Xserve G5

Technology Overview
January 2004

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Introduction

What's New?

- Single or dual 2GHz PowerPC G5 processors using 90-nanometer process technology
- Gigahertz frontside bus with independent data paths in and out of the processor
- Two independent frontside buses on dual processor systems
- Point-to-point system controller
- Support for up to 8GB of 400MHz ECC memory
- Fast 133MHz PCI-X bus for Fibre Channel, RAID, SCSI, or cluster interconnect cards
- Dual Gigabit Ethernet interfaces on the main logic board
- Up to three 80GB or 250GB Serial ATA (SATA) Apple Drive Modules[1]

In May 2002, Apple introduced Xserve, a high-density, 1U rackmount server that was applauded for its value and versatility. In 2003, we built on that success with performance enhancements, more storage, and flexible build-to-order options. Now in its third generation, this highly acclaimed server gets a huge burst of power from the 64-bit PowerPC G5 processor—accelerating a wide range of intensive server chores and High Performance Computing (HPC) applications.

The groundbreaking PowerPC G5 made its debut in Apple's Power Mac G5, enabling computer users to tackle projects never before possible on a desktop system. In fact, its performance was so remarkable that Virginia Tech chose the G5 processor as the engine for its newest supercomputing facility, ranked third most powerful in the world.[2] With the introduction of Xserve G5, the same processing performance is packed into a slim 1U form factor. Combine the superefficient PowerPC G5 with high-bandwidth, server-optimized system I/O and fast internal storage, and Xserve G5 outperforms today's fastest 1U Xeon- and Opteron-based systems.[3]

In addition to robust hardware features, Xserve G5 comes complete with an unlimited-client license for Mac OS X Server software, a host of powerful network services, and integrated remote management and monitoring tools. Easy to set up and easy to maintain, Xserve G5 with Mac OS X Server dramatically reduces the complexity of system administration and minimizes maintenance costs. For added peace of mind, Apple offers enterprise-class service and support products for Xserve G5 hardware and Mac OS X Server software, with a single vendor to call.

This uniquely Apple integration results in superior performance, unparalleled manageability, and increased uptime—enabling organizations to lower their total cost of ownership and reduce the pressure on network administrators. Whether in small or large business, higher education or K–12 schools, creative departments, or science and technology research centers, the affordable Xserve G5 is the perfect server for today's new breed of UNIX-based solutions.

Product Overview

Xserve G5
Apple's new Xserve packs high-density PowerPC G5 computing power and fast, affordable storage in a 1U rack-optimized enclosure. Customers can choose from two standard server configurations and one cluster node configuration, as well as from an array of build-to-order options.

Xserve RAID
Connect Xserve to Apple's affordable Xserve RAID storage solution for enormous capacity—up to 3.5TB[1]—and advanced data protection in a high-availability 3U enclosure.

Key Features

Xserve G5 combines 64-bit processors, a high-bandwidth system architecture, and massive storage with Apple's legendary ease of use. The following features make Xserve a robust, versatile server solution for businesses and institutions everywhere.

Single or dual 2GHz processors. Each 64-bit PowerPC G5 processor features an optimized Velocity Engine unit, two floating-point units, and robust branch prediction logic. To get more work done faster, its superpipelined, superscalar architecture can handle large numbers of complex operations in parallel.

Gigahertz frontside bus. The industry's fastest frontside bus maximizes processor performance by transferring instructions and data at rates of up to 8GB/s. In dual processor systems, each PowerPC G5 has a dedicated frontside bus for a combined throughput of up to 16GB/s.

Advanced ECC memory technology. A 128-bit memory controller speeds data in and out of main memory at up to 6.4GB/s. Today's Xserve G5 supports 8GB of fast, 400MHz RAM with Error Correction Code (ECC) protection.

High-bandwidth I/O. Two open 64-bit PCI-X slots provide throughput of up to 1GB/s for PCI devices. Dual onboard Gigabit Ethernet interfaces and FireWire 800 ports offer high-performance connectivity and deployment flexibility.

Flexible storage. Three drive bays hold up to 750GB of fast, internal Serial ATA (SATA) storage[1] in hot-plug Apple Drive Modules.[4] Fast PCI-X slots and optional cards allow connection to external storage devices, including Apple's Xserve RAID storage system.

Innovative hardware monitoring. Dedicated monitoring hardware integrates with industry-leading software for remote monitoring of one or many Xserve G5 systems. The software can even send automatic notifications via email or pager.

UNIX-based operating system. An unlimited-client license for Mac OS X Server,[4] complete with easy-to-use open source workgroup and Internet services, is included at no additional cost. Built on open standards, Mac OS X Server integrates seamlessly into enterprise infrastructures. What's more, Apple has written the latest version of Mac OS X Server to maximize the computing power of the 64-bit PowerPC G5.

Server-class support products. To minimize downtime, Apple offers a suite of enterprise-class support products, including onsite hardware repairs, advanced software support, and convenient spares kits.

Rack-Optimized Server Design

With enormous processing power and ample storage in a compact 1U-high, 19-inch-wide enclosure, Xserve G5 is designed from the ground up for performance, service-ability, and easy integration into a wide range of computing environments. All the necessary rackmounting hardware is in the box, including rack rails with sliders, mounting brackets for industry-standard four-post racks and telco center-post racks, and complete setup instructions. For trouble-free servicing, the power cord connection has a cable-locking clip, and a cable management arm keeps cables with the system when you slide it out of a four-post rack.

