environments can be offered in relation to information and education systems. For VDI operation, use in combination with "FUJITSU Education Solution UnifIDone Campus Cloud,"[2] which has been developed especially for education, allows us to provide new values in line with the trends of use of smart devices and BYOD. Such values include "provision of education environments that can be used anytime, anywhere and easily" and "provision of flexible class operation environments (that can be easily switched for each class)."

4. Fujitsu's proposals

As described at the beginning of this paper, the impact of the falling birthrate and reduced subsidies in Japan have made it essential for universities to reduce their ICT investments and system scale. Under these circumstances, the key is how to provide values with new solutions while maintaining the existing operation environments to offer more comfortable and user-friendly system environments at lower costs.

To that end, we are striving to achieve both reduced costs and provision of new solutions by the following measures.

4.1 Making of service menu focused on strict cost reduction[note)]

1) Template-based solutions

We are working on creating a menu (this refers to an activity that is carried out in line with making a service menu) that makes it possible to provide solutions at low costs with a short delivery time while maintaining a certain level of quality by standardizing the solutions offered by Fujitsu and organizing device configurations and operation details into services.

2) Infrastructure industrialization

We are preparing a menu that can improve quality, equalize deliveries and minimize operations carried out by systems engineers in the field to reduce costs. These are achieved by having a collective server OS and application installation and configuration, which were individually performed in the field up to now, at manufacturing facilities before shipment. As an across-the-board approach, we are actively working on improving applications and menus under the name of education and research that is built to order (BTO).

4.2 Provision of new cloud solutions

Higher-speed Internet lines and improved specs of server devices have accelerated the rollout of solutions that use client services and server services on the Internet, which eliminates the need for universities to have assets on their premises. We offer desktop as a service (DaaS) in which services provided at Fujitsu Tatebayashi Datacenter are utilized to transfer client screens to be displayed on the terminal and a service that allows an organization to construct a server itself as a virtual OS with resources on the Internet.

4.3 All-inclusive proposal in consideration of factors other than PC environments

We offer improved management efficiency and new values for users with an all-inclusive offering of solutions to problems with PC environments combined with other solutions.

Specifically, we have made use of the experience of systems engineers who have worked on the front line of the education market to develop and introduce "FUJITSU Education Solution UnifIDone integrated ID management."[3)] This is an integrated ID management package for universities and it is especially intended for education in view of ID lifecycle and lifetime ID management of universities. At schools with many classrooms, PC environments tend to be diverse and the number of PC images increases. Accordingly, we make a proposal for reducing management person-hours and costs required for application development by using application delivery to integrate PC images.

5. Future education and research system

In the future, it is expected that virtualization and use of cloud computing will further develop and styles of classes utilizing cloud computing will undergo more changes.

5.1 Multi-device style of classes with focus on ubiquity

A style of classes not restricted by location may be realized. Making a virtual OS that is prepared on a cloud accessible anytime and anywhere, whether from home, a free space or any other place, allows users to freely utilize a familiar environment (virtual OS). We expect students will have an increasing need to take classes on devices such as smartphones and tablets, not to mention PCs. At present, this form of use is permitted only in limited environments. To create an environment that can be freely used in a real sense, the OS and application licenses will be expensive and enterprises will probably be required to revise the system of licenses in view of the increase popularity of the cloud.

For a university specialized in agriculture, for example, Fujitsu's agriculture cloud services can be used in combination with other systems to create an environment for integrated learning of management, production and sale in agriculture. In this way, a new form of classes can be created that are intended not only for students who want to enter agricultural professions in the future but also for students in departments related to economics and management or those aiming to run private businesses as a management model of a company.

note) Cost reduction here refers to considering the equipment configuration and work contents each time, and fixing quotes and services based on some provisions and conditions rather than on an estimate.

5.2 Necessity for large-scale online class system

As the birthrate has been decreasing recently in Japan, more and more services are targeting segments different from those in the past such as graduates and working adults. Up to now, education for working adults required them to go to school after work. However, by enriching classes that use the Internet, services that are not restricted by location or time can be provided, and this raises expectations for an invigoration of working adult education. In the future, it seems likely that educational approaches to age groups that are different from those in the past and to working adults who are more highly motivated will provide a promising market.

Online classes are also expected to bring changes to ordinary students and instructors. Regular classes become deliverable online and classes of other universities or those given overseas become available, and this can broaden the scope of classes and improve their efficiency. Students can allocate the free time that has been generated to other types of education or can have time to independently examine the content of study in advance to create a report. These changes are estimated to cause a transition to Western-style classes, utilized as opportunities for discussion or announcement of results, leading to the development of global human resources.

Classes of other universities and campuses including overseas ones become available by realizing online classes, and this makes it possible to provide classes not restricted by location. Fujitsu intends to create and propose new classes in consideration of the integration of campuses of small- to medium-sized universities by coordinating between different schools.

6. Conclusion

This paper has described ICT-related issues that universities are currently faced with, Fujitsu's proposals and efforts to deal with those issues and future activities. The contents of solutions proposed by Fujitsu are evolving along with the improvement of the Internet infrastructure. However, there are still many issues left to be solved such as use in consideration of universities' individual environments and license issues.

In the future, in addition to solving the issues, it may be necessary to have an ICT environment that targets human resources including those with no interest in education or those who were not fortunate enough to receive education, for example. Furthermore, activities in view of efforts for globalization are becoming increasingly desired. We are committed to making contributions to the development of universities by constructing an infrastructure that provides a global standard of university ICT. Our aim is to help bring about universities that can develop larger numbers of global human resources who are capable of thinking from a global perspective.

References

1) Ministry of Education, Culture, Sports, Science and Technology: Changes in 18-year-old population, No. of enrollees and rates of advancement to institutions of higher education, etc. (in Japanese).
http://www.mext.go.jp/b_menu/hakusho/html/hpab200701/002/003/004/2_3_3.pdf
2) Fujitsu: Realizing Education and Research Private Cloud Ideal in University Environment–FUJITSU Education Solution UnifIDone Campus Cloud (in Japanese).
http://jp.fujitsu.com/solutions/education/products/campuscloud/
3) Fujitsu: Improving Efficiency of ID Management Operation Peculiar to Universities with Diverse System Users–UnifIDone (in Japanese).
http://jp.fujitsu.com/solutions/education/products/unifidone/

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