Global Server Series Supporting Customer Asset Inheritance with High Reliability

● Takashi Chiba ● Kouji Toyonishi ● Kouji Sano ● Yoshitsugu Gotou

Fujitsu mainframes from the M series to today's Global Server (GS) series have played a core role in social infrastructure systems for over 35 years while supporting the inheritance of existing customer assets. The technology cultivated with these mainframe series has served as a basis for the development of other servers, and the technology has undergone continuous development to meet a wide range of changing needs. In recent years, integration toward large-scale systems has been accelerating with the aim of speeding up business operations and reducing information technology (IT) costs; the need for high performance and high reliability for business continuity is being felt more than ever. Reducing the environmental load by utilizing green IT and preparing for the Cloud computing era have also become important issues. This paper outlines the hardware and software and supporting technologies for the GS series and describes Fujitsu's approach to achieving high performance and high reliability in this mainframe series.

1. Introduction

Fujitsu mainframes from the M series to the GS21 series have been driving mission-critical systems for over 35 years, and the vast amount of applications, data, and know-how accumulated during that time has become an invaluable asset for Fujitsu. At present, Fujitsu's Global Server (GS) series of mainframes holds the top share in Japan with more than 2800 units delivered. As these numbers show, the GS series has made a major contribution to the construction of social infrastructure systems. Customers who have been using mainframe systems have expressed a strong desire to continue using them so that they can continue to use a vast array of existing assets and maintain system stability.

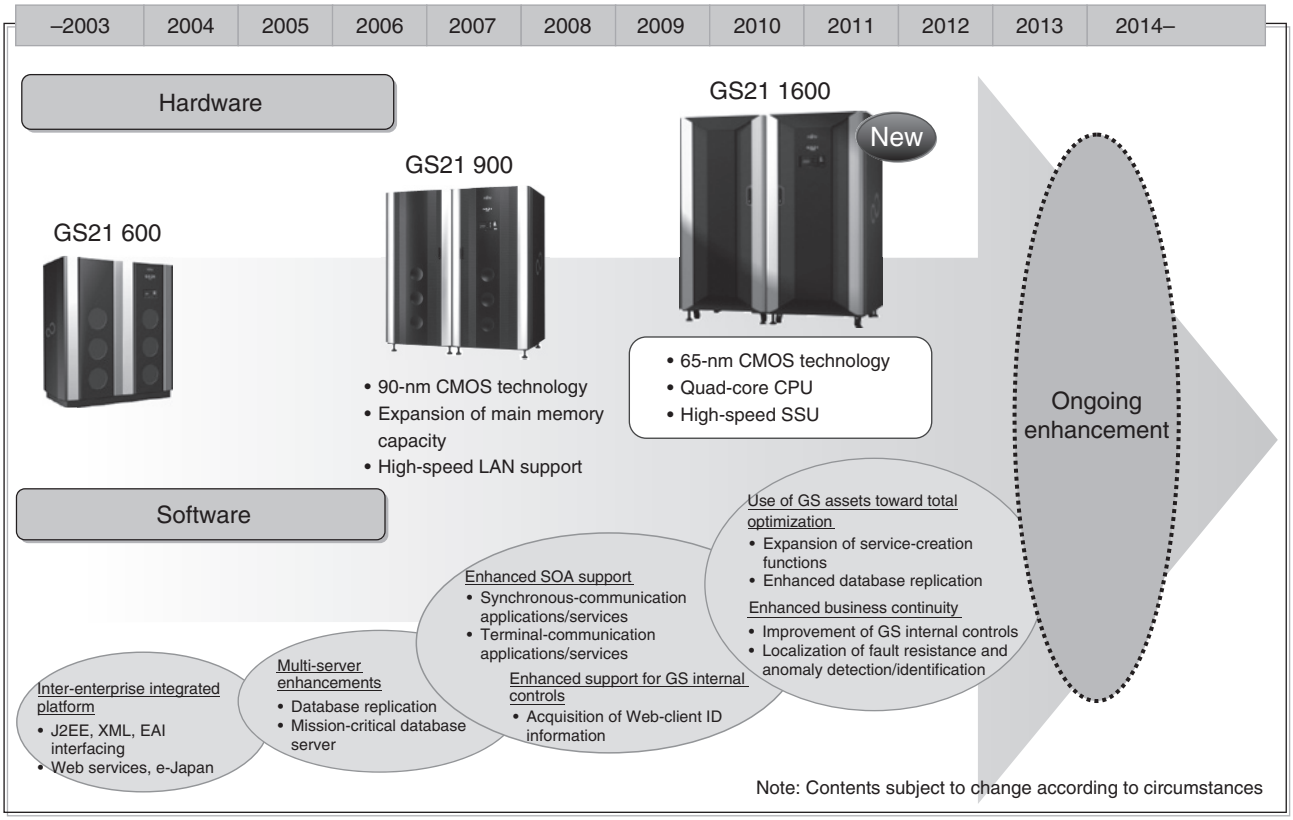
This paper introduces GS features, hardware and software, and supporting technologies.

