BladeSymphony® 1000 Architecture

White Paper

BladeSymphony 1000

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Chapter 1
Introduction

Executive Summary

Blade servers pack more compute power into a smaller space than traditional rack-mounted servers. This capability makes them an attractive alternative for consolidating servers, balancing or optimizing data center workloads, or simply running a wide range of applications at the edge or the Web tier.

However, concerns about the reliability, scalability, power consumption, and versatility of conventional blade servers keeps IT managers from adopting them in the enterprise data center. Many IT professionals believe that blade servers are not intended for mission-critical applications or compute-intensive workloads.

Leveraging their vast experience in mainframe systems, Hitachi set out to design a blade system that overcomes these perceptions. The result is BladeSymphony® 1000, the first true enterprise-class blade server. The system combines Virtage embedded virtualization technology, a choice of industry-standard Intel® processor-based blade servers, integrated management capabilities, and powerful, reliable, scalable system resources — enabling companies to consolidate infrastructure, optimize workloads, and run mission-critical applications in a reliable, scalable environment.

For organizations interested in reducing the cost, risk, and complexity of IT infrastructure — whether at the edge of the network, the application tier, the database tier — or all three — BladeSymphony 1000 is a system that CIOs can rely on.

Introducing BladeSymphony 1000

BladeSymphony 1000 provides enterprise-class service levels and unprecedented configuration flexibility using open, industry-standard technologies. BladeSymphony 1000 overcomes the constraints of previous-generation blade systems to deliver new capabilities and opportunities in the data center.[1]

Blade systems were originally conceived as a means of increasing compute density and saving space in overcrowded data centers. They were intended primarily as a consolidation platform. A single blade enclosure could provide power, cooling, networking, various interconnects and management, and individual blades could be added as needed to run applications and balance workloads. Typically blade servers have been deployed at the edge or the Web tier and used for file-and-print or other non-critical applications.

However, blade servers are not yet doing all they are capable of in the enterprise data center. The perception persists that they are not ready for enterprise-class workloads. Many people doubt that blade servers can deliver the levels of reliability, scalability, and performance needed to meet the most stringent workloads and service-level agreements, or that they are open and adaptable enough to keep pace with fast-changing business requirements.

1. This section and other sections of this chapter draw on content from “2010 Winning IT Management Strategy,” by Nikkei Solutions Business, published by Nikkei BP, August 2006.

BladeSymphony 1000 (Figure 1) is the first blade system designed specifically for enterprise-class, mission-critical workloads. It is a 10 rack unit (RU) system that combines Hitachi's Virtage embedded virtualization technology, a choice of Intel Dual-Socket, Multi-Core Xeon and/or Intel Dual-Core Itanium Server Blades (running Windows or Linux), centralized management capabilities, high-performance I/O, and sophisticated reliability, availability, and serviceability (RAS) features.

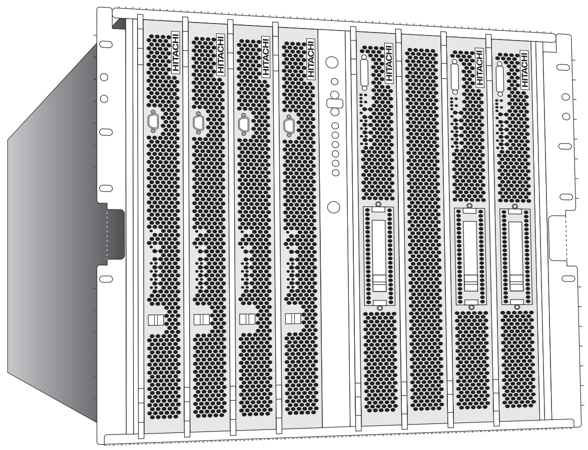

Figure 1. BladeSymphony 1000 front view

Enterprise-Class Capabilities

With BladeSymphony 1000, it is now possible for organizations to run mission-critical applications and consolidate systems and workloads with confidence — at the edge, the application tier, the database tier, or all three. BladeSymphony 1000 allows companies to run any type of workload with enterprise-class performance, reliability, manageability, scalability, and flexibility. For example:

- BladeSymphony 1000 can be deployed at the edge tier — similar to dual-socket blade and rack server offerings from Dell, HP, IBM, and others — but with far greater reliability and scalability than competitive systems.
- BladeSymphony 1000 can be deployed at the application tier — similar to quad-socket blade server offerings from HP and IBM, but with greater reliability and scalability.
- BladeSymphony 1000 ideal for the database tier — similar to the IBM p-Series or HP rack-mount servers, but with a mainframe-class virtualization solution.

Designed with to be the first true enterprise-class blade server, the BladeSymphony 1000 provides outstanding levels of performance, scalability, reliability, and configuration flexibility.

- **Performance** — BladeSymphony 1000 supports both Intel Dual-Core Itanium and Dual-Core or Quad-Core Xeon processors in the same chassis. Utilizing Intel Itanium processors, it delivers 64-bit processing and large memory capacity (up to 256 GB) in an SMP configuration, as well as single Intel Xeon blade configurations, allowing organizations to optimize for 64-bit or 32-bit workloads and run all applications at extremely high performance. BladeSymphony 1000 also delivers large I/O capacity for high throughput.
- **Scalability** — BladeSymphony 1000 is capable of scaling out to eight Intel Dual-Core Itanium processor-based server blades in the same chassis, or scaling up to two 16 core SMP servers with Intel Dual-Core Itanium processor-based server blades.

- **Reliability** — Reliability is increases through redundant components and components are hot-swappable. Other reliability features include:
  - Hitachi's mainframe-class memory management
  - Redundant switch and management modules
  - Extremely reliable backplane and I/O
  - Multi-configurable power supplies for N+1 or full redundancy options
  - Failover protection following the N+M model — there are "M" backup servers for every "N" active servers, so failover is cascading
  - In the event of hardware failure, the system automatically detects the fault and identifies the problem by indicating the faulty module, allowing immediate failure recovery.
- **Configuration Flexibility** — BladeSymphony 1000 supports Itanium and/or Xeon processor-based server blades, Windows and/or Linux, and industry-standard, best-of-class PCI cards (PCI-X and PCI Express), providing flexibility and investment protection. The system is extremely expandable in terms of processor cores, I/O slots, memory, and other components.

Data Center Applications

With its enterprise-class features, BladeSymphony 1000 is an ideal platform for a wide range of data center scenarios, including:

- **Consolidation** — BladeSymphony 1000 is an excellent platform for server and application consolidation because it is capable of running 32-bit and 64-bit applications on Windows or Linux, with enterprise-class performance, reliability, and scalability.
- **Workload Optimization** — BladeSymphony 1000 runs a wide range of compute-intensive workloads on either/both Windows and Linux, making it possible to balance the overall data center workload quickly and without disruption or downtime.
- **Resource Optimization** — BladeSymphony 1000 enables the IT organization to increase utilization rates for expensive resources such as processing power, making it possible to fine-tune capacity planning and delay unnecessary hardware purchases.
- **Reduce Cost, Risk, and Complexity** — With BladeSymphony 1000, acquisition costs are lower than traditional rack-mount servers. Enterprises can scale up on demand in fine-grained increments, limiting capital expenditures. BladeSymphony 1000 also reduces the risk of downtime with built-in sophisticated RAS features. And with support for industry standards such as Windows and Linux, Itanium and Xeon processors, and PCI-X and PCI Express (PCIe) I/O modules, BladeSymphony 1000 is designed for future and protects previous investments in technology.

Chapter 2

System Architecture Overview

BladeSymphony 1000 features a very modular design to maximize flexibility and reliability. System elements are redundant and hot-swappable so the system can be easily expanded without downtime or unnecessary disruption to service levels. The key components of the system, illustrated in Figure 2, consist of:

- Server Blades — Up to eight depending on module, available with Intel Xeon or Itanium processors
- Storage Modules — up to two modules supporting either three or six SCSI drives
- I/O Modules — available with PCI-X slots, PCIe slots, or Embedded Fibre Channel Switch, up to two modules per chassis
- Small footprint chassis containing a passive backplane — eliminates a number of FC and network cables
- Redundant Power Modules — up to four hot-swap (2+1 or 2+2) modules per chassis for high reliability and availability
- Redundant Cooling Fan Modules — four hot-swap (3+1) per chassis standard configuration for high reliability and availability
- Switch & Management Modules — hot-pluggable system management board, up to two modules per system for high reliability and availability

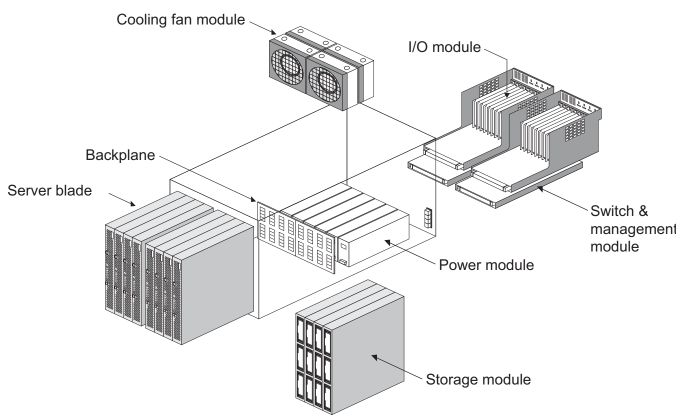

Figure 2. Key BladeSymphony 1000 components

The server blades and I/O modules are joined together through a high speed backplane. Two types of server blades are available: Intel Xeon Server Blade and Intel Itanium Server Blade. A 10 RU BladeSymphony 1000 server chassis can accommodate eight server blades of these types. It can also accommodate a mixture of server blades, as well as storage modules. In addition, multiple Intel Itanium Server Blades can be combined to build multiple Symmetric Multi Processor (SMP) configurations. Figure 3 shows a logical diagram of modules interconnecting on the backplane for a possible configuration with one SMP server and one Intel Xeon server, as well as various options for hard drive and I/O modules.

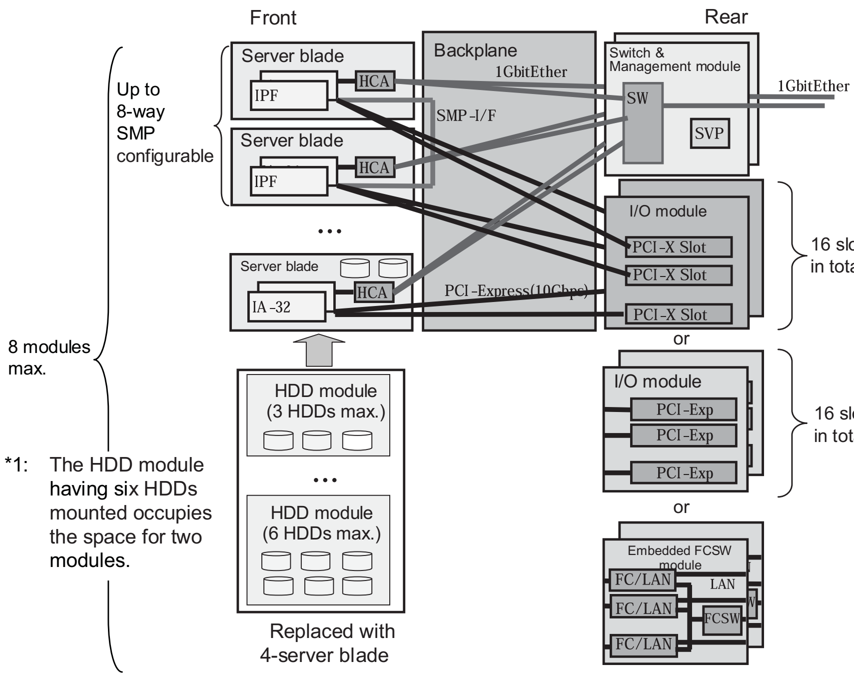

Figure 3. Logical components of the BladeSymphony 1000

The following chapters detail the major components of BladeSymphony 1000, as well as management software and Virtage embedded virtualization technology.

- “Intel Itanium Server Blade” on page 8 provides details on the Intel Itanium Server Blades and how they can be combined to create SMP systems up of to 16 cores and 256 GB of memory.
- “Intel Xeon Server Blade” on page 20 provides details on the Intel Xeon Server Blades.
- “I/O Sub System” on page 26 provides details on the PCI-X, PCIe, and Embedded Fibre Channel Switch modules.
- “Chassis, Power, and Cooling” on page 36 provides details on the two chassis models, as well as Power and Cooling Fan Modules.
- “Reliability and Serviceability Features” on page 39 discusses the various reliability, availability, and serviceability features of the BladeSymphony 1000.
- “Management Software” on page 45 discuss software management features.
- “Virtage” on page 48 provides technical details on Virtage embedded virtualization technology.

Chapter 3

Intel Itanium Server Blade

The BladeSymphony 1000 can support up to eight blades for a total of up to 16 Itanium CPU sockets, or 32 cores, running Microsoft Windows or Linux. Up to four Intel Itanium Server Blades can be connected via the high-speed backplane to form a high-performance SMP server of up to 16 cores.

Each Intel Itanium Server Blade, illustrated in Figure 4, includes 16 DDR2 main memory slots. Using 4 GB DIMMs, this equates to 64 GB per server blade (16 GB per core) or 256 GB in a 16 core SMP configuration, making it an ideal candidate for large in-memory databases and very large data sets. Each server blade also includes two gigabit Ethernet ports, which connect to the internal gigabit Ethernet switch in the chassis, as well as two front-side accessible USB 1.1 ports for local media connectivity and one RS-232 port for debugging purposes.

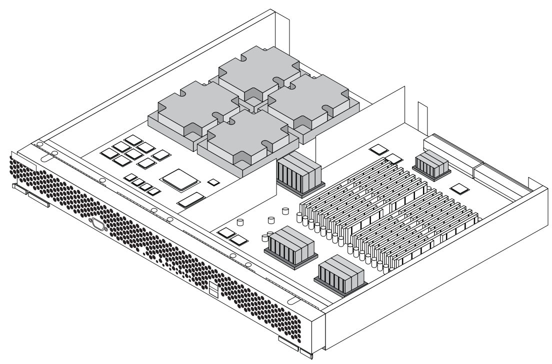

Figure 4. Intel Itanium Server Blade

Intel Itanium Server Blades include the features listed in Table 1.

