The Sun Fire™ V880 Server Architecture

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Enterprise Computing Meets Workgroup Servers

Once defined as small groups of workers sharing file and print services, workgroups now routinely include hundreds or even thousands of individuals working together. Today, departments, teams, and even small businesses have come to rely on a unique class of small server systems to help them complete their tasks. Modern workgroup servers, like those available from Sun Microsystems, are routinely tackling business- and mission-critical applications such as groupware and messaging, e-commerce, database, and enterprise resource planning (ERP) applications.

Workgroup servers are attractive to systems administrators, users, and MIS directors alike because they are powerful enough to handle large workloads, yet economical enough to be dedicated to singular tasks. As a result, when a new requirement for service arises, administrators can often avoid many of the disruptions associated with introducing a new application to a single, large server (performance degradation, service interruptions, administration and security loopholes) by simply dedicating an entire workgroup server to the job.

Finding the right workgroup server is easy when choosing from the Sun product lineup. Sun workgroup servers include systems that are designed to meet a wide variety of requirements, including economy, scalability, reliability, and performance. From entry-level, uniprocessor systems to small-footprint, data center-ready, multiprocessor workgroup servers, all Sun systems are powered by UltraSPARC™ technology, run the same version of the Solaris™ Operating Environment, and are fully binary compatible with existing applications. Binary compatibility through the entire Sun product line of workstations and servers affords users the opportunity to scale their
applications from workgroup servers all the way up through the Sun Fire™
3800-6800 midframe servers to Sun’s most powerful system, the 106-processor
Sun Fire 15K server.

With many businesses now seeing an increased reliance on the Net, the
demand for uninterrupted operation has never been greater. Where around-the
clock operations were once a requirement for a select few, it is now standard
operating procedure for most. And recently, users have begun to employ
workgroup servers in roles that demand very high levels of availability.
Enterprises have found that for many applications, groups of smaller servers
are often more available, and in certain roles, many smaller servers are better
performing and easier to configure than a single large system. Today, system
architects are employing small servers to power specialized network services
(email, gateways, firewalls, encryption and search engines), financial services
applications, on-line transaction processing, and e-commerce backbones.

In the past, workgroup server architectures had roots in desktop systems. It
was common, and reasonable, to reconfigure a powerful workstation or high-
end personal computer with additional storage, more memory, and enhanced
network throughput and label the result a workgroup server.

Times have changed. As they assume new, more mission-critical roles, the
desktop ancestry of workgroup servers has become increasingly inadequate.
System managers are demanding enhanced reliability, more robust behavior,
greater capacity, and improved manageability from workgroup servers. In
short, enterprises need capabilities in their workgroup servers that resemble
those found in larger systems rather than desktops.

Perhaps no company is better positioned to meet this demand than Sun
Microsystems. With an established reputation for powerful, reliable, and
scalable enterprise systems, Sun has been applying its large-scale server
technologies, such as those found in the Sun Fire 3800-6800 midframe systems
into workgroup servers. Today, products like the Sun Enterprise™ 250, Sun
Enterprise 450, and Sun Fire 280R workgroup servers, all equipped with
powerful UltraSPARC processors, deliver deskside reliability and performance
that re-engineered PCs are hard-pressed to match. Now, Sun’s newest
workgroup server design promises to deliver even more of what system
administrators, network managers, and MIS directors are asking for, and with
economies that readily compete with less-capable, PC-based servers.
The Sun Fire V880 Server

Able to tackle the complex needs of modern enterprise and technical computing teams, Sun’s line of workgroup servers are well-known for their performance and economy. Based on UltraSPARC processor technology, Sun Enterprise 220R, 420R, 250, 450, and Sun Fire™ 280R workgroup servers have gained the attention of the industry as important solutions for commercial and technical workgroup computing.

Recognizing a need for greater capacity and performance in a workgroup computing package, Sun has introduced the Sun Fire V880 volume server. With performance enhancements in nearly every dimension, the Sun Fire V880 server gives enterprises the capabilities of large systems with the economies found only in workgroup servers. The Sun Fire V880 server also features a number of enhancements to improve the availability of systems running mission-critical or datacenter applications, including redundant, hot-swappable components and optional redundant paths to internal storage.

The Sun Fire V880 server is an ideal platform for creating large network infrastructure, transaction processing systems, database servers, or e-commerce servers, bringing enterprise users an entirely new way to access the performance, reliability, and scalability that users have come to expect from Sun Microsystems.
Figure 2-1  The Sun Fire V880 server is an ideal platform for creating large network infrastructure, transaction processing systems, database servers, or e-commerce servers.

Key Technologies

Sun Fire V880 server systems use advanced materials, components, software, and fabrication technologies in their packaging, board design, subsystems, and components. This section briefly describes the features common to all models. More detailed discussions of the processor, interconnect, and I/O architectures can be found in chapter 3.

Processor Summary

Sun Fire V880 servers can be configured with up to eight 64-bit UltraSPARC III processors. Each processor is configured with 8 MB of external cache and operates at 750 MHz. The system will support upgrades to higher performance versions of the UltraSPARC III as they become available, with Sun's roadmap including processors clocked at higher speeds. Binary compatible with all Sun SPARC based systems, the third-generation UltraSPARC III microprocessor provides the very high integer and floating-point performance needed to
address the most computationally demanding applications. With 64-bit data and addressing, UltraSPARC III processors have a number of other important features to improve operating system and application performance:

- Larger cache, improved branch prediction, lower cache latency, and higher clock rates all combine to increase the performance of the UltraSPARC III processor over previous generations
- 4-way superscalar issue against six functional units
- Enhanced VIST™ instruction set with three new instructions for high performance on multimedia applications
- High efficiency trap management
- 16 K-entry branch prediction array
- 23 million transistor design (including cache) implemented using 0.18 micron, 7-layer aluminum CMOS technology operating at 1.8 volts. Packaged using a 1368-pin ceramic Land Grid Array (LGA).
- Extensive error correction and isolation features extended to Level 2 cache
- 2 KB 4-way set-associative pre-fetch and write caches
- 4-way associative on-chip 64 KB Data and 32 KB Instruction cache, with up to 8 MB of external level-two cache through integrated controller
- Support for data prefetch and multiple outstanding memory requests
- Integrated DRAM controller with support for up to 8 GB of memory can transfer data at up to 2.4 GB/sec.

**Sun™ Fireplane Interconnect**

In recent years, processor technology has moved so quickly that it has challenged developers to create comparable performance in memory systems and interconnects. With the all-new Sun™ Fireplane Interconnect, the Sun Fire V880 server continues the tradition of providing superior memory and I/O bandwidth on desktop systems, providing predictable performance and scalability under demanding loads.

Features of the Fireplane Interconnect include:

- Fast 150 MHz operating frequency offers greatly increased performance over previous designs
- Crossbar switch design enables high performance by allowing simultaneous transfers between processors, memory, and the I/O subsystem
- Low latency memory access
- Completely separate address/control and data paths for flexible implementation
• Out-of-order transaction processing enables multiple “in-flight” transactions on the bus at one time
• High throughput paths to memory via 576-bit wide paths including ECC
• More economical implementation through distributed control (no central memory controller required)
• Integrated support for multiprocessor configurations

**ECC-protected Memory**

Using 512 MB modules added in groups of four, Sun Fire V880 server systems support a maximum of 4 GB per CPU using 3.3V SDRAM DIMMs. Throughput to memory from the UltraSPARC III processors reaches speeds of up to 2.4 GB/sec.