Xserve G5 Server Configuration

Front view

Back view

(1) **Indicator lights.** Xserve G5 gives you continuous feedback on the status and activity of hardware components. Indicator lights display the health and status of power, enclosure lock, drives, Ethernet links, and processor, as well as drive and processor activity.

(2) **System identifier.** Duplicate buttons on the front and back can be turned on manually or by using remote monitoring software, making it easy to locate a particular server in a rack. The buttons also illuminate if a system event occurs.

(3) **FireWire and USB ports.** Xserve G5 has two FireWire 800 ports on the back and one FireWire 400 port on the front for high-speed connectivity to storage, backup devices, and other servers. Two USB 2.0 ports on the back connect to industry-standard peripherals.

(4) **Air ducts.** A robust cooling system provides front-to-back airflow over high-performance system components. It uses large air ducts and an array of eight fans managed by a microcontroller. For minimal noise and power consumption, the fans run only as required to cool the system effectively. If a single fan fails, the others speed up to compensate.

(5) **Drive bays.** Three bays support up to 750GB[1] of hot-plug SATA internal storage on three independent channels.[4] Hot-plug support allows you to add storage without bringing down the server. Apple Drive Modules have LEDs that indicate drive status and health using Self-Monitoring, Analysis, and Reporting Technology (SMART) data.

(6) **Optical drive.** The slot-loading 24x-speed CD-ROM drive is convenient for software installation and recovery. Or choose the optional Combo drive for reading DVD data and backing up files on CDs.[4]

(7) **Gigabit Ethernet interfaces.** Xserve G5 comes with dual Gigabit Ethernet links on the main logic board. These fast interfaces operate independently to provide deployment flexibility and support for large numbers of clients.

(8) **Serial port.** The DB-9 serial port allows for system access through a serial console session, even when the network is down.

(9) **PCI-X slots.** Two open 64-bit PCI-X slots allow you to add one card running at up to 133MHz or two cards running at up to 100MHz. Throughput of up to 1GB/s maximizes performance of transaction-intensive applications and high-performance networking and storage systems.

Most innovative HPC hardware

HPCwire, a leading journal of High Performance Computing, gave Apple its Editors Choice award for the hardware vendor delivering the most innovative overall HPC technology in 2003.

High-Density Cluster Node Configuration

With the compute performance of two superscalar 2GHz PowerPC G5 processors, the Xserve G5 cluster node configuration is ideal for High Performance Computing (HPC) in scientific and technical environments, as well as for workgroup clusters and render farms. One dual processor node can execute over 9 billion double-precision floating-point operations per second, or 9 gigaflops per U. That means a rack filled with Xserve G5 systems can offer over 378 gigaflops of processing power. Single-precision floating-point performance is also remarkable: With a dual-pipeline Velocity Engine on each processor, the Xserve G5 cluster node can execute over 30 gigaflops. Best of all, by eliminating the cost of unneeded components, Apple has made this high-density 1U system extremely affordable.

For more information about Apple solutions for computational clusters, see www.apple.com/xserve/cluster.

Xserve G5 Cluster
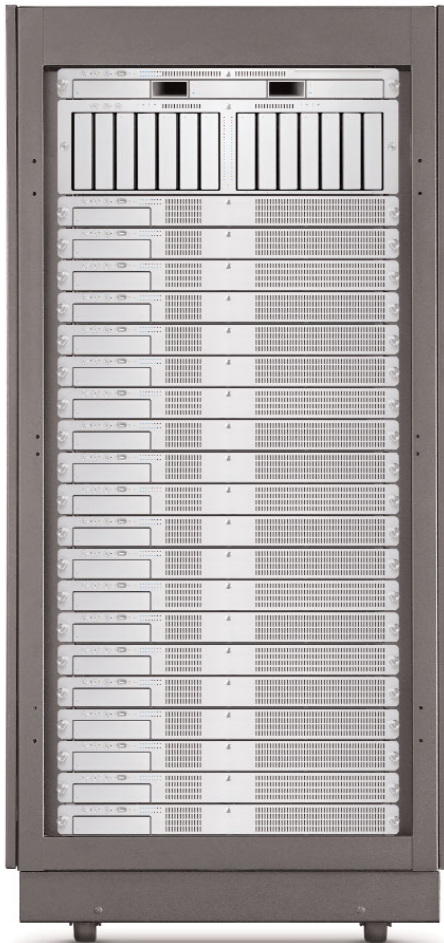
An Xserve G5 cluster uses a dedicated server system as the head node, which can manage hundreds of Xserve cluster nodes. Apple's Xserve RAID adds high-performance, high-availability storage. Each cluster node has these robust features:

- **Computational power.** Dual 2GHz PowerPC G5 processors provide high-performance computation and superior scalability.

- **Fast PCI-X.** Two PCI-X slots support cluster interconnect technologies, such as InfiniBand and Myricom's Myrinet.

- **Dual Gigabit Ethernet.** Two onboard high-speed interfaces enable independent gigabit connections to the head node for network services and to the cluster interconnect for loosely coupled cluster environments.

