Fujitsu's Approach to Environmental Protection Using "PRIMERGY" PC Server

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IT equipment now accounts for about 5 percent of the total electric power consumed in Japan, and the Ministry of Economy, Trade and Industry predicts that the total power consumed by IT equipment will increase about fivefold over 2006 levels by 2025. Unlike in other industries that are seeing trends toward saving energy, only IT-related industries are exhibiting the opposite trends concerning power consumption. Moreover, corporate customers are paying more attention to saving energy from a business standpoint, since energy savings for PC servers will in turn reduce data center operating costs, such as costs for air-conditioning and electric power. In line with such market trends, Fujitsu has been active in saving energy for PC servers in offices. This paper introduces the latest energy-saving technologies, citing the example of PRIMERGY TX120, a product that has achieved the highest level of energy saving in the industry, and describes Fujitsu's contributions in the fields of developmental concepts and decreasing environmental burdens.

1. Introduction

Some companies that operate data centers need to invest in air-conditioning equipment or pay operating costs for air conditioning because the PC Servers installed in their data centers now generate more heat in accordance with the increase in PC servers' power consumption. Because of the limited capability of data centers' resources, such as the limit on their ability to supply electric power or their limited cooling capabilities, the number of PC servers which can be installed in data centers is also limited. Therefore, energy saving is one of the relevant requirements for data center customers.

In line with such a trend, Fujitsu has been active in saving energy for PC servers in data centers.

This paper introduces the latest energy-saving technology as part of our environmental efforts for the PC server PRIMERGY, citing the example of PRIMERGY TX120, a product that has achieved the highest level of energy saving in the industry, and describes Fujitsu's contributions in the fields of reducing environmental burdens.

2. Approach to energy saving

In general, costs and Time To Market (TTM) are the top priorities when developing a PC server. Differentiating such servers from the standpoint of energy saving has been considered difficult because all of their main components such as the CPU, hard disk drive (HDD) and memories are standardized. Therefore, Fujitsu set the three approaches shown below as its core approaches in developing PRIMERGY:

1) Presenting an optimum platform to fit market needs
2) Adopting differentiating technologies in sections other than main components
3) Visualizing and controlling electric power consumption

These approaches are explained in more de-

tail in the following sections.

3. Presenting an optimum platform to fit market needs

Analyzing characteristics and usage of PC servers by customer through detailed market research, Fujitsu proposes optimal platforms to customers. **Figure 1** indicates the CPU portfolio used in Fujitsu's PC servers and compares power consumptions and other characteristics. For instance, Fujitsu offers the high-performance, Quad Core/Dual Core CPU shown in the table to customers who use PC servers as a database server or application server, since high performance is needed for such use. But for web front applications, Fujitsu offers a low-voltage CPU which consumes less power in order to contribute to energy saving, since such usage does not require a high-performance server but requires a number of servers.

4. Adopting differentiating technologies

Introducing the latest technologies used in PRIMERGY

1) Power supply unit (PSU) and voltage regulator module (VRM, high efficiency DC-DC converter)

Inside a server, electric power is supplied to the main components such as the CPU through a power source module called a PSU and a VRM for voltage transformation. If we improve the efficiency of the VRM, we can reduce the server's power consumption. Fujitsu is trying to minimize power consumption by enhancing the power efficiency of PSU and VRM through increasing the efficiency of the switching circuits and adopting low-power-loss components (**Figure 2**).

2) Optimization of fan rotation control

Because PRIMERGY integrates multiple cooling fans inside its chassis, the fact that there are a number of fans and fan rotation speeds has a big influence on the PC server's power consumption. In conventional rotation control technology, we have controlled fan rotation speed in an analog fashion by changing the fan drive voltage in a stepped way, and that control method has a weak point in that it is difficult to accurately control the fan rotation speed and keep a stable rotation speed in a low-speed rotation range. To address this difficulty, the fan rotation speed should be higher than actually necessary but this results in increased power consumption. In recent years, a fan called a pulse width modulation (PWM) fan

Server CPU		Year 2005	Year 2006		Year 2007		Year 2008
		2nd Half	1st Half	2nd Half	1st Half	2nd Half	1st Half
Four-socket CPU	QC					130 W →	→
	DC	165 W →	→	150 W →	→	80 W →	→
	LV					50 W (QC)	→
Two-socket CPU	QC				120 W →	→	→
	DC	135 W →	80 W →	→	→	→	→
	LV	55 W →	→	40 W (DC)	50 W (QC) →	→	→
One-socket CPU	QC				105 W →	→	→
	DC	130 W →	→	65 W →	→	→	→

QC: Quad Core CPU
DC: Dual Core CPU
LV: Low Voltage CPU

Usage of each CPU
LV: Web front server, etc.
QC/DC: Database server, Application server, etc.