**PCI Expansion Bus**

In addition to its commitment to expand the capacity and performance of all of its systems, Sun is continually looking to increase their openness and standards compliance. Sun has chosen to support the PCI Revision 2.1 standard on all of its current workstation and server products for a variety of reasons:

• **PCI is economical.** Because of its wide acceptance and reliance on standards, PCI promises a broad choice of inexpensive, compliant adapter cards.

• **PCI is an open, architecture-independent bus.** PCI is open and shipping in volume, and has been quickly adopted by producers of computer hardware, ensuring access to a wide variety of products.

• **PCI is fast.** The PCI bus architecture is designed to provide high performance, with its I/O performance a key differentiator from other bus architectures.

Not content to simply repeat what others have done with PCI, Sun has innovated in the Sun Fire V880 servers:

• Three independent buses serve nine general-purpose, hot-plug, 64-bit PCI expansion slots for sustained high performance
• Two slots are clocked at 66 MHz with seven others clocked at 33 Mhz.
• An additional independent bus dedicated to the integrated Fibre Channel and Gigabit Ethernet controller
• Hot-swap capabilities that allow cards to be removed or inserted without interrupting operation (in conjunction with support from the Solaris Operating Environment and compliant device drivers.)

**Fibre Channel Arbitrated Loop**

Higher I/O rates, larger datasets, and distributed computing architectures are driving more data through systems and networks, and as this trend continues, traditional storage technologies are more likely to become a severe bottleneck for systems, applications, and users.

Sun Fire V880 servers support Fibre Channel Arbitrated Loop (FC-AL), an industry-standard, high-speed serial data transfer interface. Developed with storage connectivity in mind, FC-AL is an enhancement to the Fibre Channel standard that supports either copper or optical media and loops containing up to 126 devices, such as disks. FC-AL supports hot-plug and is highly tolerant of failures.

The FC standard supports bandwidths of 133 Mb/sec., 266 Mb/sec., 532 Mb/sec., 1.0625 Gb/sec., 2.12 Gb/sec., and 4 Gb/sec. (proposed) at distances of up to ten kilometers. The Sun Fire V880 server’s implementation of FC-AL supports the 1 Gb/sec. standard, which equates to about 100 MB/sec. throughput (200 MB/sec. full-duplex) including protocol overhead.

In addition to its strong performance characteristics, FC-AL also provides powerful networking capabilities, incorporating switches and hubs to interconnect systems and storage into tightly-knit clusters. Clusters can provide high levels of performance for file service, database management, or general purpose computing. Because it is able to span up to 10 kilometers between nodes, FC-AL also enables the very high speed movement of data between systems that are geographically separate from one another.

FC-AL is also a high-reliability interconnect: the interface is robust enough to allow multiple devices to be removed from the loop at one time with no interruption in data transfer; FC-AL devices can disassociate themselves with failed host adaptors and seek an alternate to provide service; and the interface attaches sophisticated error detecting codes to each packet of user data, requesting retransmission in the event of an error.

While Fibre Channel’s performance and reliability are impressive, it also has other important characteristics:
• **Industry standard.** The FC-AL development effort is part of the ANSI/ISO accredited SCSI-3 standard, helping to avoid the creation of non-conformant, incompatible implementations.

• **Broadly supported.** All major system vendors, including Sun, HP, Compaq, and others, are implementing FC-AL, as are many disk drive and storage subsystem vendors. Such wide support ensures competition, lower costs, and user choice.

• **Greater flexibility.** Fibre Channel can also be used for more than disk I/O — the Fibre Channel specification supports high speed system and network interconnects using a wide variety of popular protocols, including HIPPI, TCP/IP, IPPI, FDDI, ATM, as well as SCSI. Nearly all of the interconnect requirements of even the largest enterprises can be met by Fibre Channel, promising lower costs, easier administration, and the easy deployment and redeployment of computing resources.

Sun Fire V880 server’s FC-AL installation and cabinet supports up to twelve drives. A second loop can be configured for failover or additional bandwidth.

**Enclosure**

Including casters, the Sun Fire V880 server deskside enclosure measures 18.9” wide by 28.1” high by 32.9” deep (71.4 cm by 48.0 cm by 83.6 cm). The unit can be rackmounted by simply adding a rackmount tray. Rackmounted, Sun Fire V880 server systems occupy a total of 17 rack units (figure 2-2). The enclosure includes a key switch and LED status displays.

The Sun Fire V880 server includes space for two 5.25” half-height or one full-height removable media device(s) in addition to the DVD. The base system also includes space for up to six 1” 10,000 RPM Fibre Channel drives, with optional expansion for an additional six drives. Side-panels provide easy access to components, including CPU modules, PCI slots, and fan trays. Access to the power supplies is from the back of the rack.
Standard Interfaces

Networking support includes an optical external connector for Gigabit Ethernet and one twisted-pair connector to support 100 Mbps IEEE 802.3 Fast Ethernet using twisted pair Category 5 interfaces, downward compatible with 10 Mbps Ethernet (autosense).

For users requiring a larger number of network interfaces, or access to other networking protocols, Sun provides connectivity through a family of high performance PCI expansion cards.

Other interfaces standard with every Sun Fire V880 server include:

- Two external 12 Mb/sec. Universal Serial Bus (USB) connectors to support keyboard and mouse.
- Two 460 Kb/sec. asynchronous (384 Kb/sec. synchronous) RS-232/RS-423 serial ports are available through a splitter cable.
- Flash PROM for boot-time configuration. Can be reprogrammed in the field from a CD-ROM or over a local-area network.
SCSI

All Sun Fire V880 server models feature an integrated, internal SCSI bus to support DVD and other removable media devices. A 20 MB/sec. bus compliant with the Fast-10 standard, it is downward compatible with standard 8-bit 5 MB/sec. SCSI devices.

Software

Solaris 8 Operating Environment is standard as are the OpenWindows™ software and Motif windowing systems and the CDE desktop environment. ONC™+, NIS+, NFS™, TCP/IP, IPX/SPX, NetBEUI, NetBIOS, OSI, X.25, SNA, and DECnet networking technologies enable maximum interoperability. Support for Ethernet, ATM, ISDN, T1 and E1 network hardware technologies is standard. MS mail, UNIX® mail, POP3, and IMAP mail system support are provided.

The Solaris Operating Environment supports a wide range of management protocols, administration and installation tools, and products to support interoperability among a wide range of platforms.

Input Devices

Available USB keyboards include Sun Type 6, AT-101 or UNIX layout. Eighteen international layouts are available to support a worldwide customer base.

An optional, opto-mechanical 3-button mouse is available.

Reliability, Availability, and Serviceability Features

Sun continues to enhance the reliability, availability, and serviceability features in its workgroup server line by incorporating additional features already proven in their data center servers. Features available in the Sun Fire V880 server include:

- Extensive power-on self test
- ECC or parity on all major data buses and memory
- Software memory scrubbing
- ECC on external cache RAMs
• Up to three hot-swappable power supplies are supported, with two required. A third power supply allows uninterrupted operation with one failed unit.
• Thermal faults result in customer alerts and/or shutdowns to avoid component damage
• SunVTS™ software diagnostics can be run as needed or at scheduled times to periodically validate system functionality
• StorEdge™ Traffic Manager software allows multipathing to external Sun StorEdge T3 and Sun StorEdge A5100/5200 arrays (these arrays may not contain boot devices).
• Visual diagnostics through the use of on-board LEDs and the front panel
• Sun™ Remote System Control enables access, monitoring, and control of the server from a remote location, using any of a number of client devices
• Modular hot-plug components include disks, PCI slots, power supplies, and cooling fans
• Common fasteners are used throughout for easy servicing
• Minimal use of jumpers
• Support for Sun Cluster high-availability configurations
• Sun™ Management Center software provides environment and performance monitoring and early detection of failures
• Support for Sun’s Automatic System Recovery

Regulatory Specifications

Meets all relevant international and domestic safety, ergonomics, EMI, and environmental requirements.