2. GS features

The GS series of mainframes expands upon the central-processing technologies and high-reliability technologies cultivated under Fujitsu's M series of mainframes. Fujitsu began providing the GS8000 series in 1995 and has been providing the GS21 series using gigahertz-class processors since 2002. The GS series is compatible with the huge amount of existing customer assets. It has been developed on the basis of an architecture optimized for driving business systems requiring high performance and high reliability. All GS hardware, software, and middleware have been developed by Fujitsu itself, and ease of maintenance is a major feature. As such, the GS series has come to be known as a core platform for running social infrastructure systems (**Figure 1**).

2.1 Customer asset protection

Fujitsu mainframes have been developed with priority placed on the continued use of existing customer assets. Fujitsu treats



CMOS: Complementary metal oxide semiconductor
EAI: Enterprise application integration
ID: Identity
J2EE: Java 2 platform, enterprise edition
LAN: Local area network
SOA: Service oriented architecture
XML: Extensible markup language

Figure 1
GS roadmap.

even slight differences in system behavior when extending functions or introducing new technologies as incompatibilities and strives to maintain asset inheritance and guarantee compatibility over the long term.

2.2 High performance

High-performance patch processing, online processing, and database processing have been achieved by using cutting-edge technologies and developing high-speed processors. For example, 65-nm-process multicore processors have helped to improve processing capability. Furthermore, high-speed, large-volume processing, and high reliability have been achieved through parallel processing in the form of a multicluster system that features high-speed connections among multiple clusters via a system storage unit (SSU).

2.3 High reliability

The GS series has a function for re-executing instructions in the event of a fault within a central processing unit (CPU), a patrol function for periodically checking memory, and a memory-switching mechanism for automatically allocating reserve memory in response to a fault in a memory element. A redundant configuration for clusters and SSU hardware is also used to enable hardware expansion and maintenance to be performed while the system is operating. A multicluster system configured within the same data center (**Figure 2**) can suspend operations in a cluster where a fault has occurred and perform a hot standby (switching to a standby cluster) within a few seconds. Similarly, if a primary data center suffers damage from an earthquake or other disaster, operations can

be quickly reestablished by having a remotely located backup data center take them over until the primary data center recovers. The end result is uninterrupted system operation twenty-four hours a day, seven days a week (24/7).

2.4 Virtualization

Beginning with the M series of mainframes, Fujitsu has been providing virtual machine (VM) systems that simultaneously run multiple operating systems on one cluster with the aim of reducing the customer's total cost of ownership (TCO). Fujitsu has been working to improve extendibility and reliability in VM operation from the start and has extended the use of VM in developed equipment to standby VM in hot standby operation. In recent years, customers have made an increasing number of requests for effective utilization of different clusters, and Fujitsu has been stepping up its support for VM use for running systems that demand high reliability.

2.5 Social and environmental support

2.5.1 Green mainframes

The GS series promotes Green Policy Innovation, a project for reducing the environmental load through the use of green IT, in accordance with Fujitsu Group policies. The GS21 1600 model group is being provided as a Super Green Product excelling in its level of environmental consideration through reduced power consumption and improved ease of installation. It is also being provided as a product that features high energy-savings by incorporating various measures such as reducing the number of clusters in the entire system. In these ways, the GS21 1600 series has been contributing to environmental load reduction efforts.

2.5.2 Security

The need for internal controls within companies is growing in response to the Personal Information Protection Law and Financial Instruments and Exchange Law (Japan's version of the American Sarbanes-Oxley [SOX] Act). Fujitsu is making ongoing enhancements in the GS series to functions required for internal controls, such as user management functions for preventing malicious system penetration, access control functions for allowing system access to only authenticated users, and monitoring/logging functions for monitoring access violations.