Table 1: Intel Itanium Server Blade features

Item		Specifications
Processors	Processor model and maximum number of installed processors	Intel® Itanium® 2 Processor 9100 series, 1.66 GHz L3=24 MB FSB=667 MHz: 2 Intel Itanium Processor 9100 series, 1.66 GHz L3=18 MB FSB=667 MHz: 2 Intel Itanium Processor 9100 series, 1.42 GHz L3=12 MB FSB=400 MHz: 2
	SMP configuration	Maximum 16 cores with four server blade configuration

Table 1: Intel Itanium Server Blade features

Item		Specifications
Memory	Capacity	Max. 64 GB/server blade (if 4 GB DIMM is used)
	Type	DDR2 240-pin registered DIMM, 1 rank, 2 rank Frequency: DDR2-400 3-3-3 Capacity: 512 MB, 1 GB, 2 GB, 4 GB (DDR2-533) Configuration: 4 bit x 18 devices, 36 devices
	Availability	Advanced ECC, on-line spare memory, and scrubbing supported
Backplane interface	Node link for SMP	Three interconnect ports
	PCI Express	x 4 links, 2 ports
	Gigabit Ethernet	GbE (SerDes 1.25 Gb/sec.) 2 ports, Wake on LAN supported
	USB	Two ports per partition
	Fast Ethernet (LAN management)	Two100Base/10Base ports
	I2C	One port
Interface on the front of module	USB	Two ports per physical partition Compatible with USB 1.1
	Serial	One RS-232C port, for debugging only
I/O function	SCSI or RAID	None (I/O module required for this function
	VGA	None (I/O module required for this function)

Table 2 provides details on each of the components in the Itanium Blade.

Table 2: Main components of the Intel Itanium Server Blade

Component	Manufacturer	Quantity	Description
Processor	Intel	Maximum 2	Intel Itanium
Node Controller (NDC)	Hitachi	1	Node controller — controls each system bus
MC	Hitachi	2	Memory controller
DIMM		Maximum 16	DDR2 SDRAM

Table 2: Main components of the Intel Itanium Server Blade

Component	Manufacturer	Quantity	Description
Bridge	Intel	1	PCIe to PCI-X bridge
South Bridge	Intel	1	South bridge — connects legacy devices
SIO	SMSC	1	Super I/O chip — contains the COM port and other legacy devices
FW ROM	ATMEL/ STMicro	8 MB	A flash ROM storing the images of system firmware Also used as NVRAM under the control of the system firmware
Gigabit Ethernet	Intel	1	Gigabit Ethernet interface controller, two ports, SerDes connection Wake on LAN supported TagVLAN supported PXE Boot supported
USB controller	VIA	1	Compatible to UHCI and EHCI
BMC	Renesas	1	Management processor
BMC SRAM	Renesas	2 MB, with parity	Main memory for management processor
FPGA	Xilinx	1	Controls the BMC bus, decodes addresses and functions as a bridge for LPC
Flash ROM	Fujitsu	16 MB	Backs up BMC codes and SAL
BUS SW switching over BMC-SVP		1	Reserved for the SVP duplex (future)

Intel Itanium Processor 9100 Series

The Dual-Core Intel Itanium 9100 series 64-bit processor delivers scalable performance with two high-performance cores per processor, memory addressability up to 1024 TB, 24 MB of on-die cache, and a 667 MHz front-side bus. It also includes multi-threading capability (two threads per core) and support for virtualization in the silicon.

Explicitly Parallel Instruction Computing (EPIC) technology is designed to enable parallel throughput on a enormous scale, with up to six instructions per clock cycle, large execution resources (128 general-purpose registers, 128 floating point registers and 8 branch registers) and advanced capabilities for optimizing parallel throughput.

The processors deliver mainframe-class reliability, availability, and serviceability features with advanced error detection and correction and containment across all major data pathways and the cache subsystem. They also feature integrated, standards-based error handling across hardware, firmware, and the operating system.

The Intel Itanium is optimized for dual processor-based platforms and clusters and includes the following features:

- Wide, parallel hardware based on Itanium architecture for high performance
  - Integrated on-die cache of up to 24 MB, cache hints for L1, L2, and L3 caches for reduced memory latency
  - 128 general and 128 floating-point registers supporting register rotation
  - Register stack engine for effective management of processor resources
  - Support for predication and speculation
- Extensive RAS features for business-critical applications
  - Full SMBus compatibility
  - Enhanced machine check architecture with extensive ECC and parity protection
  - Enhanced thermal management
  - Built-in processor information ROM (PIROM)
  - Built-in programmable EEPROM
  - Socket Level Lockstep
  - Core Level Lockstep
- High bandwidth system bus for multiprocessor scalability
  - 6.4 GB/sec. bandwidth
  - 28-bit wide data bus
  - 400 MHz and 533 data bus frequency
  - 50-bits of physical memory addressing and 64-bits of virtual addressing
- Two complete 64-bit processing cores on one chip running at 104W

Cache

The processor supports up to 24 MB (12 MB per core) of low-latency, on-die L3 cache (14 cycles) providing 102 GB/sec. aggregate bandwidth to the processor cores. It also include separate 16 KB Instruction L1 and 16 KB Data L1 cache per core, as well as separate 1 MB Instruction L2 and 256 KB Data L2 cache per core for higher speed and lower latency memory access.

Hyper-Threading Technology

Hyper-Threading Technology (HT Technology) enables one physical processor to transparently appear and behave as two virtual processors to the operating system. With HT Technology, one dual-core processor is able to simultaneously run four software threads. HT Technology provides thread-level parallelism on each processor, resulting in more efficient use of processor resources, higher processing throughput, and improved performance on multi threaded software, as well as increasing the number of users a server can support. In order to leverage HT Technology, SMP support in the operating system is required.

Intel Cache Safe Technology and Enhanced Machine Check Architecture

Intel Cache Safe Technology is an automatic cache recovery capability that allows the processor and server to continue normal operation in case of cache error. It automatically disables cache lines in the event of a cache memory error, providing higher levels of uptime.

Enhanced Machine Check Architecture provides extensive error detection and address/data path correction capabilities, as well as system-wide ECC protection. It detects bit-level errors and manages data corruption, thereby providing better reliability and uptime.

Intel VT Virtualization Technology

The Dual-Core Intel Itanium processor includes hardware-assisted virtualization support that helps increase virtualization efficiency and broaden operating system compatibility. Intel Virtualization Technology (Intel VT) enables one hardware platform to function as multiple *virtual* platforms. Virtualization solutions enhanced by Intel VT allow a software hypervisor to concurrently run multiple operating systems and applications in independent partitions.

Demand Based Switching

The Demand Based Switching (DBS) function reduces power consumption by enabling the processor to move to power-saving mode when under a low system load. The DBS function must be supported by the operating system.

Hitachi Node Controller

The Hitachi Node Controller controls various kinds of system busses, including the front side bus (FSB), a PCIe link, and the node link. The Hitachi Node Controller is equipped with three node link ports to combine up to four server blades. The server blades connect to each other through the node link, maintain cache coherence collectively, and can be combined to form a ccNUMA type multiprocessor configuration. The Hitachi Node Controller is connected to memory modules through memory controllers.

The Hitachi Node Controller provides the interconnection between the two processors, two memory controllers, three PCI bus interfaces, and connection to up to three other Intel Itanium Server Blades. Three x 5.3 GB/sec. links can connect up to three other Intel Itanium Server Blades over the backplane in order to provide 8, 12, or 16 core SMP capabilities. These direct connections provide a distinct performance advantage by eliminating the need for a cross bar switch found in most SMP system designs, which reduces memory access latency across server blades.

The Hitachi Node Controller is equipped with three PCIe ports to connect to I/O devices. Two of the PCIe ports are used to connect to the I/O modules. The remaining port connects to an onboard I/O device installed on the server blade, which serves a gigabit Ethernet controller, USB controller, and COM ports.

The Hitachi Node Controller is designed for high performance processors and memory. Throughput numbers to the processors, memory, and other nodes are listed in Table 3.

Table 3: Bus throughput from the Hitachi Node Controller

Bus	Throughput
Processor bus	400 MHz FSB = 6.4 GB/sec. 667 MHz FSB = 10.6 GB/sec.
Memory bus	400 MHz FSB = 4.8 GB/sec. 667 MHz FSB = 5.3 GB/sec.

Table 3: Bus throughput from the Hitachi Node Controller

Bus	Throughput
Connection between nodes	400 MHz FSB = 4.8 GB/sec. 667 MHz FSB = 5.3 GB/sec.

Baseboard Management Controller

The Baseboard Management Controller (BMC) is the main controller for Intelligent Platform Management Interface (IPMI), a common interface to hardware and firmware used to monitor system health and manage the system. The BMC manages the interface between system management software and the hardware in the server blade. It is connected to the service processor (SVP) inside the Switch & Management Module. The BMC and SVP cooperate with each other to control and monitor the entire system. Sensors built into the system report to the BMC on different parameters such as temperature, cooling fan speeds, power, mode, OS status, etc. The BMC can send alerts to the system administrator if the parameters vary from specified preset limits, indicating a potential failure of a component or the system.

Memory System

Intel Itanium Server Blades are equipped with 16 DIMM slots, which support Registered DDR2-400 SDRAM in 512 MB, 1 GB, 2 GB, and 4 GB (DDR2-533) for a total of up to 64 GB per server blade, or 16 GB per core. The memory system is designed to control a set of four DIMMs for the ECC and the memory-device replacing function. Accordingly, if DIMMs are added, they must be arranged in four DIMM units. The different DIMMs in each row can be used logically as shown in Figure 5.

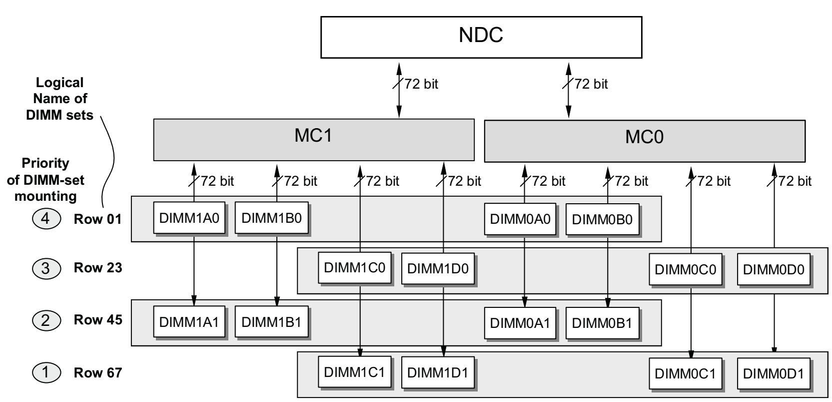

Figure 5. Memory configuration

The memory system of the Intel Itanium Server Blade includes several RAS features:

- ECC protection (S2EC-D2ED) — Detects an error in any two sets of consecutive two bits and corrects errors in any one set of consecutive two bits.

- ECC — The ECC can correct an error in consecutive four bits in any four DIMM set (i.e., a fault in one DRAM device). This function is equivalent to technology generally referred to as *Chipkill* and allows the contents of memory to be reconstructed even if one chip completely fails. The concept is similar to the way RAID protects content on disk drives.
- Memory device replacing function — The NDC and MC have a function to replace a faulty DRAM device with a normal spare one assisted by the System Abstraction Layer (SAL) firmware. This keeps the ECC function (S2EC-D2ED) operating. It can replace up to two DRAM devices in any one set of four DIMMs.
- Memory hierarchy table (size, bandwidth/latency)
- L1 cache
- L2 cache
- L3 cache
- On board memory
- Off board memory
- Interleaved vs. non-interleaved memory configuration
- ccNUMA (cache coherent Non-uniform memory access) description

SMP Capabilities

While dual processors systems are now common place, increasing the number of processors/sockets beyond two poses many challenges in computer design, particularly in the memory system. As processors are added to a system the amount of contention for memory access quickly increases to the point where the intended throughput improvement of more processors is significantly diminished. The processors spend more time waiting for data to be supplied from memory than performing useful computing tasks. Conventional uniform memory systems are not capable of scaling to larger numbers of processors due to memory bus contention. Traditional large SMP systems introduce cross bar switches in order to overcome this problem. However, this approach adds to the memory hierarchy, system complexity, and physical size of the system. SMP systems typically do not possess the advantages of blade systems, e.g., compact packaging and flexibility.

Leveraging their extensive mainframe design experience, Hitachi employs a number of advanced design techniques to create a blade-based SMP system, allowing the BladeSymphony 1000 to scale up to an eight socket, 16 core system with as much as 256 GB of memory. The heart of the design is the Hitachi custom designed Node Controller, which effectively breaks a large system into smaller, more flexible nodes or server blades in blade format. These server blades can act as complete, independent systems or up to four server blades can be connected to form a single, efficient multi-processor system, as illustrated in Figure 6.