Figure 1
Server CPU portfolio.

has been available at a reasonable price, and has made accurate rotation control and stable rotation in a low-speed rotation range feasible. Arranging some temperature sensors at optimum locations such as close to air inlets or high-temperature parts like a CPU, we can calculate thermal conditions and the necessary fan rotation speed. This mechanism enables sophisticated multi-step control of fan rotation and a resultant reduction in power consumption.

3) Optimizing the number of fans

The power consumption of a server also depends on the number of cooling fans it has. Assuming that the fan diameters are identical, having fewer fans is more advantageous for energy saving in general. By performing a thermo-fluid dynamics simulation at the design phase, the number of fans is optimized through efficient cooling (**Figure 3**).

4) Using a 2.5-inch HDD and Solid State Disk (SSD)

With PRIMERGY, Fujitsu adopts a 2.5-inch Serial Attached SCSI (SAS) HDD that is designed for enterprise use. This hard disk has both high reliability and energy-saving characteristics and reduces power consumption by about 40 percent in comparison with a 3.5-inch HDD (comparing hard disks as single units). Further, we are currently reviewing the adoption of an SSD that can reduce power consumption to between one-quarter and one-eighth the level achieved by a 2.5-inch HDD.

5. Visualizing and controlling electric power consumption

We have described the hardware-related technologies for energy saving in PRIMERGY PC-server in the previous sections. In this section, we will describe the visualization of power consumption to promote energy saving under various customers' operating conditions. When actually operating, the power consumption of a PC server does not stay constant but fluctuates frequently depending on the time of day and the applications in use. In the case of PRIMERGY (two-way type), the Board Management Controller (iRMC2) and server management software have functions to monitor and record the power consumption. By using a graphic presentation of the power consumption for a selected time period (i.e., visualization), we can understand the relationship between the status of server load and job status more easily (**Figure 4**).

Although it has been used mainly in note-

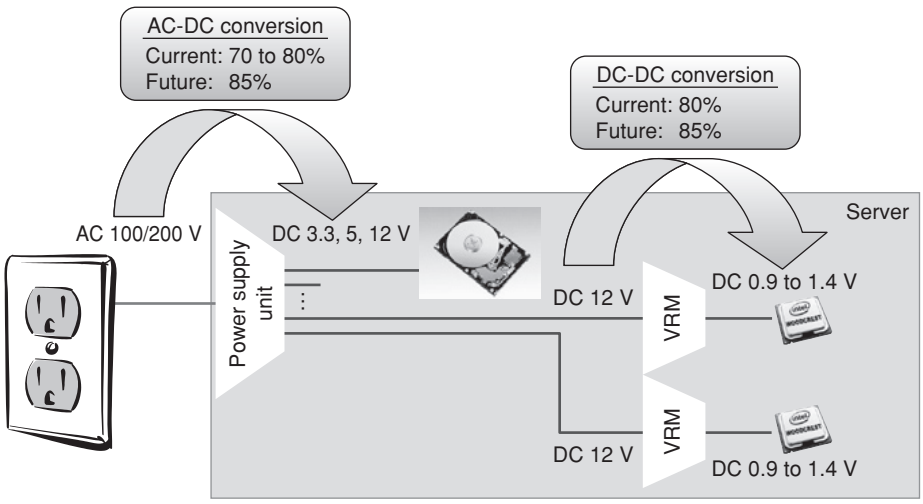
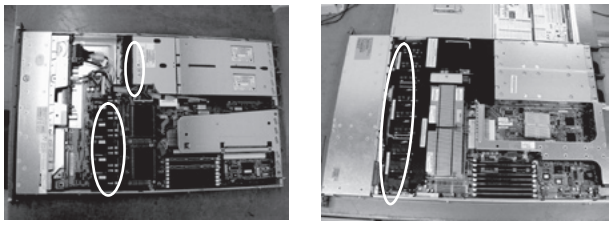