Multiprocessing Muscle Speeds Throughput

Multiprocessing, such as that found in the Sun Fire V880 server, increases productivity by running tasks in parallel — speeding database queries, providing remote file service, and accelerating computationally intensive applications — critical factors for growing enterprises. Indeed, Sun’s symmetric multiprocessing environment provides the flexibility to simply add or upgrade processors as needed, and enables binary compatibility across systems. To complete the picture, Sun provides all the tools and related technologies needed to enhance the effectiveness of multiprocessing systems.
Multiprocessing allows users to reap tangible benefits by increasing performance in several ways. Often, these improvements can be realized immediately, without rewriting a single line of source code:

- The 64-bit multithreaded kernel of the Solaris Operating Environment enhances the inherent multitasking capability of the UNIX platform. Multiple tasks can be spawned to run simultaneously on multiple processors. I/O functions, backups, complex calculations, and database searches can all run in parallel, improving the overall system performance and throughput.

- In UNIX environments, users typically run multiple applications simultaneously. Multiprocessing enhances performance and throughput because each application can run on a separate processor.

- The Solaris Operating Environment can split application system calls into separate processes, each running in parallel. Graphics, networking, compute, and I/O requests can be run on different processors at the same time.

- Developer toolkits and compilers from Sun automatically detect parallelism and spread program execution over many processors at run time.

- Multithreaded applications increase throughput by decreasing the time it takes to perform one job. Developers can assign multiple tasks in a single application to independent threads of execution, with the operating system automatically assigning each thread to an available processor.

**Target Industries and Applications**

The Sun Fire V880 server was designed as a general-purpose workgroup server capable of meeting the needs of a wide range of industry users, applications, and environments. Eight-way multiprocessing, high-speed interconnects, high-performance and capacity storage systems, and the Solaris Operating Environment all help provide the highest level of scalability, reliability, security, and performance in workgroup settings.

Key markets include:

- **Financial Services.** Branch to regional office servers, e-commerce, customer management, isolation of select applications in datacenter environments

- **Service Providers.** All Internet services including access, security, Web hosting, on-line commerce servers, order processing, and scheduling
• **Manufacturing.** IT, finance and accounting, human resources, ERP/MRP solutions, supply chain management, engineering, sales and marketing, customer service, and e-commerce

• **Telecommunications.** Internet HTTP, e-mail, ftp, directory servers, and message switching

• **Retail.** In-store systems, merchandising, inventory management, distribution, and CRM

• **Government.** Branch office systems, departmental servers, repositories for documents and plans, financial records.

• **Healthcare.** Satellite office servers, patient records, billing, claims processing, medical imaging, picture archival, communications

• **Education.** Registration and student records, financial aid administration, and academic research

• **Compute Farms.** High performance engineering and scientific applications, ECAD, EDA, MCAD, simulation and modeling, statistical analysis, scientific research, and document storage

Many applications will benefit from the Sun Fire V880 server’s performance, availability, and scalability, including:

• Database and Judicial Media Management
• Distributed Database Access
• Online Transaction Processing
• Email, Web Services, and Internet Gateway
• Decision Support
• Groupware and Collaboration
• Compute-Intensive Applications.
The Sun Fire V880 server was designed to provide high performance, scalability, reliability, flexibility, and economy in a deskside enclosure that easily fits into a variety of working environments and computing tasks. The very high levels of integration achieved with Sun server systems through the use of application specific integrated circuits (ASICs) have resulted in a greatly reduced part count, high reliability, and low cost without compromising access to a full complement of expansion options through high performance, standard interfaces.

This chapter describes the architecture of the Sun Fire V880 server system in detail, beginning with a system block diagram (figure 3-1). Many of the subsystems are closely coupled to the UltraSPARC III microprocessor, and they are carefully described. In addition, the memory subsystem, Sun Fireplane Interconnect architecture, Fibre Channel Arbitrated Loop, the PCI Bus, and standard interfaces are discussed.

The UltraSPARC™ III Microprocessor

The Version 9 Architecture

The SPARC™ architecture has been implemented in processors used in a range of systems from laptops to supercomputers. SPARC International member companies have implemented numerous compatible microprocessors since the SPARC platform was first announced — more than any other RISC (reduced instruction set computing) microprocessor family. As a result, today the SPARC
architecture boasts the support of thousands of compatible software and hardware products. SPARC Version 9 maintains upwards binary compatibility for application software developed for previous SPARC architecture implementations, including microSPARC™, TurboSPARC, SuperSPARC™, and previous versions of UltraSPARC.

Figure 3-1  Architecture of the Sun Fire V880 server

SPARC V9 processors represent a significant advance for the industry. They provide 64-bit data and addressing, fault-resilient features, fast context switching, support for advanced compiler optimizations, efficient design for superscalar processors, and a clean structure for emerging operating systems. Perhaps most significantly, all of this has been accomplished with 100-percent binary compatibility for existing SPARC processor-based applications.
UltraSPARC III Processor

The UltraSPARC III processor is part of a third generation of UltraSPARC microprocessors. In addition to using a new process technology, the UltraSPARC III processor provides a higher clock frequency, reduced on-chip latencies, support for greater amounts of level-one and level-two cache, and an integrated external memory controller. Other new features includes support for very large multiprocessor systems, as well as features designed to support increased reliability through enhanced error detection and correction. At the same time, it provides software compatibility with all previous generations of SPARC processors.

Key Features of the UltraSPARC III

The newest member of Sun’s family of SPARC CPUs, UltraSPARC III is the most sophisticated of the SPARC family of processors to date. Designed for use in uniprocessor and multiprocessor systems, UltraSPARC III offers the following key features:

- SPARC Version 9 architecture compliant
- Binary compatible with all existing SPARC applications
- Enhanced VIS Instruction Set to support advanced multimedia capabilities
- Four-way superscalar issue against six execution units — two integer execution pipelines (IEUs), one load/store, one addressing, and two floating-point/VIS execution units (FPUs).
- Selectable little- or big-endian byte ordering
- 64-bit address pointers that enjoy transparent compatibility with 32-bit addressing
- Extensive error correction and isolation features extended to Level 2 cache
- 64 KB 4-way set-associative Data Cache
- 32 KB 4-way set-associative Instruction Cache steers up to four instructions/cycle to six execution pipes
- Integrated second-level cache controller supports 8 MB caches. Sustained throughput of one load per cycle across a 256-bit wide datapath.
- 2.4 GB/second processor-memory bandwidth
- 23 million transistor design (including cache) implemented using 0.18 micron, 7-layer CMOS aluminum interconnect technology operating at 1.8 volts.
Instruction Pipeline

To meet clock rate and performance goals, the UltraSPARC III is designed with a deep, 14-stage pipeline, deeper than any previous generation of SPARC processor (figure 3-2). Each stage in the pipeline performs part of the work required to execute instructions. In the figure, instruction issue occupies stages A through J, integer execution stages R through D, with the data cache unit occupying stages E, C, M and W and floating point occupying a parallel, “side” pipeline that is coincident with stages E through D of the integer pipeline. Other functional units in the processor have unique, internal pipelines.

Figure 3-2  The UltraSPARC III processor incorporates a 14-stage pipeline, larger than in any previous UltraSPARC processor.