- **FireWire 800.** Two FireWire 800 ports support small clusters using TCP/IP over FireWire. FireWire Target Disk Mode allows easy cloning of system configurations.

- **Advanced cooling system.** An array of eight fans keeps air flowing over high-performance processing components. Intelligent management of the fan array keeps noise and power consumption to a minimum.

- **Indicator lights.** Xserve G5 provides continuous, at-a-glance information about the health and status of all the systems in the rack.

- **Built-in sensors.** Hardware sensors integrate with Server Monitor to provide easy monitoring of hundreds of systems from a single, intuitive interface.

- **Automatic setup.** Mac OS X Server makes it easy to set up an entire rack of systems automatically from a directory on the network or a USB or FireWire disk.

- **Startup options.** Front Panel Mode allows the system identifier button to be used for selecting startup options, such as booting from a network server or restoring default system settings.

Performance Overview

Apple's new Xserve G5 is designed to deliver phenomenal performance with industry-leading ease of use. Thanks to 64-bit processing power, server-optimized I/O, and a high-throughput storage architecture, Xserve G5 is optimized for demanding server and cluster operations.

Apple compared preproduction Xserve G5 units with currently available, top-selling 1U servers. The following results are based on benchmark testing performed in January 2004 by Apple in a laboratory setting using publicly available software. These server configurations were tested:

- **Apple Xserve G5.** Dual 2GHz PowerPC G5, 1GB PC3200 SDRAM, two 250GB Apple Drive Modules, dual Gigabit Ethernet, Mac OS X Server v10.3.2.

- **Dell PowerEdge 1750.** Dual 3.2GHz Xeon,1GB PC2100 SDRAM, three 36GB Ultra320 SCSI drives, dual Gigabit Ethernet, Red Hat Linux 9.0.

- **IBM eServer x335.** Dual 3.2GHz Xeon,1GB PC2100 SDRAM, two 36GB Ultra320 SCSI drives, dual Gigabit Ethernet, Red Hat Linux 9.0 (unless otherwise indicated).

- **IBM eServer x325.** Dual 2GHz Opteron,1GB PC2700 SDRAM, two 36GB Ultra320 SCSI drives, dual Gigabit Ethernet, Red Hat Enterprise Linux 3 (AMD 64-bit version).

For each system, Apple installed the operating system on one drive and used the other drive or drives to create a data volume. On the Xserve and Dell systems, the two remaining drives were configured as a single volume using RAID 0. The Xeon- and Opteron-based systems used 15,000-rpm drives.

Processor Performance

Featuring a dual-pipeline Velocity Engine and two double-precision floating-point units on each 64-bit PowerPC G5 processor, Xserve G5 can manage complex calculations crucial to users in image processing, media encoding, and scientific computing environments. In fact, the Velocity Engine on dual processor Xserve G5 systems can execute over 30 billion single-precision floating-point operations per second, or 30 gigaflops per U, compared with 19 gigaflops on the G4-based Xserve.

To demonstrate this superior processor performance, Apple tested Xserve G5 using popular benchmarks in the scientific computing community.

LINPACK
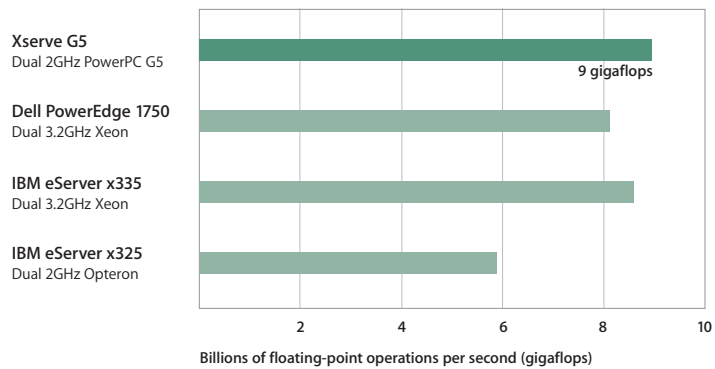Computers use double-precision floating-point mathematics to perform calculations requiring great numerical magnitude or extremely high decimal accuracy. Apple used the LINPACK benchmark to illustrate the benefits of the G5 processor's two floating-point units. LINPACK measures double-precision floating-point performance by running a program that solves a dense system of linear equations.

$333 per gigaflop

Apple offers compute power at the lowest cost per gigaflop of any tier-one vendor—only $333 per gigaflop, or $333,000 per teraflop.[5]

LINPACK: Double-Precision Calculations

Two double-precision floating-point units enable the dual 2GHz Xserve G5 to perform the linear equations 8 percent faster than the 3.2GHz Xeon-based servers and 50 percent faster than the 2GHz Opteron-based server.

A/G BLAST

A/G BLAST is a version of NCBI BLAST developed by Apple in collaboration with Genentech. Optimized for dual PowerPC G5 processors, the Velocity Engine, and the symmetric multiprocessing capabilities of Mac OS X, A/G BLAST makes a wide variety of searches available at higher speeds.