Figure 2
Improvement of power efficiency.

book PCs in the past, we have adopted Intel's SpeedStep technology in a PC server that enables a user to select between two different modes (high-performance mode [maximum frequency] or energy-saving mode [low frequency]) based on controlling the CPU frequency by iRMC2. Originally, the technology was such that the battery operation time could be prolonged by running the CPU at a high clock rate while the computer was connected to a power supply with an AC adapter, and by running the CPU at a lower clock rate when it was being powered by the battery. Based on these technologies, it is possible to graphically present the power consumption at PC servers in each time period by using server control software as indicated in **Figure 5**. Analyzing the server load status in connection with its job status, we can control power consumption depending on each load, for example by using an energy-saving mode during the nighttime when there is a lower load level.

In the case of a data center, chronologically analyzing PC servers' power consumption and heat generation, we can estimate the heat distribution inside a data center or rack. According to the estimated heat distribution, we can rearrange the layout of PC servers inside data centers in consideration of the heat distribution.

Recent trends of PC servers in data centers have seen servers being consolidated through virtualization technology with blade servers. In such an environment, further energy saving can be achieved based on the above-mentioned technologies, virtualization and the middleware controlling both technologies.[1] **Figure 6** indicates an example. In this case, the middleware will combine the virtual machines (VMs) into one physical server by watching the server load and heat generation in periods such as during the nighttime and holidays, when loads applied on servers are low. In this way, power consumption of servers can be minimized by turning off the power switch of those servers that are not in operation and putting those servers with a low level of operation into a power-saving mode.



(a) RX200 S3 (Fan 13 pcs.)

(b) Competitor's product (Fan 18 pcs.)

Figure 3
Saving energy by reducing number of fans.

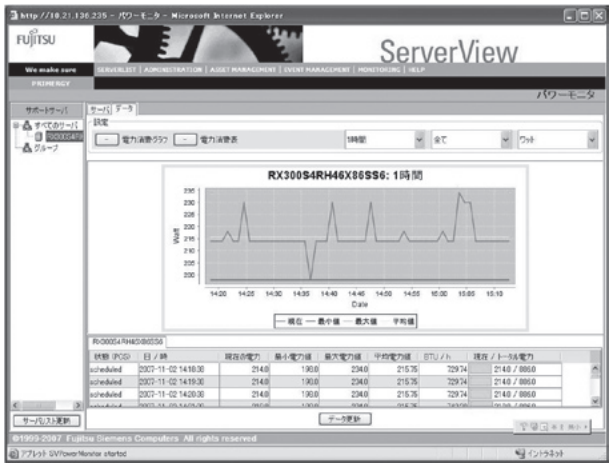


Figure 4
Visualization of power consumption.

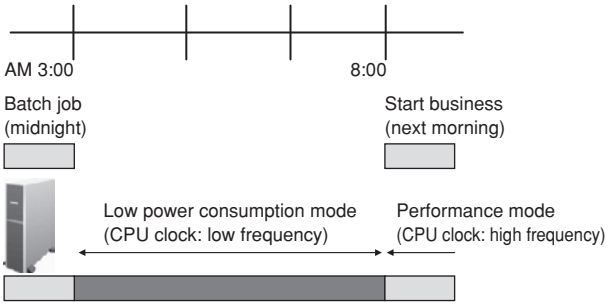


Figure 5
Control of power consumption using SpeedStep technology.

6. Contributing to the environment with PRIMEGY TX120

In this section, we will introduce PRIMERGY TX120, a product that has achieved the highest level of environmental performance in the industry in the area of office servers.[2)] PRIMERGY TX120 is a compact server with dimensions equivalent to those of the most popular kind of desktop PC (W 99 mm × D 399 mm × H 340 mm). This size is achieved by consolidating various size-reduction technologies. In comparison with PRIMERGY TX150 S5, the footprint for installing PRIMERGY TX120 is less than one-third and the space required is less than one-quarter (**Figure 7**).