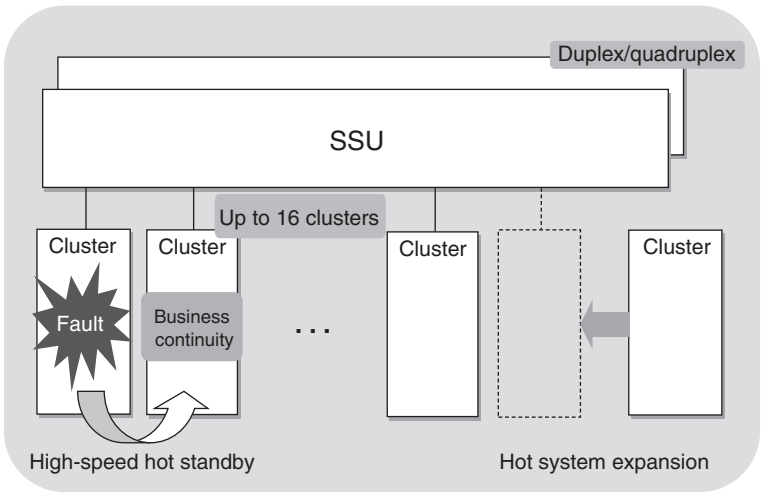


Figure 2
GS21 multicluster system.

Fujitsu is responding to changes in the social environment in this way.

3. GS hardware

3.1 System configuration

The single-cluster model of the new GS21 1600 model group features up to 16 CPUs, up to 256 channels, and up to 256 GB of main memory. The multicluster model can interconnect up to 16 clusters via an SSU having up to 256 GB of memory, so it can provide a system with up to 256 CPUs. The SSU interconnecting multiple clusters comes in a duplex configuration as standard or quadruplex configuration as an option.

3.2 Performance

The GS21 1600 model group has 30% higher single-cluster-system performance than its predecessor (GS21 900). The performance range from its entry model to its high-end model is about 44 times, which enables the construction of an optimal system to suit the amount of processing capability needed. Processing capability can be increased by CPU upgrades. Moreover, in the multicluster model, the system can be extended by adding CPUs and increasing the number of clusters.

3.3 Supporting technologies

3.3.1 Multicore technology

The number of transistors per chip has been increased to about 600 million by using 65-nm copper wiring, which is adopted for advanced complementary metal oxide semiconductor (CMOS) technology. Moreover, the use of recently developed multicore technology enables four CPUs with a 128-KB primary cache memory to be implemented on a single chip together with a 6-MB secondary cache memory, which improves integration and performance.

3.3.2 High-density packaging technology

The GS21 1600 model group uses a thin-glass-ceramic flip chip ball grid array (FCBGA) package to improve power-supply characteristics. A CPU is enclosed in a CPU module mounted onto the system board via a connector, which enables a faulty CPU in the customer's system to be exchanged. The use of a single-board system (**Figure 3**) holding up to 16 CPUs as well as main memory and other important units saves space and power.

3.3.3 High-speed processing technology

Three key measures have been taken in the GS series to achieve high-speed processing:

- Support for a high-speed architecture such as the super scalar system, which processes multiple instructions in parallel, and out-of-order execution, which executes subsequent instructions, if executable, before instructions that are currently waiting for CPU access.[1)]
- Use of Fujitsu-developed ultrahigh-speed

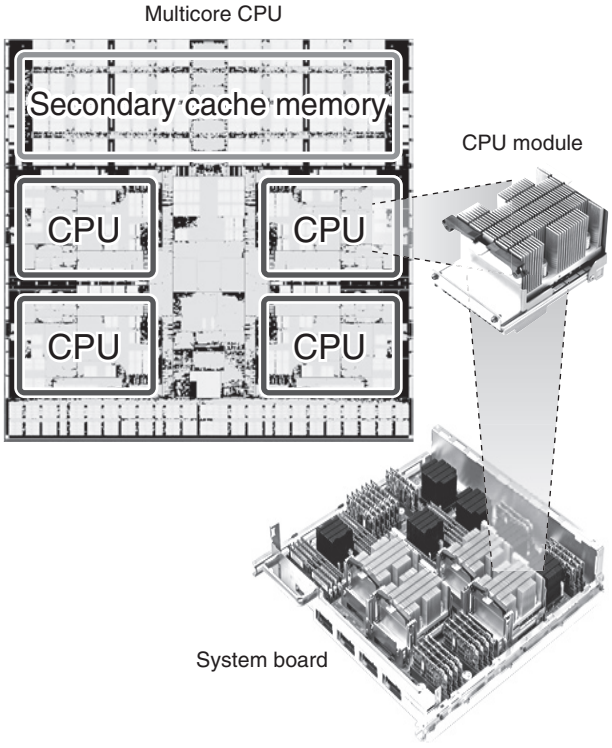


Figure 3
Multicore-CPU and single-board system.

inter-chip synchronous transmission technology on the buses interconnecting chips mounted on the system board. This technology enables high-speed transmission even over long distances and improves total system throughput by incorporating automatic clock-phase adjustment and automatic adjustments for each data line in response to environment-related variations in voltage, temperature, and other characteristics.