BLAST

To demonstrate the advantages of Xserve G5 for processor-intensive scientific analysis, Apple used Basic Local Alignment Search Tool, or BLAST. BLAST is a popular open source biotechnology application used by life science researchers to find matches in DNA and protein sequences. BLAST searches are based on word size, or the number of nucleotide pairs specified by the researcher to register as a match. Different word sizes are used for different kinds of research, and users can adjust word size to the sensitivity appropriate to their needs. With long-word-size, or high-performance, searches, the researcher is looking for similarities between DNA sequences that are nearly identical. For short-word-size searches (fewer than 11), the researcher is comparing more distantly related sequences; these searches require high resolution to find the small matches between dissimilar sequences.
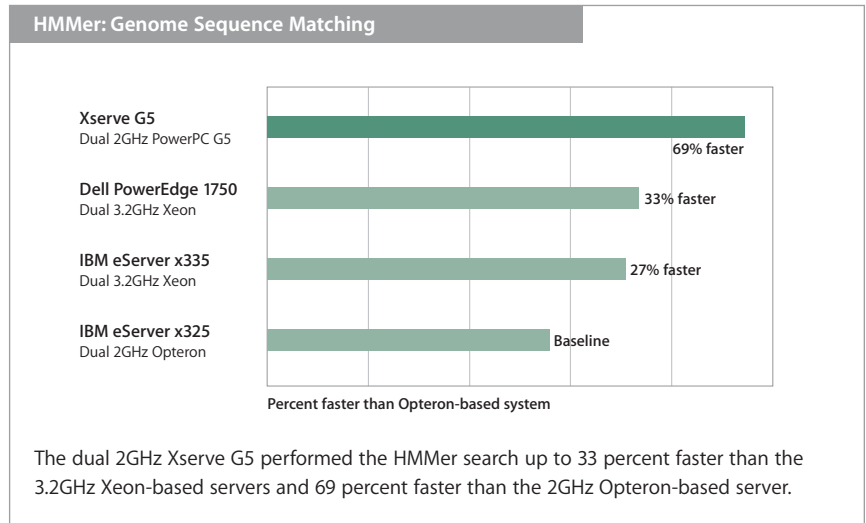
BLAST: DNA Sequence Matching
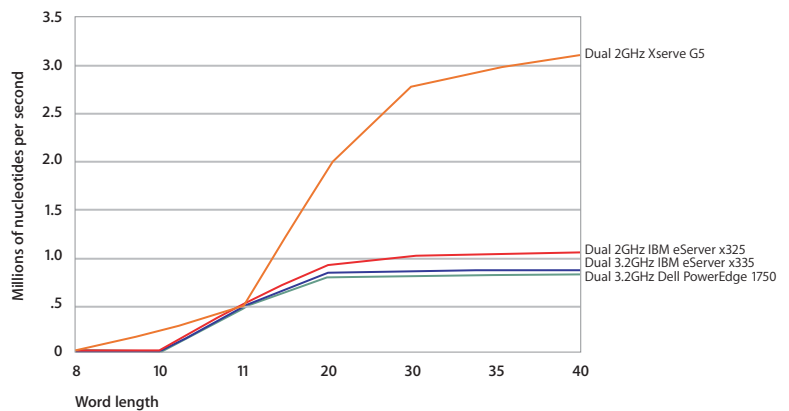
In common searches using a word size of more than 11, Xserve G5 far outperformed the Xeon-based servers. Even at word size 11, for which NCBI BLAST has been extensively optimized, Xserve G5 performed on par with the competition.

HMMer 2.3.3

HMMer is another application that demonstrates the advantages of Xserve G5 with Velocity Engine for processor-intensive scientific analysis. HMMer is a genome sequence–matching application that uses Hidden Markov Models (HMMs) to identify similarities in genetic structures. The core routines of HMMer repeatedly perform the same operation on large amounts of data. To test the performance of the HMMer code, Apple searched for an HMM created from a 358-residue sequence in the protein databank (PDB) and measured the time to search the entire PDB.

HMMer: Genome Sequence Matching

Xserve G5 Dual 2GHz PowerPC G5	69% faster
Dell PowerEdge 1750 Dual 3.2GHz Xeon	33% faster
IBM eServer x335 Dual 3.2GHz Xeon	27% faster
IBM eServer x325 Dual 2GHz Opteron	Baseline

Percent faster than Opteron-based system

The dual 2GHz Xserve G5 performed the HMMer search up to 33 percent faster than the 3.2GHz Xeon-based servers and 69 percent faster than the 2GHz Opteron-based server.

Networking Throughput

To minimize bottlenecks and ensure maximum data throughput, Xserve G5 features a high-performance I/O architecture optimized for server tasks.

NetBench SMB

Xserve G5 provides the best balance of processor, network, and disk performance— critical for delivering file services to large numbers of network clients.