Under the development concept of a "full-scale one-way server of a compact size that can be used on a desk along with a desktop PC", Fujitsu planned a product for the SOHO/SME market and conducted marketing research. As a result, Fujitsu identified that, while the extension capability was regarded as less important in the target market, securing high reliability as a full-scale server for 24/7 operation with an integrated back-up device was considered to be essential. In addition, quiet operation and energy-saving characteristics are regarded as key features. Accordingly, we have focused on a selection of CPUs as an optimum choice for a platform, since a CPU is the main source of heat generation. And we chose the Dual Core Intel Xeon Processor 3000 series considering its low power consumption. In comparison with the conventional Intel Pentium D Processor, its power consumption is up to 30 percent lower. A 2.5-inch SAS HDD was adopted to achieve both high reliability and energy-saving characteristics. Further, based on the thermo-fluid dynamics simulation inside the chassis, we achieved effective cooling by arranging the heat-generating components in a linear configuration (**Figure 8**). By arranging multiple temperature sensors at optimum locations in the chassis, we can perform sophisticated rotation control with a PWM fan. Combining the above-mentioned effects, we were able to reduce the power consumption by about 60 percent of the level achieved by conventional one-way servers.

Fujitsu uses a method called life cycle assessment (LCA) for analyzing and evaluating the actual effects on the environment (environmental burden) through the whole life cycle of a product. **Figure 9** shows the results of comparing the LCA of PRIMERGY TX120 and TX150 S5, which is a typical one-way server of an equivalent

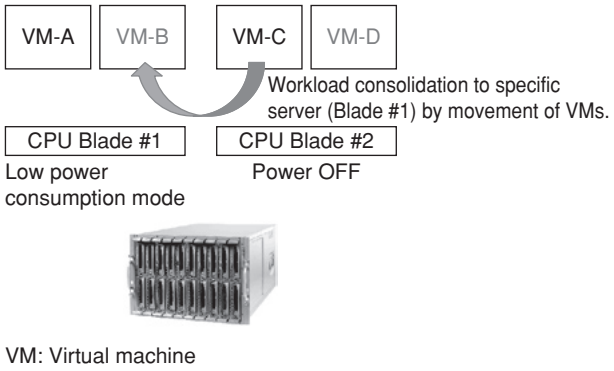


Figure 6
Server's power consumption control by middleware.

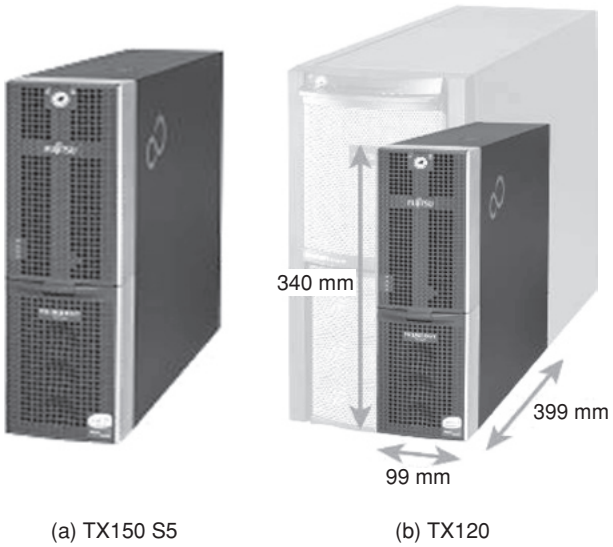


Figure 7
Appearance of TX120 and comparison of size with typical one-way server TX150 S5.

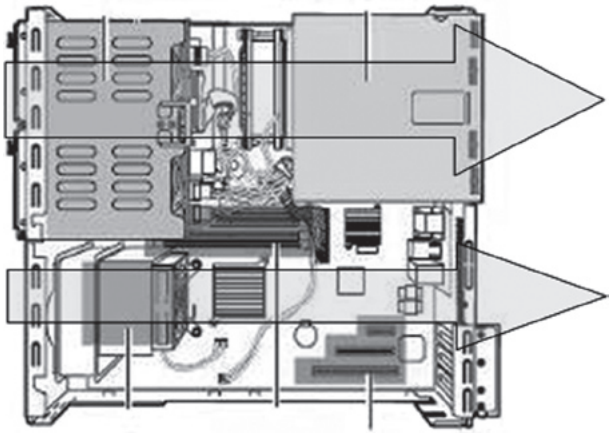


Figure 8
Straight cooling method.

generation. As a whole life cycle, PRIMERGY TX120 can reduce the environmental burden by more than 30 percent versus the level achieved by TX150 S5.