- Reduction of data-transfer overhead in the dedicated interface between the SSU and clusters to improve data-transfer speed by as much as 80% compared with prior equipment (GS21 900).

3.4 Reliability, availability, and serviceability

The interface between the SSU and clusters in the multicluster model has a redundant configuration so that a redundant path can be used in the event of a fixed fault in the interface. This enables operations to continue while data-transfer performance is maintained. Moreover, in the event of intermittent faults at two or more locations, the system executes hardware-based retries so that operations can continue while a redundant configuration is maintained without disconnection. Error checking and correction (ECC) is used in inter-unit interfaces within clusters and the SSU so that data can be automatically corrected even in the case of a 1-bit fixed fault and operations can be continued. A redundant configuration is also used in channels, the power supply, and cooling fans, which enables hot replacement in the event of a fault without the system being halted.

3.5 Channels

Simultaneous operation of up to 32 multiplexed channels per Fibre Channel link (FCLINK) can be achieved by connecting an FCLINK, which provides high-speed, high-capacity data transfer (up to 100 MB/s), to disk array equipment (ETERNUS) via an FCLINK switch. This channel-path consolidation improves input/output (I/O) throughput and reduces the number of I/O cables that must be installed. The number of FCLINK channels per cluster has also been increased by 50% from 122 to 186 to support system integration and business expansion and fortify the I/O connection environment.

3.6 SSU

The SSU, which consists of high-speed, large-capacity semiconductor memory devices, can connect to up to 16 clusters. It enables the system to perform high-speed inter-cluster communications control and inter-cluster exclusive control. Thus, it provides the basis for constructing a high-reliability system. It also supports battery-powered operation, which enables data to be protected in the event of a power outage. A 10 Gigabit (10-Gb/s) attachment unit interface (XAUI) is used in the interface between the GS21 1600 SSU and clusters to achieve high-speed data transfers. The occupation time of management tables used by multiple clusters, which has traditionally been a concern, has been shortened by speeding up exclusive-control instructions and thereby raising the processing capability of the entire system. Finally, the SSU's memory size has been increased four-fold compared with prior equipment (GS21 900).

3.7 Green IT

3.7.1 Low-power design

Power consumption has been reduced by about 20% compared with the prior product (GS21 900) by using multicore processors, using flash memory in disk devices used for system control, using low-on-resistance devices in power-supply units, and raising efficiency through an enhanced transformer structure.

3.7.2 Reduction of harmful materials

Volatile organic compounds (VOCs) have

been completely eliminated from the paint used on the chassis and replaced by solventless powder coating. Fujitsu is promoting the use of lead-free solder in the mounting of all electronic devices on printed circuits boards, such as the system board and channel boards, and is complying with EU's Restriction of Hazardous Substances (RoHS) directive and laws and regulations governing harmful materials in various countries.

4. GS software

GS software provides up-to-date functions in response to social changes and market trends while making the most of hardware features.

4.1 Large-scale, high-reliability, and high-performance operations

System scale is growing as business platforms expand to accommodate corporate mergers and business integrations. At the same time, the ability to access a huge amount of stored information quickly and securely at any time is becoming a prime customer requirement. GS software is responding to these trends in system requirements in the following ways.

4.1.1 Support for large-scale systems

To simplify system integration and business expansion, GS software supports system expansion by expanding main-memory size and SSU capacity, the number of disk devices that the system can connect to, the number of applications, the number of jobs per system, etc.

4.1.2 Support for high-reliability requirements

GS software supports 24/7 business continuity and protects customer assets by incorporating diverse measures. These include early detection of anomalies in GS hardware, localization of adverse effects on jobs in the event of a CPU fault, elimination of adverse effects on business at the time of a main-memory fault by alternative-page allocation, high-speed hot standby to deal with a cluster failure in a multicluster configuration, fallback operation of a faulty SSU, and hot system maintenance and expansion of clusters and SSUs.