One potential performance issue in the handling of pipelined systems occurs when an event like a data cache miss occurs. In events such as this, traditional designs issue a global pipe stall signal to freeze the pipeline. With the UltraSPARC III processor, the event is handled like a trap, with a nonstalling pipeline. The pipeline is flushed, and the state restored by refetching instructions that were in the pipeline starting at the A stage.

Branch misprediction can also create a performance penalty in deep pipelines. In the UltraSPARC III processor, improved branch prediction logic results in misprediction much less frequently. The UltraSPARC III processor also has a small amount of alternate path buffering in the I stage, so if a misprediction does occur, a few instructions are immediately available to start in the I stage, effectively halving the potential penalty.
UltraSPARC III Functional Units

In a single chip implementation, the UltraSPARC III processor features a very high level of integration which include the following six key components (figure 3-3):

- **Instruction Issue Unit (IIU)**

  The IIU feeds the execution pipeline with instructions, independently predicting control flow through a program and fetching the predicted path from the memory system. Fetched instructions are staged in a queue before dispatch to the integer or floating point units at up to four instructions/cycle. The IIU includes a 32 KB, four-way associative instruction cache, instruction address translation buffer, and a 16 K-entry branch predictor. A 20-entry instruction queue decouples the fetch and execution units, allowing each to proceed at its own rate.
• **Integer Execution Unit (IEU)**

The IEU executes all integer data-type instructions, including loads, stores, arithmetic, logical, shifts, and branches. Four independent data paths permit up to four instructions per cycle to be executed with the following per-cycle concurrent instruction mix: 1) two arithmetic, logical, or shifts; 2) one load or store; 3) one branch.

• **Floating Point Unit (FPU)**

The FPU incorporates all data paths and logic to execute floating- and partitioned fixed-point instructions. Three independent data paths can concurrently execute one instruction per cycle from each of the following classes: single, double, or partitioned divide and multiply; single, double, or partitioned add, subtract, or compare; and an independent division data path which lets a non-pipelined divide continue in parallel with the pipelined multiple and add data paths.

The FPU also incorporates most of the functionality associated with the VIS Instruction Set, with two independent execution units (one ALU plus one multiply) dedicated to graphics operations.

• **Data Cache Unit (DCU)**

The DCU manages all level-one on-chip cache memories and the data address translation buffer. The three first-level, on-chip caches include a 64 KB four-way associative data cache; a 2 KB, four-way associative prefetch cache; and a 2 KB, four-way associative write cache.

The design of the on-chip memory system in UltraSPARC III processor was central to overall performance and scalability of the processor. This was done by scaling both bandwidth and latency. Latencies were improved through the use of sum-addressed cache and improvements in both level 2 and external memory latencies. On-chip memory bandwidths were scaled through the use of high-performance “wave-pipelined” SRAM designs for the on-chip caches and the use of a write cache for store traffic. As a result, UltraSPARC engineers were able to shorten average memory latency from earlier UltraSPARC designs by more than the clock-rate multiplier.
• **External Memory Unit (EMU)**

The EMU controls both the SRAM level-two off chip data cache and the main memory system (implemented with existing SDRAM memory technology.)

Bandwidth to L2 cache is kept high through the use of a 256-bit-wide data-bus, delivering the entire 32 bytes of data in a single cycle. To support the 8 MB of L2 cache, the EMU is equipped with a 90 KB in-chip tag RAM, which also allows early detection of L2 misses, reducing the latency to main memory. Cache coherency in multiprocessor architectures is achieved by dedicating 50% of cycles of the on-chip L2 cache tags to snoops from other processors.

Moving the main memory controller on-chip reduces memory latencies when compared with previous designs and scales memory bandwidth as processors are added. In multiprocessor systems, the SDRAM banks can be interleaved across per-processor memory controllers. The 512-bit wide data bus to memory minimizes the latency to complete data transfers, a critical design point since misses from large caches tend to cluster, with adjacent misses impacting performance in systems without high memory transfer rates.

• **System Interface Unit (SIU)**

Charged with the task of all other off-processor communications (memory, other processors, and I/O devices) the SIU can handle up to 15 pending transactions. It also supports full out-of-order data delivery on each transaction, enabling memory banks in a multiprocessor system to service a request as soon as a bank is available. All processor interfaces use error detection and/or correction codes to quickly detect errors. In the event of an error on the system bus, an independent 8-bit-wide “back door” bus allows the use of automated diagnostics to isolate the problem.

**CPU/Memory Modules**

Sun Fire V880 servers can accommodate up to eight UltraSPARC III processors populated onto dual CPU/memory modules. Each module includes two processors, 8 MB of cache memory per processor, and main memory (up to 4 GB) for each processor.
Memory Subsystem

External Cache Memory

Sun Fire V880 server systems feature 8 MB of external secondary cache per processor with 64-byte line size. Synchronous SRAMs are used for data and for tag. The datapath to the external cache is 288 bits wide (256-bits of data plus ECC.)

Main Memory

Sun Fire V880 servers have a memory system which uses 3.3V synchronous DRAM DIMMs. Each CPU/memory module currently supports up to 4 GB per CPU in 8 slots, for a system-wide total of 64 DIMMs and 32 GB. Supported DIMMs include 128 MB, 256 MB, and 512 MB modules.

To increase memory system performance, Sun Fire V880 server systems employ a wide 576-bit memory architecture. DIMMs must be added to system in groups of four, two groups per processor. All DIMMs populating a group must be of the same capacity, but different groups may use DIMMs of different capacities. No partially populated groups are allowed.

The Sun Fireplane Interconnect

With the rapid movement of processor technology and performance, bus technology has been hard-pressed to keep up. The all-new Sun Fireplane Interconnect reverses this trend by providing superior memory and I/O bandwidth, ensuring balanced and predictable performance under the most demanding loads.

Separate Address and Data Paths

One of the major architectural innovations of the Sun Fireplane system interconnect is the ability to combine the simplicity of a single bus and the high bandwidth normally associated with a switch-based interconnect. This is accomplished with the complete separation and independence of address and data paths.
The address and data paths in most computer systems are very closely related, especially in their low-level sequencing, forcing a strong coupling between the transport of addresses and data between system components. This can cause performance-robbing delays while the system waits for transactions to complete. The Sun Fireplane system interconnect breaks away from this traditional methodology by completely separating the address and data paths — both at the topological level and in low-level sequencing.

**Ordering on the Interconnect**

One of the ways that the Sun Fireplane interconnect is able to achieve significant bandwidth gains is by allowing multiple transactions to be “in flight” on the interconnect at the same time. This out-of-order execution feature reduces the time spent waiting for transactions to complete by allowing multiple transactions to be interleaved on the interconnect and within the processor.

Each of the devices on the Fireplane interconnect maintains a record of the order in which it has issued requests, with each transaction tagged and identifiable by the requestor. Requests may be fulfilled in a different order than they were issued.

With the Sun Fireplane interconnect, each device can have up to fifteen outstanding 64-byte data transfers. This capability is important to maintain the performance of the UltraSPARC III processor as it uses aggressive pre-fetching to fill both internal and external caches.

**The Sun Fireplane Interconnect in Sun Fire V880 Server Systems**

The address and command structure of Sun Fireplane Interconnect is based on a 6-port crossbar switch. In the Sun Fire V880 server, the address and command lines are extended through two levels of repeaters which preserve the bus model.