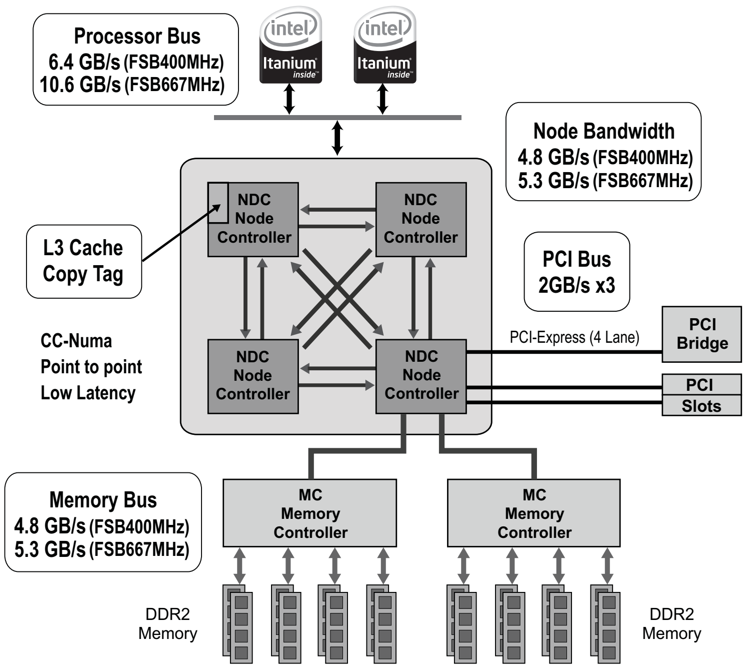

Figure 6. Hitachi Node Controller connects multiple server blades

By dividing the SMP system across several server blades, the memory bus contention problem is solved by virtue of the distributed design. A processor's access to its on-board memory incurs no penalty. The two processors (four cores) can access up to 64 GB at the full speed of local memory. When a processor needs data that is not contained in its locally attached memory, its node controller needs to contact the appropriate other node controller to retrieve the data. The latency for retrieving that data is therefore higher than retrieving data from local memory. Since remote memory takes longer to access, this is known as a non-uniform memory architecture (NUMA). The advantage of using non-uniform memory is the ability to scale to a larger number of processors within a single system image while still allowing for the speed of local memory access.

While there is a penalty for accessing remote memory, a number of operating systems are enhanced to improve the performance of NUMA system designs. These operating systems take into account where data is located when scheduling tasks to run on CPUs, using the closest CPU where possible. Some operating systems are able to rearrange the location of data in memory to move it closer to the processors where its needed. For operating systems that are not NUMA aware, the BladeSymphony 1000 offers a number of memory interleaving options that can improve performance.

The Node Controllers can connect to up to three other Node Controllers providing a point-to-point connection between each Node Controller. The advantage of the point-to-point connections is it eliminates a bus, which would be prone to contention, and eliminates the cross bar switch, which reduces contention as a bus, but adds complexity and latency. A remote memory access is streamlined because it only needs to pass through the two Node Controllers, this provides less latency when compared to other SMP systems.

SMP Configuration Options

BladeSymphony 1000 supports two socket (four-core) Intel Itanium Server Blades that can be scaled to offer up to two 16 core servers in a single chassis or eight four core servers, or a mixture of SMP and single module systems, thus reducing footprint and power consumption while increasing utilization and flexibility. SMP provides higher performance for applications that can utilize large memory and multiple processors, such as large databases or visualization applications.

The maximum SMP configuration supported by BladeSymphony 1000 is:

- Four Dual Core Intel Itanium Server Blades for a total of 16 CPU cores
- 256 GB memory (64 GB per server blades x 4)
- Eight gigabit NICs (2 on-board per server blade) connected to two internal gigabit Ethernet switches
- Eight PCI-X slots (or 16 PCI-X slots with chassis B)

With its unique interconnect technology, BladeSymphony 1000 delivers a new level of flexibility in adding computing resources to adapt to changing business needs. BladeSymphony 1000 can address scalability requirements by scaling-out (horizontally), or by scaling-up (vertically). Scaling out is ideally suited to online and other front-end applications that can divide processing requirements across multiple servers. Scaling out can also provide load-balancing capabilities and higher availability through redundancy.

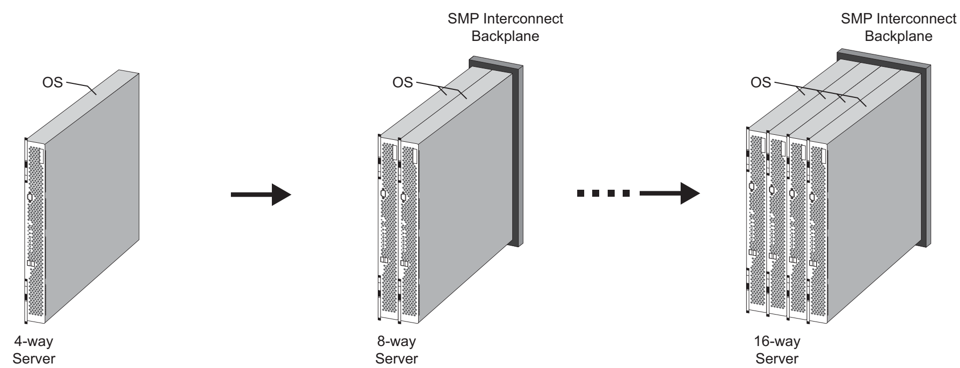

Figure 7. Scale-up capabilities

Scaling up is accomplished through SMP, shown in Figure 7. This approach is better suited to enterprise-class applications requiring 64-bit processing, high computational performance, and large memory addressability beyond that provided in a typical x86 environment. BladeSymphony 1000 SMP Interconnect technology and blade form factor allow IT staff to manage scale-up operations on their own, without a service call. The interconnect allows up to four server blades to be joined into a single server environment composed of the total resources (CPU, memory, and I/O) resident in each module.

NUMA Architecture

The Intel Itanium Server Blade supports two memory interleave modes, full and non-interleave. In full interleave mode, the additional latency in accessing memory on other server blades is averaged across all memory, including local memory, to provide a consistent access time. In non-interleave mode, a server blades has faster access to local memory than to memory on other server blades. Both of these options are illustrated in Figure 8.

- Full interleave mode (or SMP mode) — Intended for use with an OS without support for the NUMA architecture or with inadequate support for NUMA. In full interleave mode, main memory is interleaved between CPU modules in units. Since memory accesses do not concentrate on one CPU module in full interleave mode, memory bus bottlenecks are less likely and latency is averaged across CPUs.
- Non-interleave mode — This mode specifies the ratio of local memory at a constant rate. Use non-interleave mode with an OS that supports NUMA. In non-interleave mode, memory is not interleaved between CPU modules. An OS supporting NUMA performs process scheduling and memory allocation so that memory accesses by processors only take place within the subject node (CPU module). An OS with APIs for NUMA also allows applications running on it to perform optimization, taking advantage of node-localized memory accesses and enabling higher system performance.

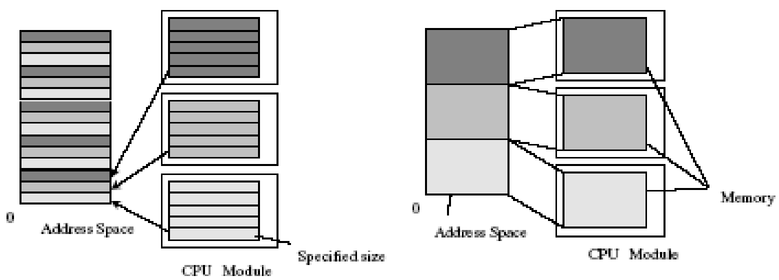

Figure 8. Full interleave mode and non-interleave mode

- Mixture mode — This mode specifies the ratio of a local memory at a constant rate. There can be some restrictions on the ratio of local memory, according to the NUMA function support level of operating system in use. Figure 9 shows examples of all three types of modes.

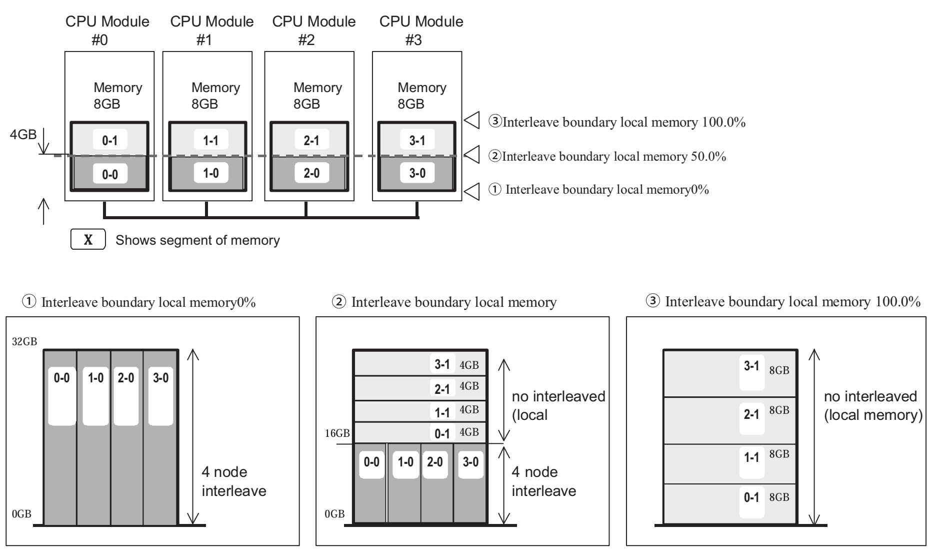

Figure 9. Examples of interleaving

L3 Cache Copy Tag

The data residing in caches and main memory across Intel Itanium Server Blades are kept in sync by using a snooping cache coherency protocol. When one of the Intel Itanium processors needs to access memory, the requested address is broadcast by the Hitachi Node Controller. The other Node Controllers that are part of that partition (SMP) listen for (snoop) those broadcasts. The Node Controller keeps track of the memory addresses currently cached in each processor's on-chip caches by assigning a tag for each cache entry. If one of the processors contains the requested data in its cache it initiates a cache-to-cache transfer. This reduces latency by avoiding the penalty to retrieve data from main memory and helps maintain consistency by sending the requesting processor the most current data. In order to save bandwidth on the processors' front side bus, the Node Controller is able to use the L3 Cache Copy Tags to determine which memory address broadcasts its two local processors need to see. If a requested address is not in the processors' cache, the Node Controller filters the request and does not forward the request to the local processors. This process is illustrated in Figure 10.

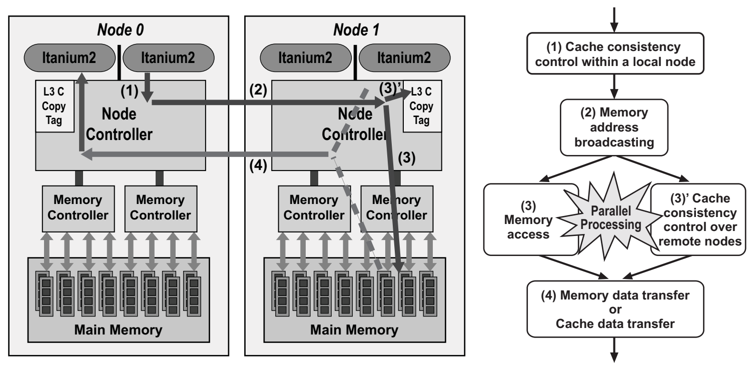

Figure 10. L3 cache copy tag process

Intel Itanium I/O Expansion Module

Some applications require more PCI slots than the two that are available per server blade. The Intel Itanium I/O Expansion Module provides more ports, without the expense of additional server blades. Using the Itanium I/O Expansion Module with the Intel Itanium Server Blade can increase the number of the PCI expansion-card slots that can be connected to the Intel Itanium Server Blade. The Itanium I/O expansion module cannot be used in with the Intel Xeon Server Blade.

The Intel Itanium I/O Expansion Module increases the number of PCI I/O slots to either four or eight slots depending on the chassis type. The type A chassis enables connection to four PCI I/O slots (Figure 11), and the type B chassis enables up to eight PCI I/O slots (Figure 12).

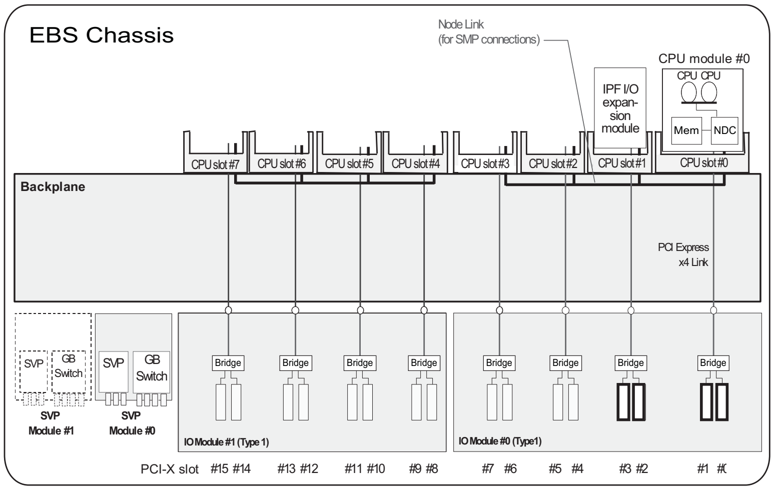

Figure 11. Intel Itanium I/O Expansion Module in type A chassis provides up to four PCI slots per server blade

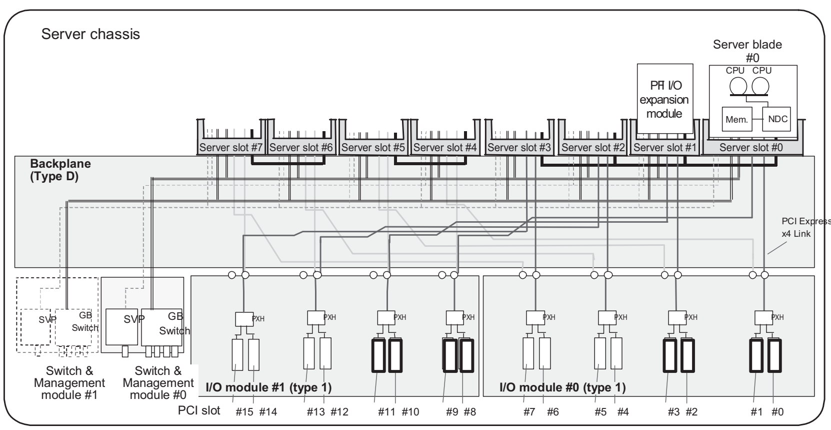

Figure 12. Intel Itanium I/O Expansion Module in type B chassis provides up to eight PCI slots per server blade

Chapter 4
Intel Xeon Server Blade

The eight slot BladeSymphony 1000 can accommodate a total of up to eight Dual-Socket, Dual-Core or Quad-Core Intel Xeon Server Blades for up to 64 cores per system. Each Intel Xeon Server Blade supports up to four PCI slots, and provides the option of adding Fibre Channel or SCSI storage. Two on-board gigabit Ethernet ports are also provided, along with IP KVM for remote access, virtual media support, and front-side VGA and USB ports for direct access to the server blade.