As a recent trend, Japan's IT industry has been evaluating new products from the viewpoint of their environmental burden, which is called the eco-efficiency factor. Most customers purchase TX120 as a replacement for their existing servers. Because the average service life for a PC server is four years, the eco-efficiency factor was calculated in comparison with TX150 which was the mainstream product four years ago (**Table 1**).

Based on this evaluation, TX120 achieved an eco-efficiency factor of 6.5. Because Fujitsu

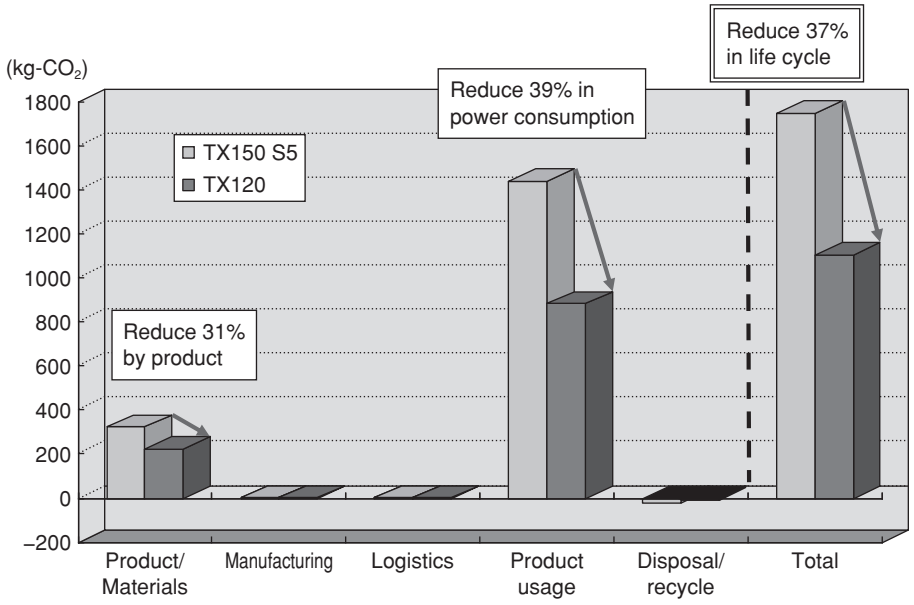


Figure 9
Comparison of environmental burden between TX150 S5 and TX120.

Table 1
TX120 Eco-efficiency factor compared with TX150.

Item		TX150	TX120	Improved rate
Numerator	CTP value (MTOPS)	7093	29140	4.11 (times)
Denominator	LCA result (kg-CO_2)	1750	1106	0.63 (times)
Environmental efficiency factor	—			6.50 (times)

CTP: Composite theoretical performance
MTOPS: Million of theoretical operations per second

defines the target eco-efficiency factor as around 2.9 on average, TX120 is considered to be a highly valuable product from the standpoint of reducing environmental burdens.

7. Conclusion

This paper introduced the latest energy-saving technologies for PC servers, citing the example of PRIMERGY TX120, a product that has achieved the highest level of energy saving in the industry. While the recent discussion of energy saving for PC servers has focused on the rack-type and blade-type servers used in data centers, the energy-saving technologies described in this paper can be applied to office servers. There are some other innovative energy-saving technologies in the IT industry not mentioned in this paper, such as an efficient management of the data center environment as a whole, based on the analysis of air conditioning and air flow dynamics in the data center. In recent years, a high-voltage DC power supply is one of the features that data centers have used to improve the efficiency of power transformers. Considering the status of data center infrastructure, Fujitsu plans to review the possibility of introducing a high-voltage DC power source. Fujitsu will not only focus on improving a single server unit but also focus on providing solutions for the infrastructure in data centers in the market. Further, Fujitsu is aiming for more environmentally friendly PC servers by watching the trends and providing solutions for data center infrastructure, visualizing power consumption, examining the heat generated by PC servers and controlling middleware, which has a close relation with each of the factors mentioned above.

Note: Fujitsu launched the TX120 in December 2006 but it has already been phased out. Nevertheless, Fujitsu is keeping the concept of adopting energy-saving functionalities in office servers. Recently, Fujitsu launched a follow-up product to TX120, called TX120 S2.

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