The Sun Fireplane crossbar interconnect is a 288-bit bus implemented inside a set of four identical ASICs. This approach couples a wide data path with a high clock frequency of 150 MHz. The connection between devices (UltraSPARC III processors and a custom I/O bridge) and the crossbar ASICs use a point-to-point model which allows the best possible clocking rate for chip-to-chip communication. The crossbar ASICs also provide a switch between the internal data bus and the processor.
With the bus model of the Fireplane interconnect, the need for a centralized arbitration is eliminated, and control is distributed between all attached devices. The arbitration for the address and control lines is performed simultaneously by all devices which has the added benefit of reducing latency.

Cache Coherency

To maintain the high level of performance demanded by today’s applications, Sun Fire systems use external cache located on the processor module. Data that has been recently used, or whose impending use is anticipated, is retrieved and kept in cache memory — closer to the processor that will need it. In a multi-processor, shared-memory system, the task of keeping all of the different caches within the system consistent requires assistance from the system interconnect.

The Sun Fireplane system interconnect implements cache coherency through a technique known as “snooping”. With this approach, each cache monitors the addresses of all transactions on the system interconnect, watching for transactions that update addresses it possesses. Since all processors need to see the broadcasted addresses on the system interconnect, the address and command signals arrive simultaneously. The address and command lines are connected in a point-to-point fashion.

Performance

The Fireplane interconnect provides a number of key capabilities that make it ideal for the Sun Fire V880 server.

• High Bandwidth

The Sun Fireplane Interconnect takes advantage of VLSI and packing technology improvements by widening the data path segments to 288 bits (256 bits of data, and 32 bits of ECC). With a 150 MHz clocking rate, the interconnect delivers 4.8 GB/sec. of sustainable bandwidth per bus segment and a total system throughput of 9.8 GB/sec. In Sun Fire V880 server systems, 4.8 GB/sec. is the peak bandwidth of the system as the sustainable bandwidth is limited by the 2.4 GB/sec. bandwidth of the memory system.
• **Low Latency**

Many multiprocessor systems provide a high-bandwidth interconnect at the expense of increased latency. Given the wide application of the Sun Fireplane Interconnect to a range of Sun’s multi-processor systems, special care was taken to avoid increased latency with the interconnect.

For example, integrating the memory controller with the CPU reduces latency without software optimization. In addition, the interconnect implements special techniques for delivering data to the caches that minimizes latency. Finally, the UltraSPARC III processor provides a very sophisticated write-buffer with plenty of “head-room” so that even pathological behavior does not impact performance.

• **Innovative Flow Control**

In most previous-generation systems, data is “pushed” onto the interconnect when a write transaction is issued by any device. This model requires a complex flow-control mechanism which often results in suspension of write traffic on the interconnect. In contrast, the Sun Fireplane Interconnect introduces a novel method for data writes with the target device “pulling” the data rather than it being “pushed” by the writer. A device which is a target of a write transaction simply informs the writer when it is ready to accept the data. This approach helps ensure a balanced usage of system bandwidth between processors and translates into a more predictable response time under heavy load.

• **Advanced Signaling Technology**

The Sun Fireplane Interconnect introduces a more advanced low-level voltage signalling technology called Dynamic Transceiver Logic (DTL). DTL drivers and receivers can easily be integrated on large ASICs while still using regular cooling and packaging technologies. In particular, DTL innovates by providing self-adjusting compensation circuitry that compensates automatically for voltage, temperature, and process variations in VLSI chips. Better control over timing margins translates into a higher clock frequency on wide data paths.
PCI Connectivity

PCI provides a high performance bus that is optimized for high speed data transfers. System-board resident, the PCI bus is used as an interconnect between highly integrated components and subsystems, such as peripherals and add-on boards. The processor, main memory, and the PCI bus are connected through a PCI host bridge and interconnected by the Fireplane interconnect.

The PCI bus is based on the industry-standard PCI specification Revision 2.1. Unlike most standards, the PCI specification is very broad. It covers everything from multiple form factors and voltages to connector types. Sun has chosen to implement the most common options available:

- 33 MHz and 66 MHz buses
- 32-bit or 64-bit cards
- 5 volt cards (33 MHz bus)
- 3.3 volt cards (33 and 66 MHz bus)
- 7 inch (short) cards
- 12 inch (long) cards
- Low power operation

To enable sustained high performance, Sun Fire V880 server systems support nine slots distributed among three independent, 64-bit PCI buses. Each PCI slot is hot-plug capable to provide enhanced availability by allowing failed components to be replaced without disrupting operations.

Each slot can supply up to 25 W of power. Table 3-1 summarizes slot configuration data.

<table>
<thead>
<tr>
<th>PCI Slot Number</th>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
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<th>5</th>
<th>6</th>
<th>7</th>
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<td>✔</td>
<td>✔</td>
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<td>✔</td>
</tr>
<tr>
<td>33 MHz Clock</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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</tr>
<tr>
<td>5 Volt or Universal Cards</td>
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<td>✔</td>
<td>✔</td>
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<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>3.3 Volt or Universal Cards</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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<td>64-bit Slot</td>
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<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

*Table 3-1* Available configurations, speeds, and voltages for PCI slots.
Sun supports a variety of PCI-based adaptor cards, including Ethernet, ATM, and ISDN networking cards, video, SCSI, and high-speed serial and parallel interfaces. In addition, Sun has developed a host of third-party alliances to develop PCI hardware and software that is certified for operation on all systems running the Solaris Operating Environment.

**Peripherals, Networking, and Back Panel**

In addition to PCI connectivity, Sun Fire V880 server servers support a standard complement of I/O devices through connectors on the back panel (figure 3-4):

- 10/100 BaseT
- Gigabit Ethernet (1000 Base SX)
- USB ports
- Serial ports

*Figure 3-4* In the tradition of all Sun systems, the Sun Fire V880 server features broad connectivity and expansion options
Ethernet Support

To support higher performance network connectivity, all Sun Fire V880 server models support 10/100 Mbps (Fast) Ethernet and an independent 1 Gbps Ethernet.

Fast Ethernet is a direct extension of the 10Base-T Ethernet standard, but is capable of supporting a wider range of applications requirements with its greater throughput. Particularly compelling is its compatibility with the installed base of wiring currently employed for 10Base-T, making it a very cost-effective migration path for most users. The 10/100 Mbps Ethernet interface in Sun Fire V880 server systems support access to Category 5 twisted pair through a single RJ45 connector.

Gigabit Ethernet is typically deployed as a backbone interconnect between 10/100 Mbps Ethernet switches, and as a connection to high performance servers. Gigabit Ethernet is an ideal way to connect multiple workgroups accessing information stored on high-end servers or for server-to-server back-ups. Gigabit Ethernet also provides a natural upgrade path for systems that require more bandwidth than can be provided by Fast Ethernet.

Like its predecessor, the standards for Gigabit Ethernet are well defined and accepted throughout the industry, and a large number of compatible products are available from a variety of vendors. Sun Fire V880 server systems provide support for Gigabit Ethernet through a 1000 SX optical connector on the rear panel of the system.

Fibre-Channel Arbitrated Loop Storage Connectivity

Sun Fire V880 servers feature standard support for Fibre Channel Arbitrated Loop (FC-AL), an industry-standard, high-speed serial data transfer interface. Developed for storage connectivity performance, FC-AL is an enhancement to the Fibre Channel standard that supports copper media and loops containing up to 126 devices, or nodes. FC-AL loops are hot-pluggable and tolerant of failures.