NetBench SMB: Windows File Serving

With more than 12 NetBench clients, Xserve G5 with Mac OS X Server delivers Windows file services significantly faster than the Xeon-based server with Windows Server 2003, and its performance remains high even as clients are added to the network.
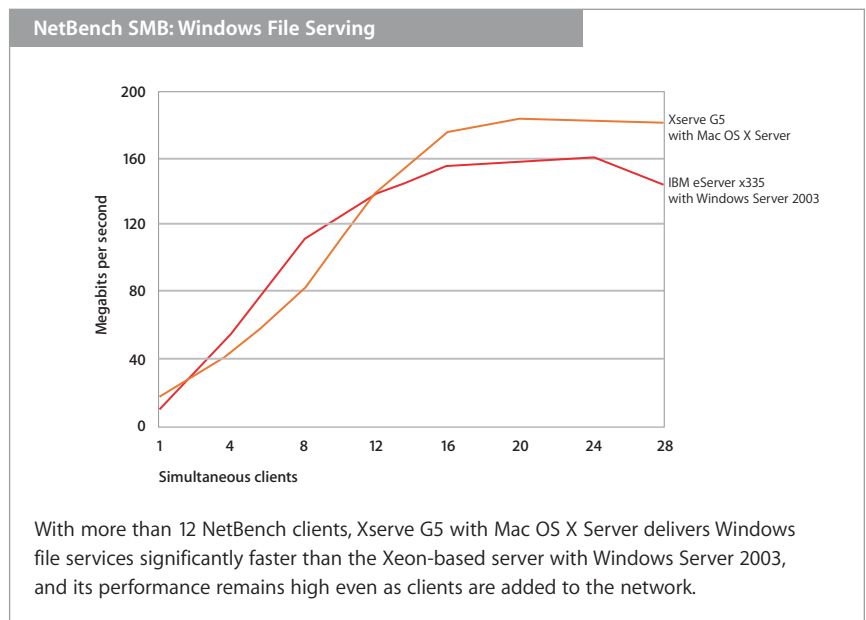
WebBench

For fast network throughput, Xserve G5 features dual onboard Gigabit Ethernet controllers, as well as optimized network drivers and a high-performance BSD network stack in Mac OS X Server. Apple used WebBench from eTesting Labs to demonstrate the superior web server performance of Xserve G5 based on the number of connections each server can support.

WebBench: Apache Web Serving

Xserve G5 easily supports a large number of network connections. With more than 16 WebBench clients, it outperforms the Xeon- and Opteron-based servers, and its performance advantage increases as clients are added to the network.
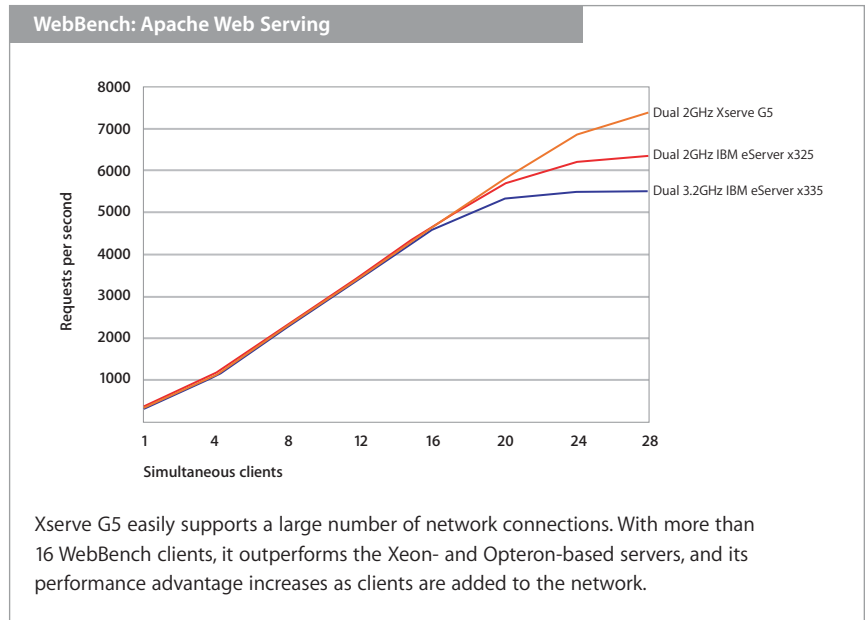
Apple performed the NetBench and WebBench tests without the supervision or verification of eTesting Labs, which makes no representation or warranty of the results. eTesting Labs WebBench version 4.1 was used with the standard test suite STATIC_WB41.TST, with the threads variable set to 5 and with 28 client computers. For the WebBench test, Xserve G5 ran Apache 1.3; the IBM systems ran Apache 2.0.
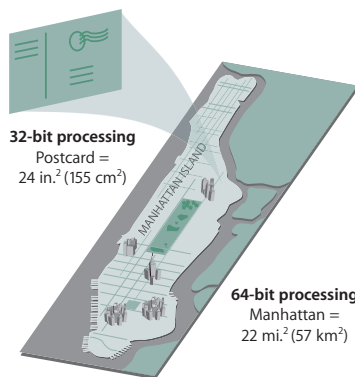
PowerPC G5 Processor

The breakthrough performance of the 64-bit PowerPC G5 is now available to Apple server customers. With 64-bit-wide data paths and registers, this revolutionary processor can address vast amounts of main memory, while handling multiple 64-bit integer and double-precision floating-point math calculations in a single pass. Its wide execution core manages immense operations in parallel, supporting up to 215 in-flight instructions.

Apple and IBM Partnership

The PowerPC G5 is the product of a long-standing partnership between Apple and IBM, two companies committed to innovation and customer-driven solutions. In 1991, they co-created a PowerPC architecture that could support both 32-bit and 64-bit instructions. Leveraging this design, Apple went on to bring 32-bit RISC processing to desktop and portable computers, while IBM focused on developing 64-bit processors for enterprise servers. The new PowerPC G5 represents a convergence of these efforts: Its design is based on the PowerPC instruction set, as well as the POWER Architecture that drives IBM's top-of-the-line enterprise servers.