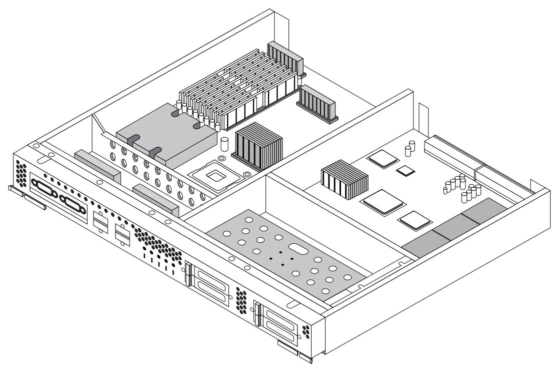

Figure 13. Intel Xeon Server Blade

While the Intel Itanium Server Blades provide SMP and the raw performance that the Itanium processors bring to number-crunching jobs, the Intel Xeon Server Blades, which require less power and cooling, and are less expensive, are ideal for supporting infrastructure and application workloads, as well as 32-bit applications. The components of the Intel Xeon Server Blade are listed in Table 4.

Table 4: Intel Xeon Server Blade components

	Dual Core Intel Xeon Processor			Quad Core Intel Xeon Processor	
Processor Series	5110 Series	5140 Series	5260 Series	E5430 Series	X5460 Series
Processor Frequency	1.60 GHz	2.33 GHz	3.33 GHz	2.66 GHz	3.16 GHz
Number of Processors	Maximum 2 (maximum 4 cores)			Maximum 2 (maximum 8 cores)	
Cache Memory	L2: 4 MB		L2: 6 MB	L2: 2 x 6 MB	
System Bus (FSB) Frequency	1066 MHz	1333 MHz			
Main Memory	ECC DDR2-667 FB-DIMM Advanced ECC / Memory Mirroring				

Table 4: *Intel Xeon Server Blade components*

	Dual Core Intel Xeon Processor			Quad Core Intel Xeon Processor	
Capacity	Maximum 32 GB				
Memory Slots	8				
Internal HDD	Up to four 2.5 inch, 73 GB or 146 GB 10K RPM SAS HDD				
Internal Expansion Slot	One (dedicated for RAID card of internal SAS HDD)				
Network Interface	1 Gigabit Ethernet (SERDES), two ports				
Power Consumption (Max)	255 W	306W	370W	370W	420W
Supported OS	Microsoft Windows Server 2003 SP2, Standard Edition Microsoft Windows Server 2003 SP2, Enterprise Edition Microsoft Windows Server 2003 SP2, Standard x64 Edition Microsoft Windows Server 2003 SP2, Enterprise x64 Edition Red Hat Enterprise Linux ES4 Red Hat Enterprise Linux AS 4				

Intel Xeon 5200 Dual Core Processors

The Dual-Core Intel Xeon 5200 Series processors utilizes two 45 nm Hi-k next generation Intel Core microarchitecture cores. The processors feature fast data throughput with Intel I/O Acceleration Technology, up to 6 MB of L2 cache memory that can be allocated entirely to one core, and they support both 32-bit and 64-bit applications. The energy-efficient processors are optimized for low-power, dual-core, 64-bit computing.

Intel Core Mircroarchitecture integrates an efficient 14-stage pipeline and memory architecture design for greater processor throughput with power management technologies that reduce power consumption without affecting performance. The architecture also supports direct L1-to-L1 cache transfer and improved memory pre-fetch.

Other technologies featured in the Intel Xeon 5200 processors include:

- Hyper-Threading Technology — described in “Hyper-Threading Technology” on page 11.
- Intel Virtualization Technology — provides hardware assistance for software-based virtual environments to support new capabilities, including 64-bit operating systems and applications.
- Intel I/O Acceleration Technology (I/OAT) — hardware and software supported I/O acceleration that improves data throughput. Unlike NIC-centric solutions (such as TCP Offload Engine), I/OAT is a platform level solution that addresses packet and payload processing bottlenecks by implementing parallel processing of header and payload. It increases CPU efficiency and delivers data to and from applications faster with improved direct memory access (DMA) technologies that reduce CPU utilization and memory latencies associated with data movement. Finally, I/OAT optimizes the TCP/IP protocol stack to take advantage of the features of the high bandwidth rates of modern Intel processors, thus diminishing the computation load on the processor.

- Intel VT Flex Migration — Intel hardware-assisted virtualization provides the ability to perform live virtual machine migration to enable fail-over, load balancing, disaster recovery, and real-time server maintenance.
- New features include Error Correcting Code (ECC) system bus, new memory mirroring, and I/O hot-plug

Intel Xeon 5400 Quad Core Processors

The Quad-Core Intel Xeon 5400 Series is designed for mainstream, new business, and HPC servers, delivering increased performance, energy efficiency, and the ability to run applications with a smaller footprint. Built with 45 nm enhanced Intel Core microarchitecture, the Quad-Core Intel Xeon 5400 Series delivers 8-thread, 32- and 64-bit processing capabilities with 12 MB of L2 cache per processor, providing more computing for threaded applications in a variety of deployments.

Intel's 45 nm uses 820 million transistors in the Intel Xeon processor 5400 series (Intel Xeon processor 5300 series has 582 million transistors). More transistors deliver more capability, performance, and energy efficiency through expanded power management capabilities. Other enhancements are designed to reduce virtualization overhead. And 47 new Intel Streaming SIMD Extensions 4 (SSE4) instructions can help improve the performance of media and high-performance computing applications.

Other features include:

- Fully Buffered DIMM (FBDIMM) technology that increases memory speed to 800 MHz and significantly improves data throughput
- Memory mirroring and sparing designed to predict a failing DIMM and copy the data to a spare memory DIMM, increasing server availability and uptime
- Support for up to 128 GB memory
- Enhanced Intel SpeedStep technology allows the system to dynamically adjust processor voltage and core frequency, which results in decreased power consumption and heat production

Memory System

The Intel Xeon Server Blade is equipped with eight FBDIMM slots supporting Registered DDR1 SDRAM. Supported capacity includes 512 MB, 1 GB, and 2 GB, DDR1-266 DIMMs. The memory system is designed to control a set of two DIMMs for the memory device replacing function. Accordingly, if DIMMs are added, they must be installed in two-DIMM units. The DIMMs in the same bank must be of the same type. The DIMMs in different banks can be of different types.

FB-DIMM Advantages

Intel supports Fully Buffered DIMM (FBDIMM) technology in the Intel Xeon 5200 dual-core and 5400 quad-core processor series. FBDIMM memory provides increased bandwidth and capacity for the Intel Xeon Server Blade. It increases system bandwidth up to 21 GB/sec. (with DDR2-667 FBD memory). FBDIMM technology offers better RAS by extending the currently available ECC to include protection for commands and address data. Additionally, FBDIMM technology automatically retries when an error is detected, allowing for uninterrupted operation in case of transient errors.

Advanced ECC

Conventional ECC is intended to correct 1-bit errors and detect 2-bit errors. Advanced ECC, also known as Chipkill, corrects up to four or eight bits of an error that occurs in a DRAM installed on a x4- DRAM or x8-DRAM type DIMM, respectively. Accordingly, the system can operate normally even if one DRAM fails, as illustrated in Figure 14.

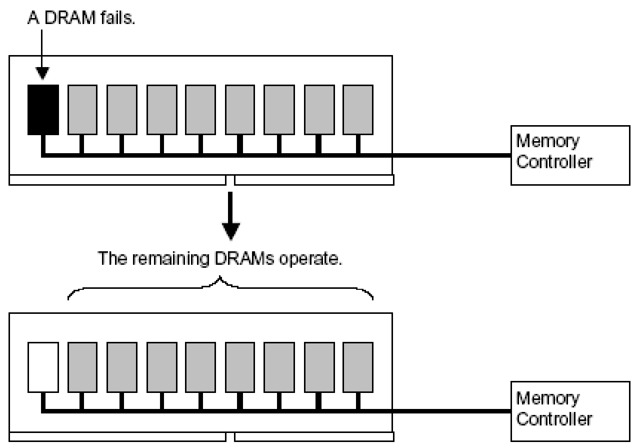

Figure 14. Advanced ECC

Online Spare Memory

Online spare memory provides the functionality to switch over to spare memory if correctable errors frequently occur. This function is enabled to prevent system downtime caused by a memory fault.

BladeSymphony 1000 supports the online spare memory function in the ten patterns of memory configurations listed in Table 5. The shaded sections represent spare banks. Online spare memory excludes the use of the memory mirroring function.

Table 5: Online spare memory supported configurations

Bank	Bank1		Bank2		Bank3		Bank4	
Slot	Slot 1	Slot 2	Slot 3	Slot 4	Slot 5	Slot 6	Slot 7	Slot 8
Configuration 1	2 GB	2 GB	2 GB	2 GB	2 GB	2 GB	2 GB	2 GB
Configuration 2	1 GB	1 GB	1 GB	1 GB	1 GB	1 GB	1 GB	1 GB
Configuration 3	512 MB	512 MB	512 MB	512 MB	512 MB	512 MB	512 MB	512 MB
Configuration 4	2 GB	2 GB	2 GB	2 GB	2 GB	2 GB	None	None
Configuration 5	1 GB	1 GB	1 GB	1 GB	1 GB	1 GB	None	None
Configuration 6	512 MB	512 MB	512 MB	512 MB	512 MB	512 MB	None	None

Table 5: Online spare memory supported configurations

Bank	Bank1		Bank2		Bank3		Bank4	
Configuration 7	2 GB	2 GB	2 GB	2 GB	None	None	None	None
Configuration 8	1 GB	1 GB	1 GB	1 GB	None	None	None	None
Configuration 9	512 MB	512 MB	512 MB	512 MB	None	None	None	None
Configuration 10	256 MB	256 MB	256 MB	256 MB	None	None	None	None

For example, in Configuration 1 the shaded BANK 4 is a spare bank. Assume that the memory correctable errors occur frequently in a memory on BANK 3. BIOS, which keeps counting the memory correctable errors on each bank, activates the online copy function automatically upon the incidence of the fourth error. All of the data on BANK 3 is copied to spare BANK 4. At the same time, a log is recorded explaining that the data is copied to the spare bank, and the system displays a message when the online sparing is complete, at which time the system operates with BANK1, BANK2, and BANK4 (12 GB), the same capacity as before the online spare memory operation occurred.

Memory Mirroring

Mirroring the memory provides a level of redundancy that enables the system to continue operating without the going down in case of a memory fault (including a plural-bits error).

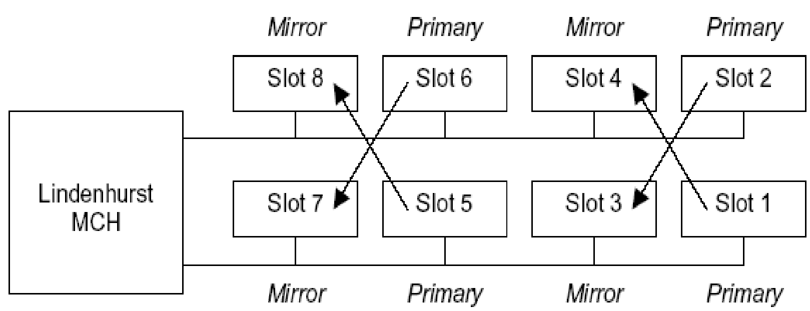

Figure 15. Memory mirroring

When operating in normal conditions, data first writes in the primary (slots 1, 2, 5, and 6), then in the mirror (slots 3, 4, 7, and 8). The arrows in Figure 15 show the relationship between the mirroring source and the destination. When data is read out, it is read out of either the primary or mirror.

No memory testing of the mirror is carried out when the system is booted up after the mirroring is set. Accordingly, only half of the total capacity of the memory installed is displayed both in the memory test screen shown when the system is booted and in the total memory capacity shown when the system is running.

If an uncorrectable error occurs in a DIMM in the primary, the mirror is used for both writing and reading data. If an uncorrectable error occurs in a DIMM in the mirror, the primary is used for both writing and reading data. In this case, the error is logged as a correctable error. If the error is uncorrectable by the primary or mirror, it is logged as an uncorrectable error.

On-Module Storage

Intel Xeon Server Blades support up to four internal 2.5-inch SAS hard drives The SAS architecture, with its SCSI command set, advanced command queuing, and verification/error correction, is ideal for business-critical applications running on BladeSymphony 1000 systems.

Traditional SCSI devices share a common bus. At higher signaling rates, parallel SCSI introduces clock skew and signal degradation. Serial Attached SCSI (SAS) solves these problems with a point-to-point architecture where all storage devices connect directly to a SAS port. Point-to-point links increase data throughput and improve the ability to find and repair disk failures. The SAS command set is parallel SCSI, frame formats are from Fibre Channel, and physical characteristics are from Serial ATA. SAS links are full duplex, enabling them to send and receive information simultaneously, which reduces latency. The SAS interface also allows multiple links to be combined, creating 2x, 3x, or 4x connections to increase bandwidth.

Chapter 5
I/O Sub System

I/O Modules

Hitachi engineers go to great lengths to design systems that provide high I/O throughput. BladeSymphony 1000 PCI I/O Modules deliver up to 160 Gb/sec. throughput by providing a total of up to 16 PCI slots (8 slots per I/O module). I/O modules accommodates industry standard PCIe or PCI-X cards, supporting current and future technologies as well as helping to preserve investments in existing PCI cards. In addition, by separating I/O from the server blades, the BladeSymphony 1000 overcomes the space contraint issues of other blade server designs, which can only support smaller PCI cards.

Three I/O modules are available: PCI-X I/O Module, PCIe I/O Module, and an Embedded Fibre Channel Switch Module. Two I/O modules are supported per chassis.