The Sun Fire V880 server’s implementation of FC-AL supports the 1.0625 Gb/sec. standard, translating to about 100 MB/sec. throughput. (200 MB/sec. full-duplex) after accounting for overhead.
Sun Fire V880 server systems are configured with support for a single loop (Loop “A”) and cabinetry to accommodate up to six 1”, 36.4 GB or 72.8 GB Fibre Channel, hot-pluggable SCA-2 drives. Users may extend the internal capacity with an optional storage backplane capable of supporting an additional six disks, for a total of twelve. (All twelve can be supported on a single FC-AL loop.) Independent of the number of storage backplanes and disks, one may select an optional, redundant path, i.e. Loop B, to the internal disks. Doing so will provide redundancy in the event of a failure of one path as well as potentially higher overall disk throughput. This redundancy requires optional software such as VERITAS Volume Manager with Dynamic Multipathing.

In addition to available internal expansion options, Sun Fire V880 server systems can be configured with additional PCI-based Fibre Channel and SCSI adaptors and external RAID controllers to create a variety of configurations tuned to meet a variety of requirements for capacity and reliability (figure 3-5).

Universal Serial Bus

The Universal Serial Bus (USB) has become a principal means of connecting personal computers with peripherals such printers, scanners, floppy drives, modems, cameras, keyboards, and mice. USB has helped lower the cost of many peripherals by allowing manufacturers to standardize on a single I/O technology. In addition to offering a wide range of performance, USB is a hot-plug technology, allowing devices to be added and removed without power-cycling the system. Other important USB features include integrated power for low-power devices and support for up to 128 peripherals with the use of daisy-chained hubs.

The Sun Fire V880 server design includes support for USB devices, incorporating two 12 Mb/sec. external connectors on the back panel.

Keyboard and mice are supported through the USB connectors. Optionally available with each system is a Sun Type-6 USB keyboard which has a layout compatible with the common IBM AT 101-key keyboard. For others, a keyboard with a UNIX layout is also available. The optional USB mouse is an opto-mechanical, three-button design.
In addition to its internal storage, Sun Fire V880 systems can be configured with additional PCI-based Fibre Channel and SCSI adaptors and external RAID controllers to create a variety of configurations tuned to meet a variety of requirements for capacity and reliability.

**Serial Ports**

RS-232C and RS-423 serial ports provide a convenient way to connect a system to devices such as modems and terminals. All systems include support for two serial ports. A single, DB-25 connector on the back panel directly supports the first port. This connector will accept a “Y” adapter cable to reproduce the first port and add the second. Only the first port supports clocking for devices. Synchronous serial transfers at 384 Kb/sec. are supported, while asynchronous transfers can occur at up to 460 Kb/sec.
Once narrowly defined as small groups sharing basic file and print services over a LAN through personal computers, the workgroup can now include hundreds or even thousands of individuals who work together using a broad range of applications — including groupware and messaging, e-commerce, data warehousing and data marts, and enterprise resource planning (ERP) applications.

At the same time, many new workgroup applications have become mission-critical, with every minute of downtime constituting a withering expense when missed sales opportunities, idle employees, and customer dissatisfaction are considered. The industry is learning what workgroup administrators already know — applications must be available 7 days a week, 24 hours a day.

In addition to product features designed to improve the reliability of workgroup computing systems, system managers also need better, more powerful tools to help them gain an added measure of monitoring and control over their systems. To this end, Sun has provided the Sun Fire V880 server with a suite of enhancements unprecedented in workgroup computing. Incorporating innovations from previous Sun workgroup and Enterprise servers, administrators and users will find a variety of technologies designed to improve system reliability, availability, serviceability, and manageability.
Features for Reliability, Availability, and Serviceability

Redundant, Independently-Powered Components

Basic to many strategies for mitigating the disruptions caused by failures is the availability of redundant hardware. By maintaining multiple integrated, configured components that can accept the load should one fail, processing can generally continue with minimal or no interruption. In some cases, total throughput or capacity may be diminished, but essential services can generally continue to be provided. Depending on configuration, the following redundant components are available on Sun Fire V880 servers:

- Power supplies
- I/O adaptors for storage and networks
- Cooling fans

The Sun Fire V880 server is designed to operate with only two power supplies. When configured with N+1 redundancy, one of three available power supplies can fail with no loss of functionality.

Hot Plug and Hot Swap Components

Hot plug components allow the removal of failed components and insertion of replacements without first powering down the system. Once considered an innovative feature even in the largest systems, Sun Fire V880 servers feature hot-plug compatibility for power supplies, disk drives, PCI slots, and cooling fan trays.

These same hot pluggable components are also hot swappable — they can be inserted and configured for use, or disabled and then removed from a running system. This capability eliminates the need for system reboots after certain hardware configuration changes, and allows users to continue running their applications without interruption. (Note, hot-swap capabilities in PCI cards are dependent on the capabilities of device drivers for those cards. Check with vendors to ensure that they support hot swap.)

By allowing components to be added and removed from a running system, downtime can be greatly reduced. It then becomes easier to schedule maintenance because components may be added or upgraded without
rebooting the operating system. In addition, resources may be added to a system to increase capacity on an as-needed basis, avoiding downtime when the system is needed the most.

**IP Network Multipathing**

IP Network Multipathing is a feature in the Solaris 8 Operating Environment that provides fail-over and IP link aggregation. Key features include:

- **Failure Detection.** Failure detection provides the ability to detect when a network adapter has failed and automatically switch (fail-over) the network access to an alternate network adapter.

- **Repair Detection.** The repair detection feature of IP Network Multipathing senses when a network adapter that previously failed has been repaired, and initiates a switch back to the primary network adapter.

- **Outbound Load Spreading.** Outbound load spreading distributes network packets across multiple network adapters to achieve higher throughput. Load spreading occurs only when the network traffic is flowing to multiple destinations through multiple connections.

**Traffic Manager**

Many I/O devices, including Sun’s StorEdge A5200 family and StorEdge T3 array, provide multiple controller interfaces\(^1\). Traffic Manager is a new service of the Solaris Operating Environment that enables individual domains on Sun Fire servers to take advantage of these multiple connections to Fibre Channel devices — removing disk controllers as single points of failure. Traffic Manager provides two important features for Sun Fire V880 server users:

- Traffic Manager protects against I/O outages due to I/O controller failures. If one controller fails, Traffic Manager switches to an alternate.

- I/O performance can be increased through Traffic Manager’s support for load balancing across multiple I/O channels.

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\(^{1}\) Traffic Manager is not supported on external arrays which contain boot devices. If the boot devices reside within the internal storage array, VERITAS Volume Manager V3.1.1 or later is required. At this time, only VERITAS Volume Manager supports Fibre Channel loops upon which boot devices reside.
Traffic Manager is not supported on external arrays which contain boot devices. If the boot devices reside within the internal storage array, VERITAS Volume Manager V3.1.1 or later is required. At this time, only VERITAS Volume Manager supports Fibre Channel loops upon which boot devices reside.

**Automatic System Recovery (ASR)**

Specific types of hardware failures, such as a processor failure, may bring down a system. Automatic System Recovery (ASR) enables Sun Fire V880 server systems to reboot immediately following a failure, automatically configuring around a failed component. This approach prevents faulty hardware from keeping the entire system down or causing the system to fail repeatedly.

ASR tests various hardware components when the system is first powered on, or when an external reset is generated. The primary component of ASR is Power-On Self Test (POST).

**Advanced Diagnostics**

All Sun platforms are designed for easy diagnosis and problem repair. Supporting this are several PROM-resident and application-level diagnostic programs that can be applied by end-users and service personnel.