The PowerPC G5 is fabricated in IBM's new $3 billion, state-of-the-art facility in East Fishkill, New York. To get electronics so small requires miniaturization breakthroughs, and IBM's dedication to scientific research has made these advances possible. With industry-leading build, assembly, and test technology, IBM uses a 90-nanometer process to produce the PowerPC G5. More than 58 million silicon-on-insulator (SOI) transistors and eight layers of copper interconnects enable this new processor to deliver tremendous performance. The use of these advanced technologies also means the PowerPC G5 draws less power and produces less heat—allowing Apple to pack two 64-bit 2GHz processors in a 1U form factor.

64-Bit Computing Power

The labels "32-bit" and "64-bit" characterize the width of a microprocessor's data stream, which is a function of the sizes of its registers and the internal data paths that feed the registers. A 64-bit processor moves data and instructions along 64-bit-wide data paths—compared with the 32-bit-wide paths on 32-bit processors, such as the Pentium 4 and Xeon. In addition, 64-bit processors have wide registers that can store 64-bit numbers as well as 32-bit numbers.

The leap from 32-bit to 64-bit processing represents an exponential advance in computing power. With 32-bit registers, a processor has a dynamic range of 2^{32}, or 4.3 billion—which means it can express integers from 0 to 4.3 billion. With 64-bit registers, the dynamic range catapults to 2^{64}, or 18 billion billion—4.3 billion times larger than the range of a 32-bit processor.

32-bit processing
Postcard =
24 in.^{2} (155 cm^2)

64-bit processing
Manhattan =
22 mi.^{2} (57 km^2)

4.3 billion times bigger
To grasp the enormous leap from 32-bit to 64-bit processing, imagine equating the range of numbers a processor can express with a two-dimensional area. A 32-bit processor can express a range of integers equal to the size of a postcard, while a 64-bit processor can express a range of integers larger than the island of Manhattan.

**Support for more memory in
Mac OS X Server**
The latest version of Mac OS X Server
makes the most of the expanded memory
capabilities of the PowerPC G5. With up
to 4GB of memory allocated per applica-
tion, each server task can have dedicated
space in the system's generous memory.

Vast amounts of addressable memory
The move to 64-bit processing results in a similarly dramatic leap in the amount of
memory supported. A memory address is a special kind of integer, and each address
points to one byte in memory. Since memory addresses are computed in 64-bit regis-
ters capable of expressing 18 billion billion integers, the PowerPC G5 can theoretically
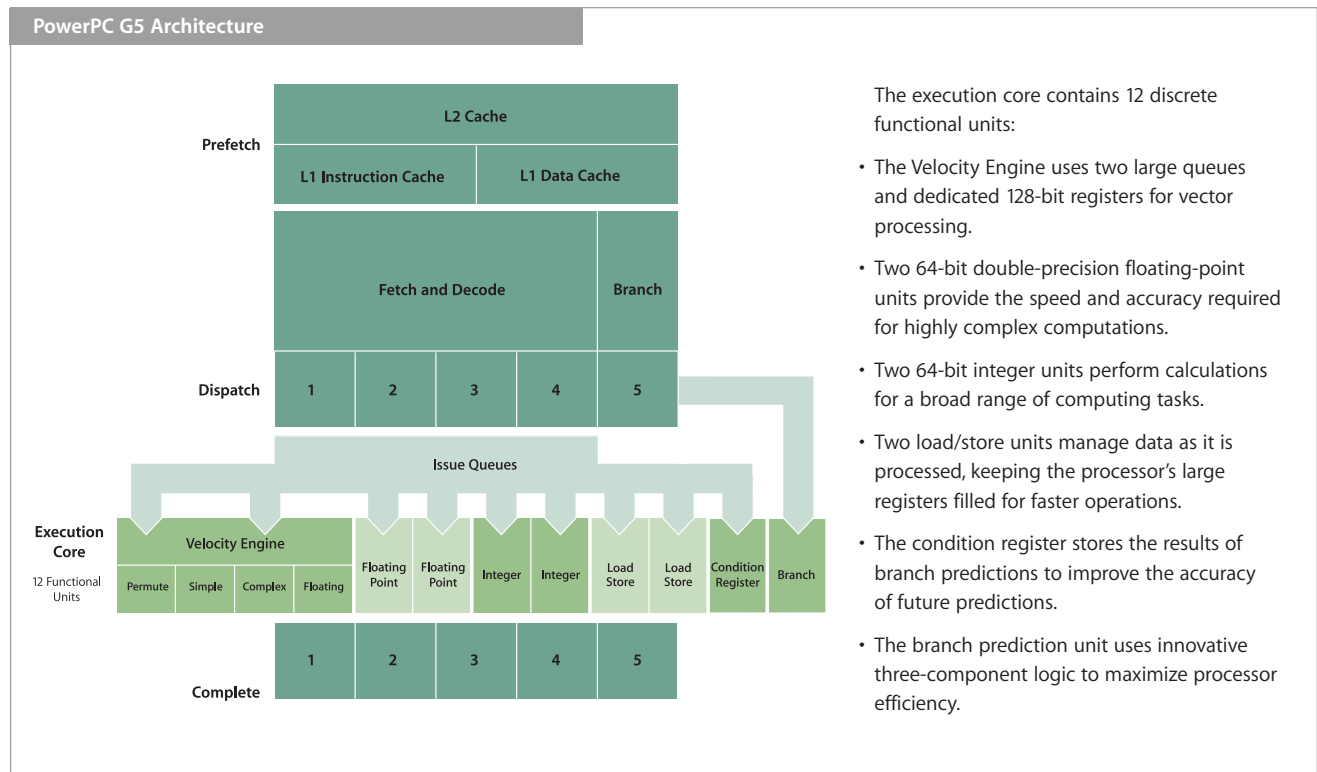address 18 exabytes (18 billion billion bytes) of virtual memory.