PCI-X I/O Module

The PCI-X I/O Module supports eight PCI-X cards in total, with a maximum of two PCI-X cards assigned to a single server blade for Chassis A and four for Chassis B. In Chassis A, eight PCI cards can be attached to four server blades, at a two-to-one ratio. In Chassis B, four PCI cards can be attached to four server blades for a four to one ratio. Hot plug is supported in specific conditions. See the BladeSymphony 1000 Users Manual for more information. The block diagram for the PCI-X I/O Module is shown in Figure 16.

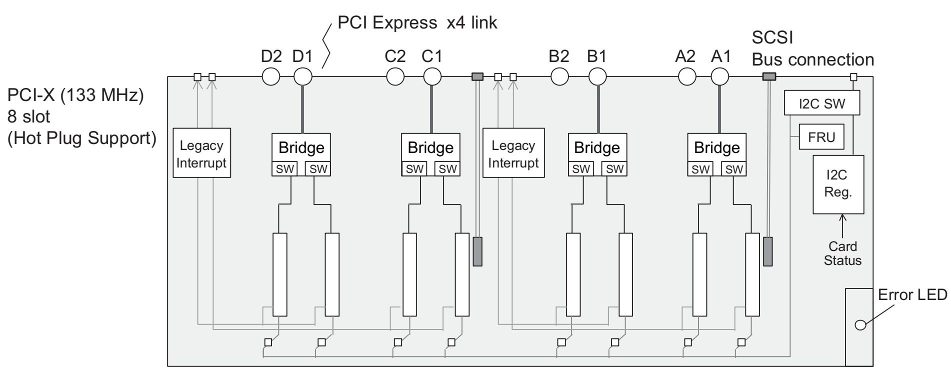

Figure 16. PCI-X I/O Module block diagram

Table 6 provides information on the connector types for PCI-X I/O Modules.

Table 6: PCI-X I/O Module connector types

Name	Protocol	Frequency	Bus Width	Remarks
PCI-X slots #0 to 7	PCI-X 133	133 MHz	64-bit	PCI Hot Plug
SCSI connector #0, #1	Ultra 320	160 MHz	16 bit LVD	Each I/O module has two SCSI connector ports

PCIe I/O Module

To provide more flexibility and to support newer PCI cards, a PCIe I/O module is available. The PCIe I/O Module supports eight PCIe cards in total, and one I/O module can have one PCIe card assigned per server blade. The PCIe I/O Module uses a PCIe hot plug controller manufactured by MICREL. Hot plug is supported for each PCIe slot in the PCIe I/O Module. The operating system must support hog plug in order for this operation to be successful.

PCIe I/O Module Combo Card

A PCIe I/O Module Combo Card is available for the BladeSymphony 1000, which can be installed in the PCIe I/O Module and provides additional FC and gigabit Ethernet configurations. The block diagram is shown in Figure 17. The card includes two1/2/4 Gb/sec. FC ports supporting FC-AL and point-to-point switch fabric. Two gigabit Ethernet ports are also included. These ports support auto-negotiation and VLAN (compatible to IEEE 8.2.1Q and a maximum of 4096 TagVLANs).

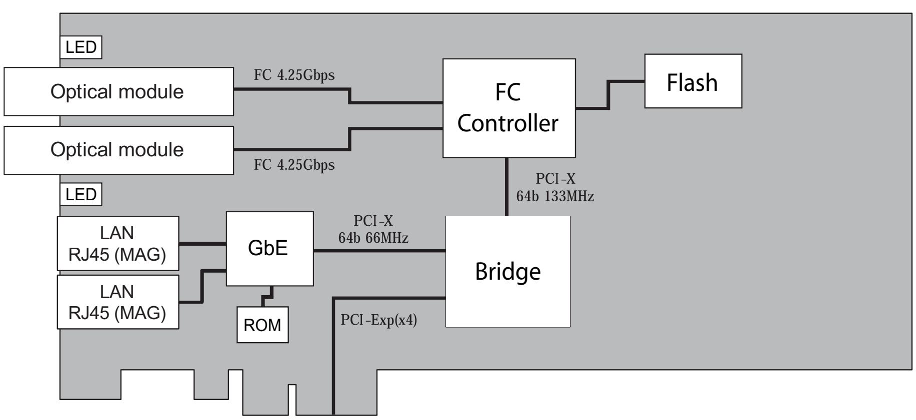

Figure 17. PCIe I/O Combo Card block diagram

Embedded Fibre Channel Switch Module

The Embedded Fibre Channel Switch Module consists of a motherboard, with one daughter card with an FC switch installed, and eight FC-HBA + Gigabit Ethernet Combo Cards. It enables the use of both FC and LAN functions from each server blade in the BladeSymphony 1000 chassis. Figure 18 shows an outside view of this module.

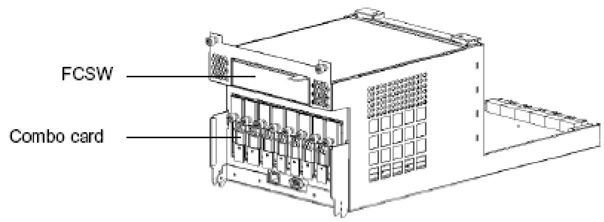

Figure 18. Outside view of the Embedded Fibre Channel Switch Module

The Fibre Channel switch within the module consists of 14 ports compatible with the 4 Gb/sec. Fibre Channel standard. Eight ports are connected internally to the FC-HBA of up to eight FC-HBA + Gigabit Ethernet Combo Cards, and six of the ports are external ports used to connect to external storage. Figure 19 depicts the back view of the module and a blow up of the Fibre Channel switch. The block diagram for the module is shown in Figure 20.

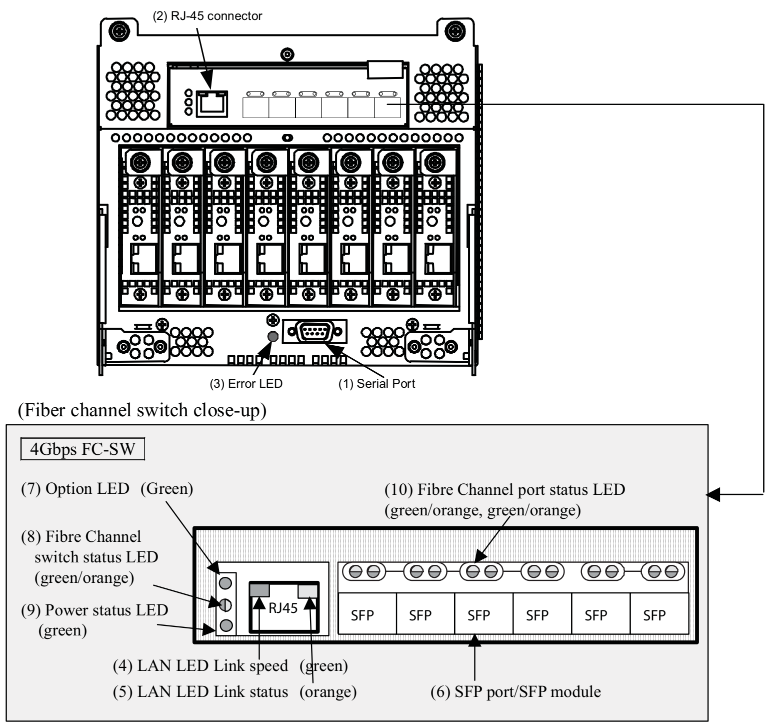

Figure 19. Back view of Embedded Fibre Channel Switch Module with blow up of the Fibre Channel switch

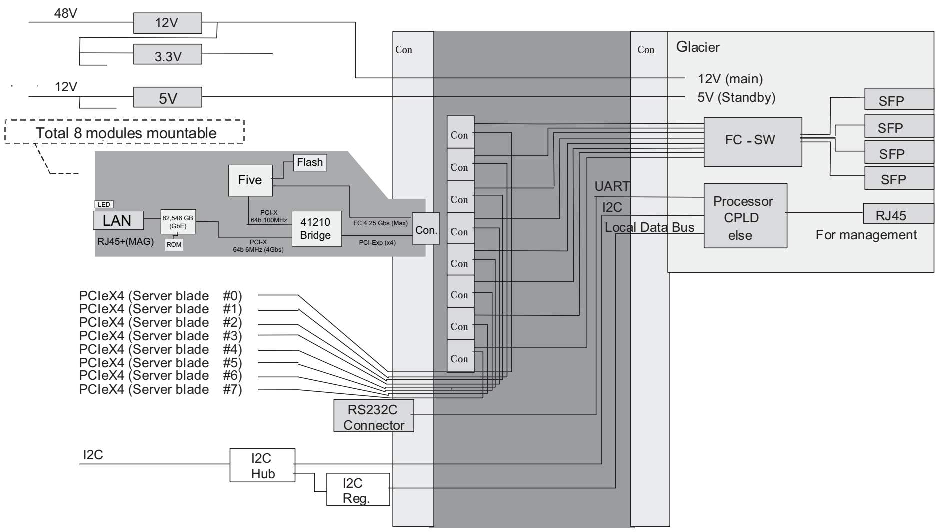

Figure 20. Embedded Fibre Channel Switch Module block diagram

The Embedded Fibre Channel Switch Module is configured with three components: A Brocade Fibre Channel switch, Fibre Channel HBAs, and network adapters. Directly connecting the HBAs to the FC switch in this manner, rather than installing them as PCI cards in the blades eliminates the 16 fiber cables that would be necessary to make these connections in other systems, as illustrated in Figure 21. Another benefit is reduced latency on the data path. This dramatically reduces complexity, administration, and points of failure in FC environments. It also reduces the effort to install and/or reconfigure the storage infrastructure.

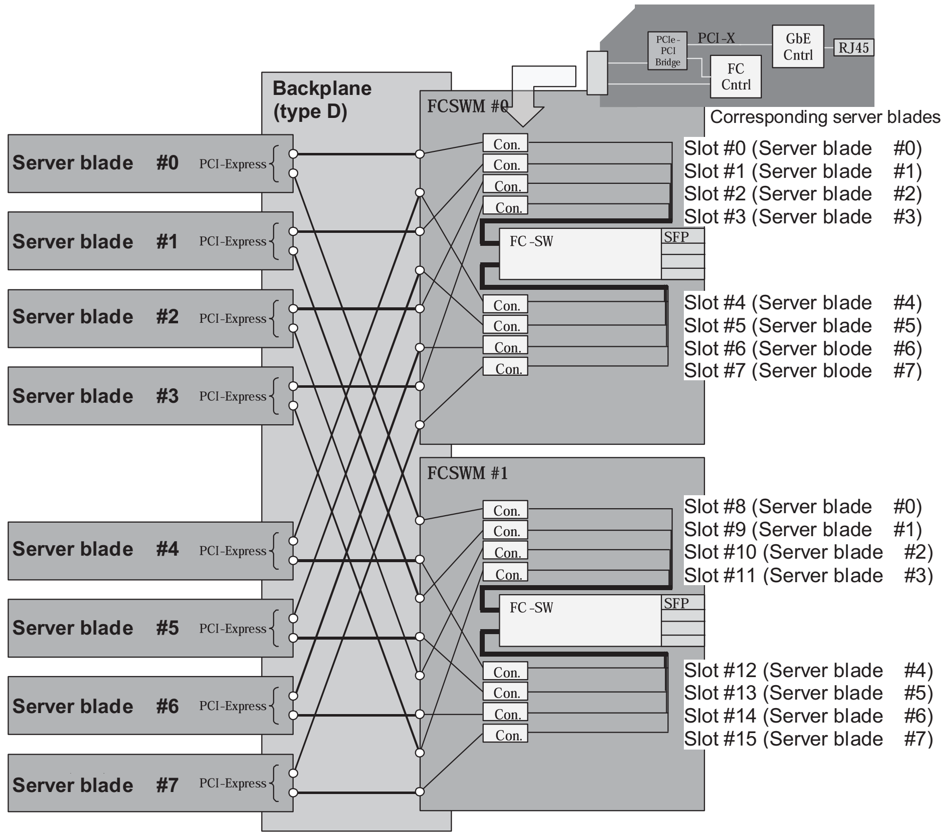

Figure 21. Embedded Fibre Channel Switch Module connection diagram, eliminating 16 cables

Table 7 provides the details on the features of the Embedded Fibre Channel Switch module.

Table 7: Embedded Fibre Channel Switch Module components

Function	Details
Supported Fibre Channel standards	FC-FG, FC_AL, FC_FLA, FC_PLDA, FC_VI, FC_PH, FC_GS_2, FC_PH_3, FC_SW, IPFC RFC, FC_AL2, FC_PH
Fibre Channel port	Universal port x14 (14 ports equipped as hardware, 8 internal ports, 6 external ports)
Port type	FL_port, F_port and E_port, with the function (U_port) to self-detect port type
Switch expandability	Full-fabric architecture configured by up to 239 switches
Interoperability	SilkWorm II, SilkWorm Express, and SilkWorm 2000 families
Performance	4.250 Gb/sec. (full-duplex)

Table 7: Embedded Fibre Channel Switch Module components

Function	Details
Fabric delay time	Less than 2 microseconds (no contention, cut-through routing)
Maximum frame size	2112-byte payload
Service class	Class 2, class 3, class F (frame between two switches)
Data traffic type	Unicast, multicast, broadcast
Media type	SFP (Small Form-Factor Pluggable)
Fabric service	SNS (Simple Name Server), RSCN (Registered State Change Notification), Alias Server (Multicast), Brocade Advanced Zoning
ISL Trunking	Supported

FC-HBA + Gigabit Ethernet Combo Card

The FC-HBA + Gigabit Ethernet Combo Card provides the FC-HBA and gigabit Ethernet functions for the Embedded Fibre Channel Switch Module.