4.1.3 Support for high-performance requirements

GS software works to make full use of GS-hardware performance to increase processing capability. For example, it uses an appropriate job-allocation system to raise memory-access performance, exploits the high-speed features of the SSU to improve database performance, and improves communication performance between clusters in a multicluster configuration.

4.2 Seamless linking with open servers

It is now possible to provide a system platform that can provide quick support for new business ventures by fusing a GS system, which features high performance, high reliability, and storage of huge volumes of information, with an open-server system (e.g., Windows, Linux, or Solaris), which consists of a wide assortment of applications, and by deploying such a fused system appropriately (**Figure 4**). Seamless linking is being achieved between GS systems and open servers on the basis of this concept.

- A service adaptor enables seamless linking with the open-server system by reusing GS business applications.
- Database replication enables up-to-date data on the GS to be supplied to the open-server system.
- Remote database access enables the open server to directly refer to and update data on the GS.

In relation to the above, the Eclipse open-source development tool, which makes effective use of the know-how of open-system software engineers in customers' information system departments, is available to support the construction of a linked environment.

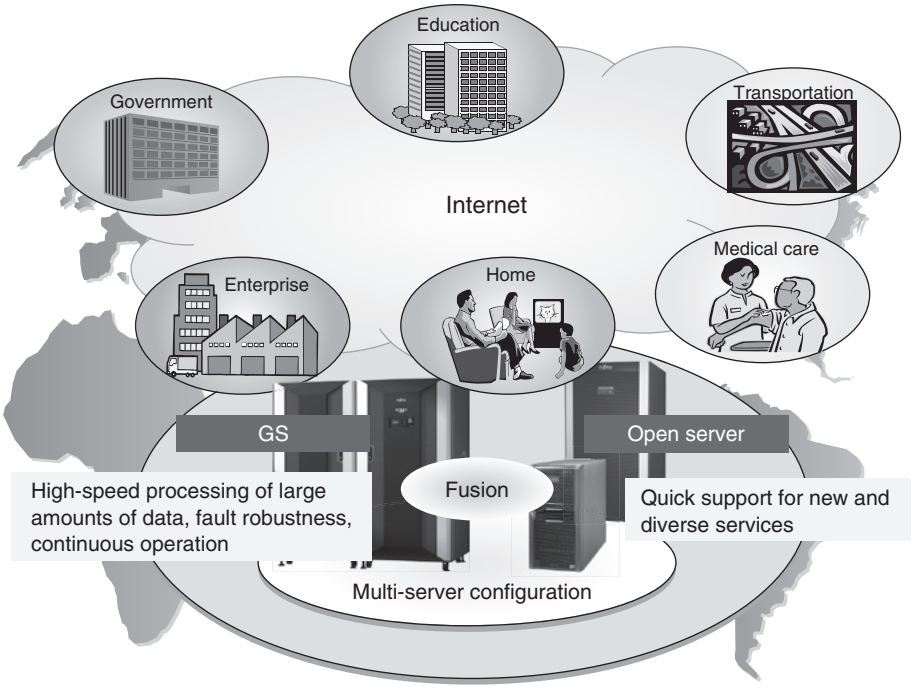


Figure 4
Fusion of GS and open server.

5. Conclusion

This paper described the features of Fujitsu's GS mainframe series and introduced Fujitsu's efforts to enhance GS hardware and software. Against the background of a dramatically changing business environment and increasing demand for cost reductions, the GS series, which plays a core role in information systems, is being asked to provide customers with an even greater level of asset inheritance as well as greater performance and reliability. Fujitsu will closely develop hardware and software to make ongoing improvements in performance and reliability and optimize the entire system. While incorporating advanced technologies, Fujitsu is working to enhance multicluster and virtualization functions, support high-speed channels and high-speed networks, and promote green IT. In the coming era of Cloud computing, Fujitsu will continue to provide evolved GS mainframes as core servers for social infrastructures and contribute to the growth and enhanced value of its customers' business operations.

Reference

1) H. Egawa et al.: Global Server: GS21. (in Japanese), *FUJITSU*, Vol. 53, No. 6, pp. 471–476 (2002).

Takashi Chiba
Fujitsu Ltd.
Mr. Chiba is engaged in the planning and development of GS software.

Kouji Sano
Fujitsu Ltd.
Mr. Sano is engaged in the design and development of GS SSU hardware.

Kouji Toyonishi
Fujitsu Ltd.
Mr. Toyonishi is engaged in the simulation of GS system hardware.

Yoshitsugu Gotou
Fujitsu Ltd.
Mr. Gotou is engaged in the design and development of GS system-board hardware.