In practice, memory addressing is defined by the physical address space of the proces-
sor. The PowerPC G5, with 42 bits of physical address space, supports a colossal 2^{42}
bytes, or 4 terabytes, of system memory. Although it's not currently feasible to purchase
4 terabytes of RAM, the advanced architecture of this new processor allows for plenty
of growth in the future.

Multiple high-precision calculations
With 64-bit-wide data paths and registers, the PowerPC G5 can execute multiple
instructions on 64 bits of data—including huge integer calculations and double-
precision floating-point mathematics—in a single pass. In contrast, a 32-bit processor
has to split up any data larger than 32 bits and process it in multiple passes. This leap
in performance, from 32-bit to 64-bit processing, brings previously unmanageable
tasks into the realm of practicality, facilitating highly accurate calculations required
for scientific analysis, technical research, 3D effects, and video encoding.

Next-Generation PowerPC Architecture

Apple and IBM built the PowerPC G5 processor for maximum efficiency and perfor-
mance. Its architecture features processing innovations that optimize the flow of data
and instructions, including a high-bandwidth execution core with dual floating-point
units and dual integer units. For more information about the PowerPC G5 architecture,
see www.apple.com/g5processor.

PowerPC G5 Architecture

The execution core contains 12 discrete
functional units:

• The Velocity Engine uses two large queues
  and dedicated 128-bit registers for vector
  processing.

• Two 64-bit double-precision floating-point
  units provide the speed and accuracy required
  for highly complex computations.

• Two 64-bit integer units perform calculations
  for a broad range of computing tasks.

• Two load/store units manage data as it is
  processed, keeping the processor's large
  registers filled for faster operations.

• The condition register stores the results of
  branch predictions to improve the accuracy
  of future predictions.

• The branch prediction unit uses innovative
 three-component logic to maximize processor
  efficiency.

High-Bandwidth Server Architecture

The PowerPC G5 is only part of the Xserve performance story. Xserve G5 features the industry's fastest frontside bus to keep data moving in and out of the processor, and a superefficient point-to-point system controller allows data to move directly between all subsystems. Bandwidth is further enhanced by a 400MHz, 128-bit memory bus and a high-speed HyperTransport interface that connects the PCI-X controller and the I/O subsystems to the system controller. Together these advanced technologies provide the power and throughput for demanding Internet applications, robust network infrastructure solutions, and high-performance computational clustering environments.

Server-Optimized Architecture

1. **Gigahertz frontside bus.** Provides up to 8GB/s bandwidth between the processor and the rest of the system.

2. **Dual independent frontside buses.** Provide up to 16GB/s aggregate bandwidth in dual processor systems.

3. **Advanced system controller.** Uses a point-to-point architecture to enable data to pass directly between subsystems.

4. **400MHz ECC memory.** Uses a 128-bit-wide data path to support high-speed PC3200 SDRAM with Error Correction Code (ECC) protection.

5. **PCI-X expansion.** Supports two high-performance 100MHz PCI-X cards or one 133MHz PCI-X card, providing total throughput of up to 1GB/s.

6. **Dual onboard Gigabit Ethernet.** Provides two independent ports, as well as hardware support for VLAN, jumbo frames, and TCP, IP, and UDP hardware checksum.

7. **High-performance I/O controller.** Integrates three fast Serial ATA (SATA) drive controllers and FireWire 800 interfaces using a HyperTransport interconnect.