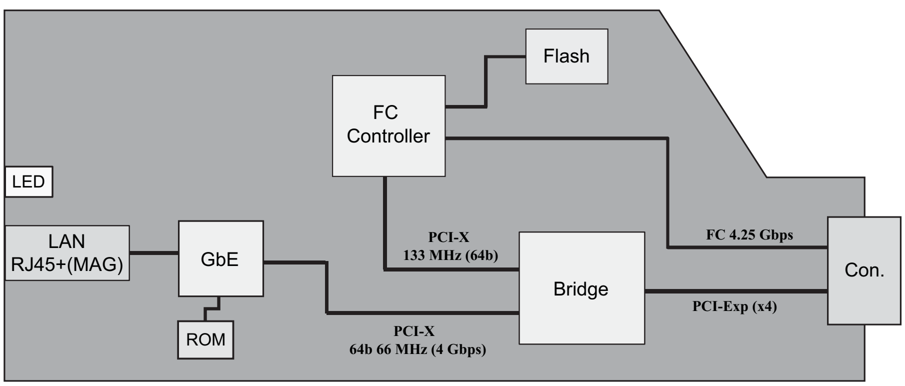

Figure 22. FC-HBA + Gigabit Ethernet Combo Card block diagram

The card includes the following components:

- One Intel PCIe to PCI-X bridge chip
- One Intel Gigabit LAN Controller
- One Hitachi FC Controller FC HBA (1 port)

The Hitachi FC Controller FC-HBA supports the functions in Table 8.

Table 8: Hitachi FC Controller FC-HBA functions

Function	Details
Number of ports	1
PCI hot plug	Supported
Port speed	1/2/4/ Gb/sec.
Supported standards	FC-PH rev.4.3, FC-AL rev. 5.8
Supported topology	FC_AL, point-to-point switched fabric
Service class	Class 2/3
Number of BB credits	256
Maximum buffer size	2048
RAS	Error injection, trace, error detection
Intel Xeon Server Blade boot support	Supported (BIOS)
Intel Itanium Server Blade boot support	Supported (BIOS/EFI)

Management Software

Developed exclusively for BladeSymphony 1000, the BladeSymphony management software manages all of the hardware components of BladeSymphony 1000 in a unified manner, including the Embedded Fibre Channel Switch Module. In addition, Brocade management software is supported, allowing the Embedded Fibre Channel Switch Module to be managed using existing SAN management software. Each component can also be managed individually.

The Fibre Channel switch is managed through a 10/100M Ethernet (RJ-45) or serial port. Either port can be used to manage the switch. The following software is supported to manage the Fibre Channel switch:

- Brocade Web Tools — An easy-to-operate tool to monitor and manage the FC switch and SAN fabric. Operated from a Web browser.
- Brocade Fabric Watch — SAN monitor for the switches made by Brocade. It constantly monitors the SAN fabric to which the switch is connected, detects any possible fault, and gives the network manager a prior warning automatically.
- Brocade ISL Trunking — Groups ISLs between switches automatically to optimize the performance of the SAN fabric.

The Fibre Channel HBA supports Common HBA API version 1.0 (partly 2.0) developed by SNIA. Common HBA API is a low-level HBA standard interface to access the information in the SAN environment, and is provided as the API in the standard C language.

The network adapter supports SNMP and ACPI management software.

Embedded Gigabit Ethernet Switch

The Embedded Gigabit Ethernet Switch is contained in the Switch & Management Module and is a managed, standards-based Layer 2 switch that provides gigabit networking through cableless LAN connections. The switch provides 12 (single) or 24 (redundant) gigabit Ethernet ports for connecting BladeSymphony 1000 Server Blades to other networked resources within the corporate networking structure. Eight of the ports connect through the backplane to server blades, and the remaining four ports are used to connect to external networks, as illustrated in Figure 23. The switch provides up to 24 Gb/sec. total throughput performance and the ability to relay packets at 1,488,000 packets/sec. Additional features are listed in Table 9.

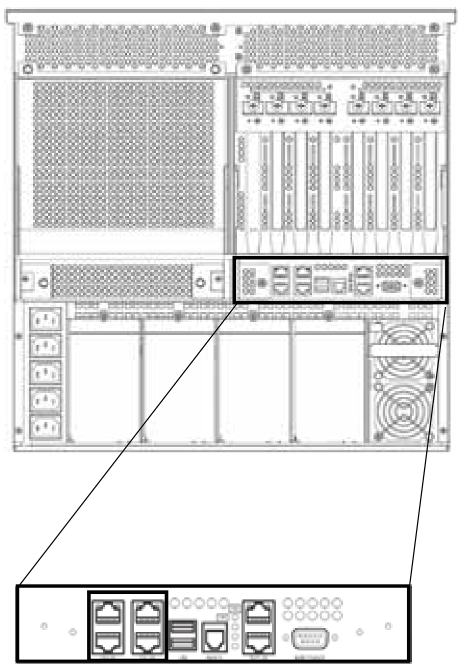

Figure 23. Back view of chassis with blow up of Embedded Gigabit Ethernet Switch

The Embedded Gigabit Ethernet Switch can be configured for high availability and fault tolerance when a second, redundant switch module is added. A single switch interconnects one (of two) gigabit Ethernet connections from each blade server blade (up to eight total). The second redundant switch interconnects each of the remaining gigabit connections for each server blade , so a single switch failure allows networking operations to continue on the remaining switch. If additional network bandwidth or connectivity is needed, PCI slots can be utilized for additional NICs. Switch features are listed in Table 9.

Table 9: Embedded Gigabit Ethernet Switch features

Item	Description
Port	Backplane side: 1 Gb/sec. x 8 External: 10 BASE-T / 100 BASE-T / 1000 BASE-t (auto connection) Auto learning of MAC address (16,384 entries)
Switch	Layer 2 switch
Bridge function	Spanning tree protocol (IEEE 802.1d compliant)
Network function	Link aggregation (IEEE 802.3ad) Trunking (up to 4 ports, 24 groups) Jumbo frame (packet size: 9216 bytes)
VLAN	Port VLAN TagVLAN (IEEE 802.1q) Maximum number of definitions: 4096
Management function	SNMP v2c agent MIB II (RFC1213 compliant) Interface extending MIB (FRC1573, RFC2233 compliant)

SCSI Hard Drive Modules

The BladeSymphony 1000 supports two types of storage modules containing 73 or 146 GB 15K RPM Ultra320 SCSI drives in the type B chassis only. The 3x HDD Module can have up to three drives installed. The 6x HDD module utilizes two server slots and can house up to six drives. Both HDD Modules are illustrated in Figure 24. Four out of eight server slots of a server chassis can be used to install storage modules, for a total of either four 3x modules or two 6x modules. The storage modules are mountable only on server slots #4 to #7 in Chassis B.

Disk drives installed in HDD modules can be hot-swapped in a RAID configuration with the RAID controller installed on the PCI card. The HDD Modules support RAID 1, 5, and 0+1 and spare disk.

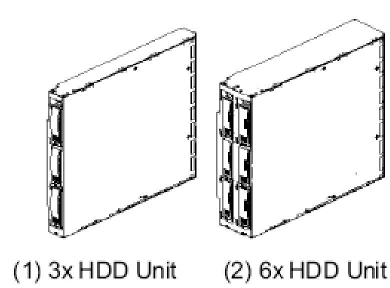

Figure 24. HDD Modules

A SCSI or RAID type PCI card must be installed in a PCI slot in an I/O module to act as the controller of the storage module. A PCI card is combined with a storage module, as shown in Figure 25, by connecting the SCSI cable from the PCI card to the SCSI connector on the same I/O module, and then connecting the board wiring from the SCSI connector to server slot #4 to #7, where the storage module is installed through the backplane. The logical numbers of the SCSI connectors on I/O module #0 and #1 are defined as #0 to #1 and #2 to #3, respectively.

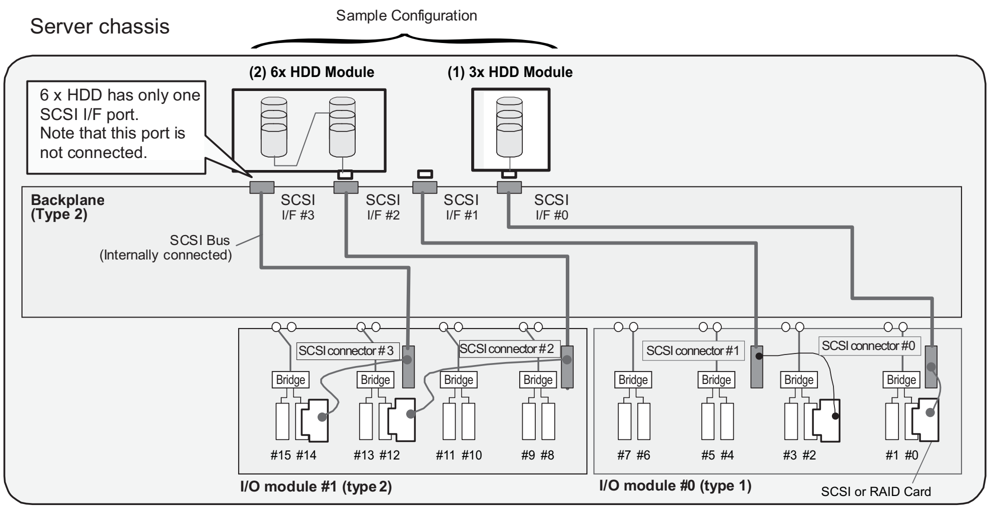

Figure 25. Connection configuration for HDD Modules

Chapter 7

Chassis, Power, and Cooling

The BladeSymphony 1000 chassis houses all of the modules previously discussed, as well as a passive backplane, Power Supply Modules, Cooling Fan Modules, and the Switch & Management Modules.

The chassis and backplane provide a number of redundancy features including a one-to-one relationship between server blades and I/O modules, as well as duplicate paths to I/O and switches. In addition, although the backplane is the only single point of failure in the BladeSymphony 1000, it intentionally uses a passive design that eliminates active components that might fail. The backplane provides connections between server blades, SCSI HDD Modules, PCI slots, FC HBAs, and LAN switch, thus eliminating a large number of cables, which reduces costs and complexity.

Two types of chassis are available, chassis A and chassis B. Chassis A provides connections between each server blade slot and two slots in a PCI module or Embedded Fibre Channel Switch Module. Chassis B provides four connections from server blade slots #1 to #4 to two slots in a PCI module or Embedded Fibre Channel Switch Module. The connections for both chassis types are illustrated in Figure 26. The specifications for each chassis type are listed in Table 10.

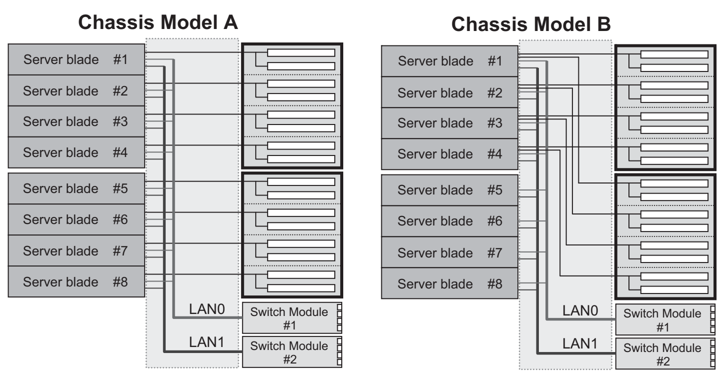

Figure 26. Chassis backplane connections

Table 10: Chassis specifications

Module	Type A	Type B
Server Blade	• Intel Xeon Server Blades: 8 max. • Intel Itanium Server Blades: 8 max.	• Intel Xeon Server Blades: 8 max. (4 exclusive against storage modules) • Intel Itanium Server Blades: 8 maximum with network boot
Storage Modules: HDD x 3	N/A	4 maximum
Storage Modules: HDD x 6	N/A	2 maximum

Module	Type A	Type B
Switch & Management Module	1 standard, 2 maximum	1 standard, 2 maximum
I/O Module (PCI-X)	2 maximum 2 slots maximum per server blade, 16 slots maximum per server chassis	2 maximum 4 slots maximum per server blade, 16 slots maximum per server chassis
I/O Module (PCIe)	N/A	2 maximum 2 slots maximum per server blade, 16 slots maximum per server chassis
I/O Module (Fibre Channel Switch)	N/A	2 Maximum
Power Module	4 maximum (N+1 redundant configuration)	
Cooling Fan Module	4 standard (3+1 redundant configuration)	
USB CD-ROM Drive	Optional	
USB Floppy Disk Drive	Optional	
Outside Dimension	17.5 x 33.5 x 17.4 inches/ 10 RU	
Weight	308 pounds (lbs)	
Input Voltage (frequency)	200-240 VAC, single phase (50/60 Hz)	
Power Consumption (maximum)	4.5 kW	
Operating Temperature	41 to 55 degrees Fahrenheit	
Humidity (no condensation)	20 to 80 percent	

Module Connections

Chassis A can have up to eight server blades mounted, with two PCI-X slots per server blade. Storage modules cannot be mounted on these chassis.

Chassis B can have three types of I/O modules mounted. If a PCI-X I/O Module is installed, the chassis can have up to four server blades with four PCI-X slots connected to each server blade, and up to four storage modules or server blades with no PCI-X connection. If a PCIe I/O Module is installed, the chassis can have up to eight server blades, with up to two PCIe slots per server blade. If a Embedded Fibre Channel Switch Module is installed, the chassis can have up to eight server blades, with up to two Fibre Channel ports and two gigabit Ethernet ports connected per server blade.

Redundant Power Modules

The Power Module includes a 200-240 VAC input, and supplies the sub- and main-power to the system. Up to four Power Modules are installable in a chassis. They are installed redundantly, and support hot swapping. The service processor (SVP) checks the power capacity when it starts up.
If SVD detects redundant power capacity, it boots the system in the normal way. If SVP cannot detect

power redundancy, it boots the system after issuing a warning by illuminating the Warning LED. Hot swapping is not possible in the absence of redundant power.