**Power-On Self-Test (POST)**

Under administrator control, a power-on self-test (POST) can be automatically executed to test the system boards, NVRAM, on-board I/O devices, and memory system each time power is applied to the system. While not intended to be a comprehensive diagnostic, POST can quickly establish that no severe problems exist with the system, and communicate that through a set of light-emitting diodes (LEDs) on the front panel. POST tests may be monitored via a serial-port connection to another desktop system or character-based terminal.
Sun Validation Test Suite (SunVTS™)

To supply robust on-line diagnostic capabilities for Sun Fire V880 server systems, Sun provides the Sun Validation Test Suite (SunVTS). The primary goal of the SunVTS software is to create an environment in which Sun systems can be thoroughly tested to ensure their proper operation and to find elusive problems or avoid imminent failures.

SunVTS software offers an easy-to-use graphical user interface (GUI) for initiating and logging test results from various subsystems (e.g., processors, memory, I/O, etc.) or the system as a whole. Some its key features are:

- **UNIX level diagnostics**, where system tests execute under the Solaris Operating Environment
- **Automatic system probing**, enabling the system configuration to be displayed via a user interface
- **Both a GUI-based interface and a character-based interface**. The SunVTS kernel is cleanly separable from the user interface such that multiple user interfaces can communicate with the same SunVTS kernel. The character-based interface permits shell scripts to control SunVTS software.
- **An Application Programming Interface**, providing a well-defined interface into the SunVTS kernel from other processes, as well as from the user interfaces. Execution can be initiated in a **cron-like fashion**, with no direct user interface at all.
- **Advanced configuration and execution control**, allowing tests to be grouped together based on user requirements, with fine grained execution control for status and logging information.

Management and Administration Tools

**Sun™ Remote System Control**

One of the many benefits of workgroup servers is their ability to be easily deployed into remote locations with no environmental control beyond that found in a typical office environment. Remote siting can, however, present difficulties for administrators when problems occur — service calls can be time consuming and expensive, even to address trivial problems.
The Sun Fire V880 server features Remote System Control (RSC), which enables access, monitoring, and control of the server from a remote location. The Remote System Control card is a fully independent processor card that resides in the cabinet, supporting a remote console through a serial line, Ethernet port, or a modem.

With the help of the RSC card, administrators can monitor multiple Sun servers and systems, devices, and network resources from a single location. Using a command-line interface (CLI), administrators can log in to the card (using telnet or the modem line) and execute commands to control the host server. In addition, RSC supports a graphical user interface (GUI) available to users of the Solaris 8 Operating Environment and Microsoft Windows 95, Windows 98, and Windows NT 4.0.

Key RSC features include:
- Remote system monitoring and error reporting, including output from power-on self-test (POST) and OpenBoot Diagnostics and the kadb kernel debugger
- Remote server reboot, power-on, and power-off on demand
- Ability to monitor the CPU temperature and fan sensors without being near the managed server, even when the server is offline
- Ability to run diagnostic tests from a remote console
- Remote event notification of server problems
- A detailed log of RSC events
- Remote console functions on both the modem and Ethernet ports

Sun™ Management Center

The most advanced systems management tool from Sun to date, Sun Management Center software offers a single point of management for all Sun systems, the Solaris Operating Environment, applications, and services for data center and highly distributed computing environments. Designed to support all Sun systems, Sun Management Center software provides a platform upon which the enterprise can base its efforts to keep systems and the services they provide highly available. Through a Web interface, Sun Management Center software enables system administrators to perform remote system configuration, monitor performance, and isolate hardware and software faults.
To support legacy networks and heterogeneous environments, Sun Management Center software is tightly integrated with all major enterprise management frameworks like CA Unicenter TNG, HP Open-View, IBM Tivoli, and BMC PATROL.

Additional features in the version 3.0 release include:

- Enhancements to core applications including alarm manager, auto discovery, Web console, log viewer, scalable tables, and data views
- Advanced Systems Monitoring add-on including full kernel reader functionality, Solaris Operating Environment health monitoring, processing monitoring, and other advanced features that are licensed on a per-node basis
- Premier Management Applications add-on includes group operations, configuration propagation, command line interfaces, and improved data views
- Enhanced development environment includes graphics module builder and console integration interfaces
- Configuration and Service Tracker module gives administrators capability to better manage Field Replaceable Units (FRUs) and patches.
- Hardware Diagnostics Suite module provides comprehensive on-line diagnostics testing and resolution without interrupting customer applications or operations.

**Solstice AdminSuite™ Software**

Standard with all Sun servers, Solstice AdminSuite™ software is a unified suite of tools for running Solaris Operating Environment distributed system administration applications. Included in the suite is a User Manager for managing user accounts, a Database Manager to manipulate administration data, a Printer Manager to help administer printing subsystems, a Host Manager for connecting client systems to the network, a Software Manager for controlling the installation of software packages, and a Serial Port Manager to allow the remote management of serial ports. All Solstice AdminSuite applications have a common look and feel and share the same network-aware features, including a centralized administration data repository, location independence, administration without superuser privileges, and name service independence.
### Clustering for High Availability and Throughput

Today, high availability of data and services is a critical necessity. Downtime means lost productivity and lost revenues, and clusters are a new and important way to address this issue. A cluster is a group of nodes (a node being a single server running its own instance of the operating system) that are interconnected to work as a single, highly available and scalable system.

Sun™ Cluster software is fully supported on the Sun Fire V880 server. It delivers high availability — through automatic fault detection and recovery — and scalability, ensuring that mission-critical applications and services are available when needed. Sun Cluster software allows multiple nodes in a cluster — enough to handle growing numbers of simultaneous users and access to large databases. With Sun Cluster software, administrators can add or remove nodes while on-line, and mix and match servers to meet specific needs.

Sun Cluster 3.0 software represents the latest phase of Sun’s clustering roadmap. It extends the functionality of earlier versions, incorporating high availability and parallel database functionality in a single offering. In addition, Sun Cluster 3.0 enables a number of cluster-wide resource building blocks, such as a Global Devices, Global File Service, and Global Network Services; faster failover; diskless failover; a sophisticated API for creating clustered applications; and simplified administration.
Solaris™ Operating Environment

The Solaris 8 Operating Environment comes pre-installed on all Sun server systems and contains the base-level functionality required for all SPARC systems. Solaris 8 Operating Environment includes a proven, scalable 64-bit kernel, standards-based networking, and Java™ technology support. These technologies provide the foundation for building and deploying enterprise-class systems for multi-vendor, multi-client workgroup environments, as well as highly available data center environments. The strengths of the Solaris Operating Environment lie in its enterprise-class reliability, scalability, and performance. Version 8 extends, and expands upon, these strengths.

The Solaris Operating Environment employs a 64-bit kernel that provides enhancements in overall performance, scalability, reliability, availability, security, and ease-of-use while maintaining backward compatibility for all existing 32-bit applications. It continues the tradition of providing exceptional functionality and performance by delivering the following major capabilities:

- **Mission-critical reliability, availability, and serviceability** for systems of all sizes. Includes support for hot plug, Alternate Pathing, hot patching and live upgrades.
- **Higher performance, greater capacity, and precision** through its complete 64-bit computing environment.
- **Enhanced scalability** with a 64-bit kernel that enables access to more system resources and the ability to consolidate applications onto a single server
- **Greater ease-of-use**, including Web-based installation, text and voice notes, and a graphical process manager
• **Improved features to support network enterprises** including support for IPV6 protocols, mobile IP, enhanced support for removable media, and optimized Java Virtual Machine (JVM™). Includes CDs with iPlanet™ Web tools and Oracle 8i Enterprise database.

• **Comprehensive global support**, including support for the Euro currency symbol, complex text formats for Arabic, Thai, and Hebrew languages, and support for the development of multilingual applications

• **Software investment protection** with complete binary compatibility that enables all of today’s 32-bit applications to run without modification

• **Extended security features** through authentication, data integrity, data privacy, and single sign-on capabilities so that tampering, snooping, and eavesdropping do not compromise data or associated transactions. Support for IPSec prevents identity spoofing and can be used to build virtual private networks. Other security features include pluggable authentication modules, Role-based Access Control (RBAC), shared-secret and public-key encryption, and smart card support. Sun’s Trusted Solaris has security extensions to enable institutions/companies to separate data in a highly secure environment.

• **32-bit and 64-bit development environment**, enabling developers to generate a single set of source code that runs on both operating modes.

Designed to deliver the power, flexibility, availability, and compatibility to support enterprise-wide computing, the Solaris Operating Environment combines key computing elements — operating system, networking, and user environment — into a stable, high-quality foundation that enables the development, delivery, and management of a wide range of computing solutions.

### Operating System

Based on UNIX System V Version 4 (SVR4), the Solaris Operating Environment provides a rich applications development environment, and fully supports symmetric multiprocessing (SMP) and multi-threaded applications on multiprocessor machines. The Solaris Operating Environment enables maximum portability across platforms by conforming to several important standards including SPARC ABI, CDE-compliant Motif, X11, POSIX 1003.1b and 1003.2, NIS, WebNFS™ protocol, HTTP, FTP, Telnet, DNS, NTP, IMAP4, DHCP, SNMP, SMTP, IPv6, IPSec, Kerberos, SASL, OCF, UNIX 95 and UNIX 98 branding, X/Open® (XPG4 base functionality), OpenGL®, Postscript™, Display PostScript™, Kodak Color Management System, and ISO 9660.
Networking

Sun’s Open Network Computing (ONC+) software enables transparent access to information and services distributed throughout the environment. The Solaris Operating Environment also defines a standard interface to ONC+ software for alternative networking technologies enabling smooth integration with enterprise computing environments. Networking products such as NIS+, NFS, and RPC/XDR are supported for remote execution and data exchange. Transport layer independence helps ensure support for a variety of network transport protocols such as TCP/IP (figure 4-1).

![Diagram](image)

**Application Programs**

<table>
<thead>
<tr>
<th>NFS</th>
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<th>NIS/NIS+</th>
<th>PC NFSD</th>
<th>Lock Mgr.</th>
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<td>TI-RPC</td>
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</tr>
<tr>
<td>Low-level Network Protocols (TCP, IPX, OSI, etc.)</td>
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<td></td>
<td></td>
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</tbody>
</table>

*Figure 4-1* The Solaris Operating Environment supports a family of advanced networking protocols and services

Interoperability with Windows NT 4.0 Environments Using Solaris™ PC NetLink

Solaris™ PC NetLink allows Sun servers to run native Windows NT 4.0 network services on the Solaris Operating Environment. Solaris PC Netlink provides Windows NT 4.0 Primary Domain Controller (PDC), Backup Domain Controller (BDC), Member Server functionality, and Windows NT file system (NTFS) and printing support to various Windows clients.

From a powerful, scalable, and reliable Sun platform, it’s possible to service Windows NT networks by enabling administrators and users to take advantage of native Windows NT services — authentication, file, print, directory, etc. — running under the proven availability and reliability of the Solaris Operating Environment.
To a Windows NT user, Sun servers look just like any other Windows NT server on the network with native support for:

- Windows NT user logon, including BackOffice authentication
- Windows NT file services, including Windows NT style access control lists (ACLs)
- Windows NT directory services, with support for all types of domains and trust relationships.

Administrators can continue to use the same management tools — user manager, server manager, host manager, etc. — that they currently use with Windows NT servers. Even scripts written using the Windows NT NET commands are supported.

Installation

Solaris™ Web Start

Solaris™ Web Start software virtually eliminates the UNIX system administration chores normally associated with software deployment through a flexible software management console that can be run from any desktop in an organization's network. An easy to use tool for software deployment and management, Solaris Web Start software is a Java technology-based utility that simplifies and accelerates the installation of the Solaris Operating Environment and associated software. A browser interface provides a familiar way to deploy and manage software resources in the workgroup and even across the Web. Customization and configuration options provide the flexibility needed for even the most unusual configurations, and by leveraging Sun's JumpStart™ technology, Solaris Web Start software provides the advanced replicated installation and remote software deployment features demanded by enterprise administrators:

- One-button and custom deployment options simplify installation and configuration.
- Java technology management console looks like a set of Web pages.
- Support for a variety of media, including CDROMs and the Web, enhances distribution options.
- Extensive context-sensitive and on-line documentation delivers help and support when needed.
- File system tools streamline the software installation process.
- Replicated installation “profiles” ease the enterprise administration burden.
• Remote option directs deployment from any desktop to any host.
• A Software Developers Kit (SDK) extends the benefits of Solaris Web Start software to all developers of applications.

**ShowMe How™ Software**

ShowMe How™ software is a documentation system that presents information in a highly understandable multimedia format. Installation and service tutorials as well as reference information provide users with comprehensive, easy-to-use instruction. ShowMe How software streamlines installation and maintenance to lower service costs and maximize system uptime. Some of the features of this tool are:

• Distributed on CD-ROM
• Movies of installation and replacement procedures are played through ShowMe TV™ software packaged with the application
• Photo sequences with narrated installation and replacement procedures
• Text-based instructions can be viewed on-line and printed, excerpted from standard Sun documentation
• Photos with active callouts link to more detailed photos and text-based reference information

**Java™ Technology**

A discussion of Sun platforms would not be complete without mentioning Java technology. Taking the industry by storm, it promises true platform-independent software development for a large number of applications. Software developers have instantly recognized the potential of Java technology, with thousands of firms currently developing, or planning to develop applications in the Java programming language. Sun, the original developer of the Java programming language, offers software developers a unique opportunity with a comprehensive product line designed to streamline applications development.

Bundled with the Solaris Operating Environment is the Java 2 Software Development Kit. The Java 2 SDK provides both essential development tools required for creating Java applications and a high-performance, scalable runtime environment that reliably delivers the faster execution of Java applications. Designed to deliver outstanding performance and scalability
across the enterprise, applications developers recognize that the runtime system in Java 2 technology sets a new standard for Java technology performance and reliability.

**Open Firmware**

All Sun systems supports the use of a standardized PROM-resident monitor program that is written in a special threaded-interpretive language. Called Open Firmware, this monitor is conformant to the IEEE 1275-1994 standard, also known as Standard for Boot (Initialization Configuration) Firmware. Open Firmware can be brought up during the power-on process if a problem is encountered, or by executing a system `shutdown` followed by a level 0 `init`.

Once the Open Firmware monitor has control, a variety of diagnostics are available for key subsystems and peripherals:

- Video graphics
- SCSI interface logic on the system board
- Ethernet interface and AUI
- Internal and external disk drives
- Tape, diskette, and CD-ROM drives
- Serial ports
- Keyboard
- Memory

The Open Firmware monitor also provides tools to allow the continuous monitoring of the network and selective probing of devices on the SCSI bus.

Boot-time behavior and some diagnostics are controlled through flash PROM. The use of flash PROMs permit the reprogramming of specific code blocks to implement updates and enhancements without requiring physical access to the PROMs. Reprogramming may be done from a CD-ROM located in the system or remotely by a system administrator over a local area network.
References