Redundant Cooling Fan Modules

The Cooling Fan Modules cool the system with variable speed fans, and are installed redundantly, as illustrated in Figure 27. The fans cool the system by pulling air from the front of the chassis to the back. The modules can be hot-plugged, enabling a failed Cooling Fan Module to be replaced without disrupting system operations. Cooling Fan Modules support the following functions:

- Control rotation
- Detect abnormal rotation
- Indicate the faulty location with LEDs
- Built-in fuse

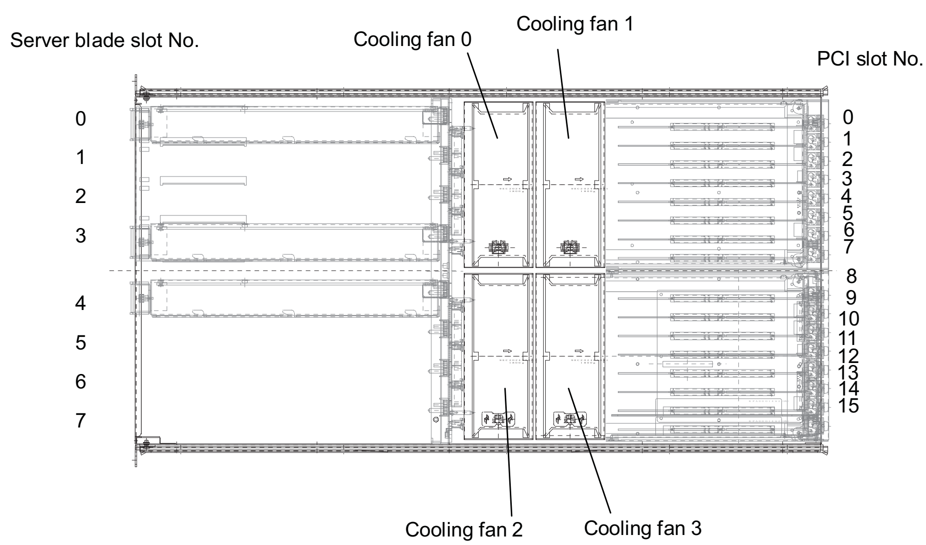

Figure 27. Top view and cooling fan modules numbers

Chapter 6
Reliability and Serviceability Features

Reliability, availability, and serviceability are key requirements for platforms running business-critical application services. In today's globally competitive environment, where users access applications round-the-clock, downtime is unacceptable and can result in lost customers, revenue, and reputation. The BladeSymphony 1000 is designed with a number of features intended to increase the uptime of the system.

Reliability Features

Intended to execute core business operations, the BladeSymphony 1000's modular design increases reliability through the high availability of redundant components. Rather than focus on creating individual highly available components, the BladeSymphony 1000 utilizes multiple industry-standard components to cost-effectively increase reliability. Redundant components also increase the serviceability of the system by allowing the system to continue operating while new components are added or failed components are replaced.

The BladeSymphony 1000 is designed with features to help ensure the system does not crash due to a failure and to minimize the effects from a failure. These features are listed in Table 11.

Table 11: Reliability features

Function	Feature
Quickly detect/diagnose failed part	BIOS self-diagnostic function Memory scrubbing function (Intel Itanium Server Blade)
Failure recovery by retry and correction	ECC function (memory, CPU bus, SMP link (Intel Itanium Server Blade), CRC retry function (PCIe, SCSI)
Dynamic isolation of failed part	Advanced ECC, online spare memory
Redundant configurations	HDD Modules, redundant Switch & Management Modules, Power Modules, and Cooling Fan Modules Memory mirroring (Intel Xeon Server Blades)
Redundant system configurations	Redundant LAN/FC modules Cluster system configuration, N+1/N+M configurations
Obtain failure information	Isolation of failed part using System Event Log, BladeSymphony Management Suite, and Storage Manager Automatic notification of failure by ASSIST via email
Block failed part	Isolation of failed part upon system boot
Repair failed part during operation	Repair CPI adapter, Switch & Management Module, Power Module, Cooling Fan Module while system is operating

Serviceability Features

Switch & Management Module

The Switch & Management Module is designed to control the system unit and monitor the environment. Figure 28 shows the block diagram of the module. This module and other system components are connected through I2C or other busses.

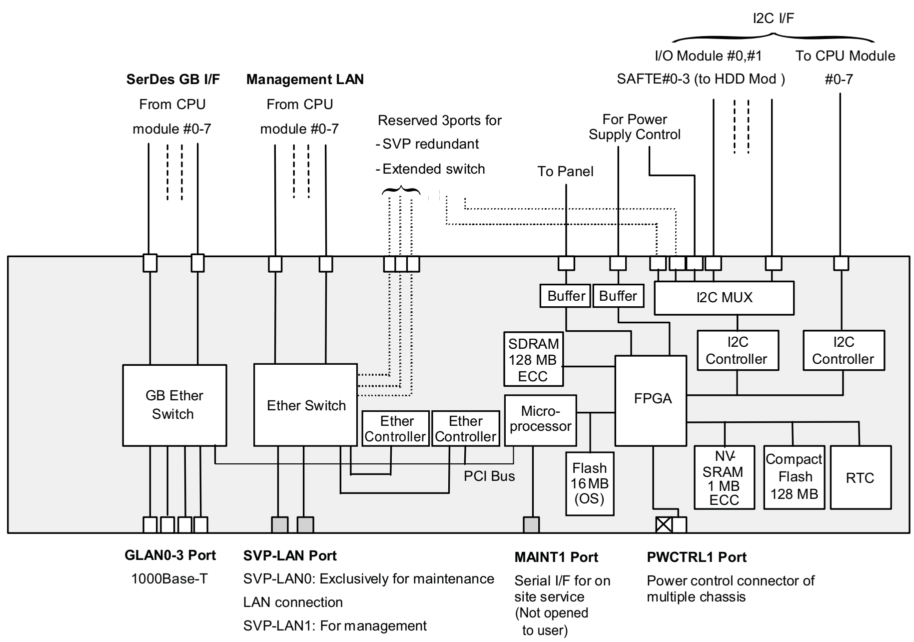

Figure 28. Switch & Management Module components

The Switch & Management Module contains the service processor (SVP) which controls the system and monitors the environment. A SVP is connected to the server blades or another SVP on the other Switch & Management Module (if mounting two Switch & Management Modules) through the backplane interfaced by 100M/10M Ethernet. Further, an SVP is connected to the server blades, another SVP or the I/O modules through the backplane by an I2C interface. The SVP performs tasks including system control, monitoring, and notice of a fault. The SVP is equipped with a console interface, which provides a user interface for maintaining and managing the system. Table 12 defines the components of the Switch & Management Module.

Two Switch & Management Modules can be installed on one chassis. In this case, the main SVP normally performs the SVP function. Health checking works between the main and sub-SVP as they monitor each other. If the main SVP fails, the sub-SVP takes over operation.

The Switch & Management Module houses the gigabit Ethernet switch, to which the gigabit Ethernet port of each server blade is connected over the backplane. When two Switch & Management Modules are installed, each switch operates independently.

Table 12: Switch & Management Module components

Component	Manufacturer	Quantity	Description
Microproces-sor	Hitachi	1	
RTC	Epson	1	Battery backed-up
FPGA	Xilinx	1	
SDRAM	-	128 MB ECC	
Flash ROM	-	16 MB	Stores the OS image
NV SRAM	-	1 MB	Battery backed up SRAM. Saves system configuration information and fault logs
Compact flash	-	128 MB, 512 MB	Backs up the SAL and BMC firmware
Ether switch	Broadcom	2	Connect the management LAN of each server blade
Gigabit Ether switch	Broadcom	1	PHY chips for External ports 10BASE-T/ 100BASETx/1000BASE-T Auto Negotia-tion, Auto MDIX
Gigabit Ether-net PHY	Broadcom	1	Converts the SerDes output from each server blade into 1000Base-T.
SVP-LAN0	-	1	LAN port for connecting the system console. Exclusively for maintenance personnel.
SVP-SAN1	-	1	LAN port for connecting the system console. Always connected to the maintenance LAN for notification by mail.
Maintenance	-	1	COM port for connecting the system con-sole. Exclusively for maintenance personnel.
GBLAN0-3	-	4	10BASE-T/100BASE-Tx/1000BASE-T Ether port
Pwrctrl	-	1	Not supported

SVP manages the entire BladeSymphony 1000 device. It also provides a user interface for management via the SVP console. SVP provides the following functions:

- Module configuration management (module type, installation location, etc.) within a server chassis
- Monitoring and controlling of modules installed on the server chassis (power control, failure monitoring and partition control)
- Monitoring and controlling of the environment (temperature monitoring, controlling fan RPM)

- Panel control
- Log information management within BladeSymphony 1000 (RC logs, SEL, SVP logs, etc.).
- SVP hot standby configuration control
- Server Conductor (server management software) interaction function. (Including a function for emulating the PCI-version SVP function.)
- HA monitor (cluster software) interaction function.
- Management interface (SVP console (Telnet/CLI, RS232C/CLI), SNMP)
- Assist function (E-mailing to the maintenance center)

BladeSymphony 1000 implements the functions of the SVP card through software emulation by BMC and SVP over fast Ethernet and I2C connections, as shown in Figure 29.

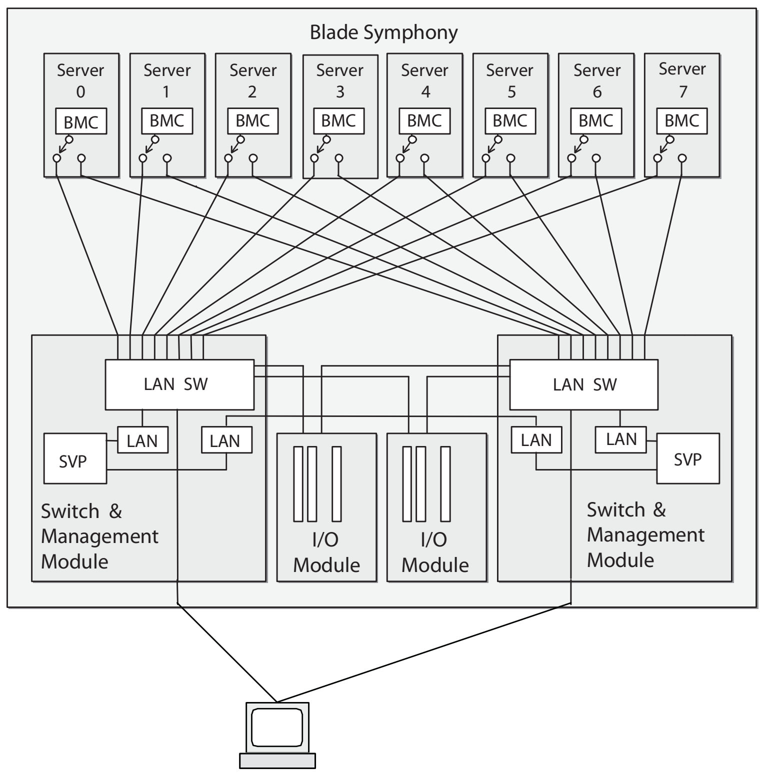

Figure 29. Fast Ethernet and I2C connections in SVP management interface

Base Management Controller (BMC)

One instance of BMC is installed for each CPU module primarily to take charge of management within the physical partition (including a single CPU module). Only one instance of SVP is active throughout the system, managing the entire system in cooperation with BMC. SVP and BMC communicate with each other via a SVP build-in 100 BASE-TX LAN. In the case of the Intel Itanium Server Blade, a BMC on the primary CPU module operates as the representative of BMCs present in the partition. This BMC is referred to as the primary BMC.

The Base Management Controller provides the following functions:

- Initial diagnosis — initial diagnosis/setting of BMC and BMC's peripheral hardware
- Power control — controlling of power input and shutdown for modules
- Reset control — controlling hard reset and dump reset
- Failure handling — handling of fatal MCK occurrence
- Log management — management RC logs, detailed logs and SEL
- Environmental monitoring — monitoring the temperature and voltage inside a module
- Panel output LOG through a virtual console (Intel Itanium Server Blade only) — status from BMC, SAL, or OS is recorded in LOG
- SVP consoles (Intel Itanium Server Blade only) — console for maintenance and assisting operation
- IPMI — standard functions of IPMI (SDR, SEL, FRU, WDT, sensor, etc.)
- Firmware updates (Intel Itanium Server Blade only) — updating SAL, BMC, and SVP

Console Functions

BladeSymphony 1000 supports the following three types of consoles:

- OS console for operating the OS and system firmware (only for the Itanium Blade)
- SVP console — system management console (can also manage L2 network switch)
- Remote console — access to the VGA, keyboard, and a mouse functionality from a remote workstation

In the Intel Itanium Server Blade, the OS console and SVP console can share one communication pathway. The OS console and SVP console are bound to local sessions (serial communications via MAINT COM connection) or remote sessions (telnet session on MAINT LAN) with the Console Manager, which controls binds between the console and the session. Console Manager is a software entity that is run on SVP, and undertakes binding of the console and a session and control of the transmission speed in each session. Settings for these bindings and communication setup can be changed by using the SVP console command or the hot key.

In the Intel Xeon Server Blade, the graphical console also functions as the OS console. Therefore, there is no communications path shared between the OS console and SVP console.

OS Console

In the Intel Itanium Server Blade, one OS console is provided for each partition. An OS console functions as the console of the System Firmware (SAL and EFI) before OS startup and a text console under the OS after the OS startup.

The OS recognizes the OS console as a serial port (COM1). The serial port of the OS console supports communication speeds of 9600 bps and (19,200 bits per second). The interface information on the OS console as a serial port is passed to the OS via System Firmware.

In the Intel Xeon Server Blades, a graphical console serves for this function and the OS console as hardware is not supported independently.

SVP Console

This function is shared between the Intel Itanium and Intel Xeon Server Blades.

SVP console is a console under SVP, and provides a user interface for system management. SVP console provides the following functions:

- Setup and display of the system's hardware information
- Display and deletion of failure information (RC and detail logs)
- Substitution of front panel operation
- Display of console logs
- Setting of remote failure reporting
- Update of System Firmware (normally using the EFI tool) [Under study for the IA32 CPU module.]
- Setting of the SVP clock
- Debugging of the system
- Setting of IP address

Remote Console

When running Linux or Windows, a graphical console is available as the OS or System Firmware console. The graphical console consists of VGA, a keyboard, and a mouse.

In the Intel Itanium Server Blade, a Windows remote desktop is used. A keyboard and mouse can be connected to the USB port on the rear connector panel. The USB port on the connector panel can be shared among multiple physical partitions by switchover operation.

In the Intel Xeon Server Blade, a special KVM connector can be connected to the KVM port on the front of each server blade to connect the monitor, keyboard, and mouse.

Chapter 8

Management Software

BladeSymphony 1000 delivers an exceptional range of choices and enterprise-class versatility with multi-OS support and comprehensive management software options.

Operating System Support

With support for Microsoft Windows and Red Hat Linux Enterprise, BladeSymphony 1000 gives companies the option of running two of the most popular operating systems — at the same time and in the same chassis for multiple applications.

For example, in a virtualized environment on a single active server blade, customers could allocate 50 percent of CPU resources to Windows, 50 percent to Linux applications — and change the allocation dynamically as workload requirements shift. This provides an unheard-of level of flexibility for accommodating spikes in demand for specific application services.

BladeSymphony Management Suite

BladeSymphony 1000 can be configured to operate across multiple chassis and racks, and this extended system can be managed centrally with BladeSymphony Management Suite software (shown in Figure 30. BladeSymphony Management Suite allows the various system components to be managed through a unified dashboard. For example, when rack management is used, an overview of all BladeSymphony 1000 racks — including which servers, storage, and network devices are mounted — can be quickly and easily obtained. In the event of any system malfunction, the faulty part can be located at a glance.

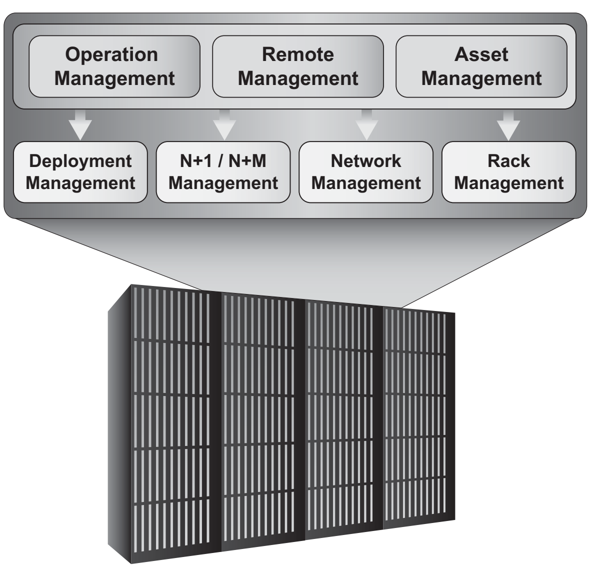

Figure 30. BladeSymphony Management Suite

BladeSymphony Management Suite provides centralized system management and control of all server, network, and storage resources, including the ability to setup and configure servers, monitor server resources, integrate with enterprise management software (SNMP), phone home, and manage server assets.

Deployment Manager

Deployment Manager allows the mass deployment of system images for fast, effective server deployment. Users can deploy system images and BIOS updates across multiple chassis in multiple locations. Updates are executed by batch distribution of service packs and Linux patches to server, saving a large number of hours for patching tasks.

N+1 or N+M Cold Standby Fail-over

BladeSymphony 1000 maintains high uptime levels through sophisticated failover mechanisms. The N+1 Cold Standby function enables multiple servers to share standby servers, increasing system availability while decreasing the need for multiple standby servers. It enables the system to detect a fault in a server blade and switch to the standby server — manually or automatically. The hardware switching is executed even in the absence of the administrator, enabling the system to return to normal operations within a short time.

With the N+M Cold Standby function there are “M” backup servers for every “N” active servers, so failover is cascading — in the event of hardware failure, the system automatically detects the fault and identifies the problem by indicating the faulty module, allowing immediate failure recovery. This approach can cut total downtime by enabling the application workload to be shared among the working servers.

Operations Management

- Reports — real-time or historical reports can be generated. Report interval and display time intervals (hour, day, week, month, year) can be specified. Graphical display drill-down is possible for detailed analysis. An export function supports output of HTML or CSV files.
- Fault and error detection and notification — when a problem occurs on a server, various notification methods including SNMP trap notification are used to quickly detect the problem. Notices can be filtered according to the seriousness of the problem and can be sent to the administrator via email or the management console to indicate only very serious problems.
- Customized fault notification rules — multiple monitoring conditions can be set, such as alarm conditions and irregular conditions. Problem notice conditions can be set according to time period and number of occurrences. And, executable actions can be set, such as send email, execute a command, or send an SNMP trap notice.
- SMNP Communication — an SNMP translator converts alert information managed by an agent service to MIB, and sends it by SNMP to and SNMP manager such as OpenView Network Node Manager. SNMP manager can be used to view information sent by SNMP.
- Windows Cluster Management — a cluster environment can be created by Microsoft Cluster Server for each server (node). However, Microsoft Cluster Server's cluster administrator can manage only clusters in the same domain, while the BladeSymphony 1000 enables centralized management of clusters from a remote location regardless of the domains. The following operations for cluster management are supported:
  - Viewing information about cluster groups and resources from a remote location
  - Reporting to the administrator as events the changes in the status of cluster groups and resources

  - Setting a failover schedule for cluster groups, based on specific dates or at specified times on a weekly schedule. The user can achieve more detailed cluster management by combining this feature with a power control schedule.
  - Using alerts to predict future server shutdown and implementing automatic failover in the event of specific alerts
- Power Scheduling — Power control schedules can be set to turn the power on or off on specific dates or at specified times on a weekly schedule.

Remote Management

The BladeSymphony 1000 can be operated from a remote management console. Chat sessions can be used between a local operator and a remote system administrator to quickly resolve and recover from problems.

- IP KVM for Intel Xeon Server Blades — keyboard mouse emulator that displays the current window from the consoles.
- Shell Console for Intel Itanium Server Blades — standard shell interface.
- BSMS Chat feature — enables a chat session between a Windows server and the management console.
- Power control — the power supply can be controlled remotely to turn power on and off.

Network Management

The BladeSymphony Management Suite Network Management function provides one-point management of network switch VLAN configuration information. Configuration information related to VLANs is obtained from the switches on the network and then managed from one port. The management GUI can be used to set up and manage configuration information regardless of the command specifications for each type of switch.

Rack Management

In the BladeSymphony 1000, networks, server blades, and storage devices are installed as modules in a single rack. Rack Management provides graphical displays of the information about the devices, such as layout, amount of available free space, and error locations. It can also display detailed information about each device (such as type, IP address, and size) and alert information in the event of failure.

Asset Management

The Asset Management functionality enables server resources and asset information (inventory information) to be checked on screen. Servers matching particular inventory information conditions can be searched and the search results can be distributed periodically through email. For example, Asset Management can be used to discover the amount of memory in a server blade, to search for servers that have old version of firmware, or to search to periodically check the status of service pack installations.

Chapter 9
Virtage

Virtage is a key technical differentiator for BladeSymphony 1000. It brings mainframe-class virtualization to blade computing. Leveraging Hitachi's decades of development work on mainframe virtualization technology, Virtage delivers high-performance, extremely reliable, and transparent virtualization for Dual-Core Intel Itanium and Quad-Core Intel Xeon processor-based server blades.

Virtage is built-in and requires no separate operating system layer or third-party virtualization software, so it safely shares or isolates resources among partitions without the performance hit of traditional software-only virtualization solutions. It is tuned specifically for BladeSymphony 1000 and is extensively tested in enterprise production environments. Virtage is designed to deliver a higher level of stability, manageability, performance, throughput, and reliability than comparable virtualization technology, and it sets a new standard for on-demand infrastructure provisioning. Virtage offers a number of benefits including:

- Reduced number of facial servers through consolidation and virtualization
- Increased server utilization rates
- Isolation of applications for increased reliability and security
- Improved manageability
- Simplified deployment
- Support for legacy systems

Virtage is Hypervisor-type virtualization, and therefore has a natural performance advantage over host-emulation virtualization offerings because guest operating systems can be simply and directly executed on virtualized environment without host intervention. Virtage leverages Intel's Virtualization Technology (VT) to help ensure that processor performance is optimized for the virtual environment, and to provide a stable platform that incorporates virtualization into the hardware layer.

Virtage can partition physical server resources by constructing multiple logical partitions (LPARs) that are isolated, and each of these environments can run independently. A different operating system (called a Guest operating system) can run on each LPAR on a single physical server.

The BladeSymphony1000 Server Blades can run in basic mode (non-virtualized), or with Virtage. The Virtage feature is embedded within the system and can be activated or de-activated based on customer needs. Each system can support multiple virtualized or non-virtualized environments based on specific preferences. A single server blade or SMP can be configured up to 16 LPARs at a time.

High CPU Performance and Features

Virtage is Hypervisor-type virtualization, and therefore features a natural performance advantage over host-emulation virtualization offerings because guest operation systems can be simply and directly executed on the virtualized environment without host intervention.

Virtage fully utilizes the Hypervisor mode created by leveraging Intel's VT-i technology, which is embedded in the Itanium processor. Therefore, Virtage can capture any guest operation requiring host intervention with minimal performance impact to normal operations.

And the host intervention code is tuned for the latest Itanium hardware features, minimizing the performance impact to guests.

Virtage offers two modes in which processor resources can be distributed among the different logical partitions: dedicated mode and shared mode, as illustrated in Figure 31.

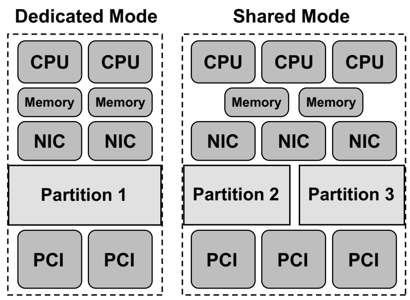

Figure 31. Share or isolate CPU and I/O resources to any partition in the same environment

Dedicated Mode

Individual processor cores can be assigned to a specific logical partition. Dedicating the core to an LPAR helps ensure that no other partition can take CPU resources away from the assigned partition. This method is highly recommended for environments that require CPU processing exclusivity, such as databases or real time applications.

Shared Mode

A single processor core or groups of cores can be assigned to multiple logical partitions, which in turn can share the assigned processing resources. This allows multiple partitions to share one or multiple CPU cores to increase utilization. Virtage can also carve up a single processor core into logical partitions for workloads that are smaller than one core.

Each partition is assigned a service rate of the processor. Another advantage is the ability to dynamically change the services ratio for any given partition. The system monitors the activity of a partition, and if one partition is idle while the other is using 100 percent of its share, the system temporarily increases the service rate until CPU resources are required by the other partition.

High I/O Performance

When deployed on Itanium processor-based server blades, Virtage employs direct execution, as is used in the mainframe world, leveraging Virtage technology embedded in the Hitachi Node Controller. The Virtage I/O hardware assist feature passes data through the guest I/O requests with minimum modification, thus does not add an extra layer for guest I/O accesses. Users can use standard I/O device drivers as they are, so they can take advantage of the latest functionality with less overhead. The hardware assist feature simply modifies the memory addresses for the I/O requests.

Also, because BladeSymphony 1000 can be configured with physical PCI slots, I/O can be assigned by the slot to any given partition. Therefore, any partition can be assigned any amount of slots and each partition can be mounted with any standard PCI interface cards. Since the PCI slots are assigned to the partition, each environment can support a unique PCI interface card.

Fiber Channel Virtualization

Hitachi also offers Fibre Channel I/O virtualization for Virtage. This allows multiple logical partitions to access a storage device through a single Fiber Channel card, allowing fewer physical connections between server and storage and increasing the utilization rates of the storage connections. This is exclusive to the 4 GB Hitachi FC card.

Shared/Virtual NIC Functions

Virtage also provides a virtual NIC (VNIC) function, which constructs a virtual network between LPARs and enables communication between LPARs without a physical NIC. There are two types of virtual NIC functions: one that only supports the communication between LPARs, which has no connection with external networks. The other is a part of the shared NIC function that realizes connection to the external physical network through the shared physical NIC.

Virtage enables multiple VNICs assigned to LPARs to share a physical NIC. This function takes full advantage of the connections between VNICs and external physical networks. The physical NIC shared between VNICs is called a shared physical NIC in the virtualization feature.

Integrated System Management for Virtual Machines

Hitachi provides secure and integrated system management capabilities to reduce the total cost of ownership (TCO) of BladeSymphony 1000 with Virtage. Hitachi offers integrated system management functionality with Virtage virtualization. Administrators can access the integrated remote console via IP to mange and configure the virtualized environments remotely. Virtual partitions can be created, re-configured, and deleted through an integrated console screen that is remotely accessible.

An integrated shell console lets users access the guest operating system directly from the console screen for ease of use. The system also monitors CPU utilization rates and allows processor CPU utilization changes dynamically for partitions operating in CPU shared mode.

Chapter 10

Summary

In the past, inadequate scalability, compromises in I/O and other capabilities, excessive heat generation, and increased complexity in blade environments caused many data center managers to shy away from using blade servers for enterprise applications. BladeSymphony 1000 overcomes these issues, proving a blade solutions that delivers server consolidation, centralized administration, reduced cabling, and simplified configuration. For companies seeking to lower cost and complexity with blade servers, BladeSymphony 1000 offers a unique solution with:

- A 10 RU chassis with hot swappable server blades that run both Windows and Linux
- Support for dual-core Intel Itanium 9000 Series processors
- Support for Intel Xeon Server Blades within in the same chassis
- Capability of scaling up or out to offer up to two16 core SMP servers in a single chassis

In addition, Virtage embedded virtualization technology brings the performance and reliability of mainframe-class virtualization to blade computing, enabling Hitachi to offer the first true enterprise-class blade server. Virtage provides an alternative to third-party software solutions, enabling companies to decrease overhead costs while increasing manageability and performance.

This powerful mix of flexibility, integration, and scalability makes BladeSymphony 1000 effective for any enterprise, but particularly for those running large custom applications or running high-growth applications. In fact, BladeSymphony 1000 represents a true breakthrough that finally delivers on the promise of blade technology.

For More Information

Additional information about Hitachi America Ltd. and BladeSymphony products, technologies, and services can be found at www.bladesymphony.com.

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