8. **Serial ATA storage.** Supports up to 750GB of affordable hot-plug internal storage[1] using three independent, high-performance 150MB/s SATA drive controllers.[4]
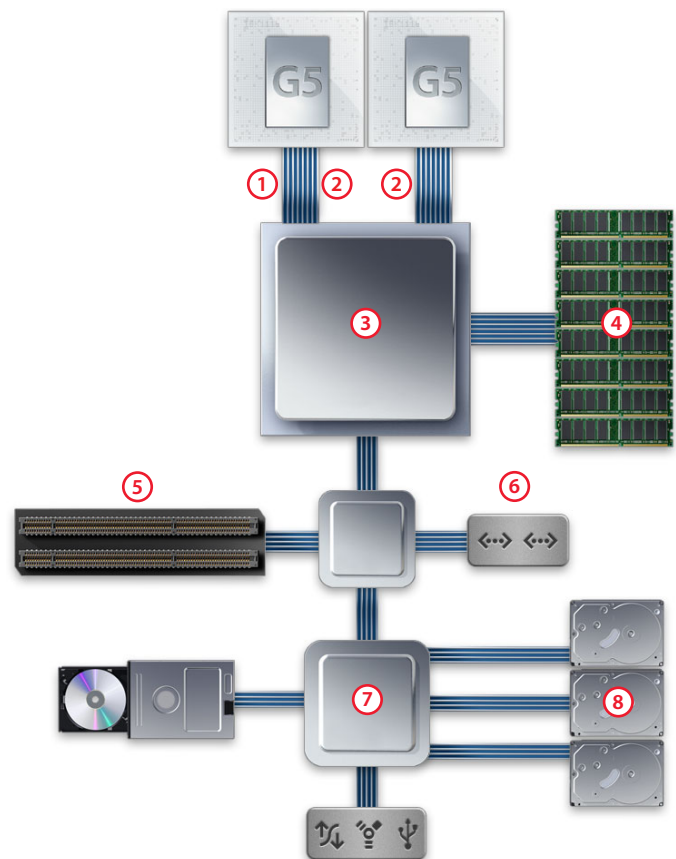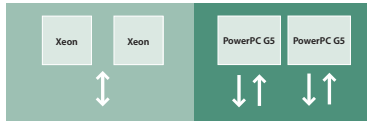
Industry's fastest frontside bus
The dual-channel frontside bus allows data to travel to and from the PowerPC G5 processor at the same time. On dual processor systems, each PowerPC G5 has its own dedicated interface to maximize throughput—compared with dual Xeon-based systems, in which the processors must share a single bus.

Gigahertz Frontside Bus

To harness the power of the G5 processor, a 64-bit Double Data Rate (DDR) frontside bus speeds up communication between the PowerPC G5 and the memory controller. Unlike conventional processor interfaces, which carry data in only one direction at a time, this dual-channel frontside bus has two 32-bit point-to-point links: One link travels into the processor and another travels from the processor, which means no wait time while the processor and the system controller negotiate which will use the bus or while the bus switches direction. This elastic interface self-tunes during startup for optimal signal quality.

On the 2GHz PowerPC G5, the frontside bus operates at 1GHz for a total theoretical bandwidth of up to 8GB/s. Dual processor systems get an even greater performance boost, because each PowerPC G5 has a dedicated frontside bus. This unique feature results in a maximum aggregate raw bandwidth of 16GB/s on dual 2GHz Xserve G5 systems. This is well over twice the 6.4GB/s maximum throughput of Itanium 2–based systems and almost four times the 4.3GB/s throughput of Xeon-based systems. Because there's a dedicated data path in each direction, transaction-intensive server operations execute fast and without contention for data—so the processor doesn't sit idle, waiting for data to arrive.

On dual processor systems, the two independent frontside buses allow each PowerPC G5 to handle its own tasks at maximum speed with minimal interruption. They also enable each processor to discover and access data in the other processor's caches, a technique called intervention, or snooping. Cache intervention guarantees cache coherency, which ensures that the processor always fetches the correct data, even if the data has been modified and is stored in the cache of the other processor.

Point-to-Point System Controller

A new system controller is central to the overall performance of Xserve G5. This revolutionary application-specific integrated circuit (ASIC)—built using advanced IBM technology—is one of the industry's fastest. A superefficient point-to-point architecture provides each primary subsystem with dedicated throughput to main memory, so massive amounts of data can traverse the system without contention for bandwidth. In contrast, subsystems on Xeon-based servers must share bandwidth, which can result in time-consuming arbitration while they negotiate for access across a common data path.

Advanced ECC Memory Technology

Xserve G5 maximizes the efficiency of its computing power with an advanced 128-bit DDR memory architecture and support for up to 8GB of RAM. This high-speed, high-capacity memory architecture enables video encoding, transaction-intensive networking, and scientific applications to perform radically faster. What's more, it works with ECC logic in the system controller to protect data from corruption or errors.

Double Data Rate (DDR) memory
Xserve G5 features a memory controller that supports 400MHz, 128-bit DDR SDRAM. With fast DDR memory and a wider 128-bit interface that addresses two banks of SDRAM at a time, Xserve G5 can reach a memory throughput of up to 6.4GB/s—more than double the throughput of the G4-based Xserve. For even greater performance, direct memory access (DMA) works with the point-to-point system controller, so subsystems can access main memory without needing to interact with the processor.

Support for up to 8GB of RAM

Xserve G5 comes standard with 512MB or 1GB of DDR SDRAM. Main memory is scalable up to 8GB in eight DIMM slots, allowing you to increase memory as application and networking requirements increase. More main memory enables the system to run strenuous processes simultaneously and to accommodate spikes in demand. Enormous files and data sets can be loaded into RAM for rapid processing by the PowerPC G5—without having to access disk storage. Data is transferred to memory 40 times faster than to the hard drive. In fact, accessing the first critical word of data from memory is 60,000 times faster than from a hard drive, so manipulation and analysis of data can be performed at remarkable speeds.

ECC protection

Xserve G5 uses Error Correction Code (ECC) logic to protect the system from data corruption and transmission errors. Each DIMM has an extra memory module that stores checksum data for every transaction. The system controller uses this ECC data to identify single-bit errors and corrects them on the fly, preventing unplanned system shutdowns and protecting data integrity. In the rare event of multiple-bit errors, the system controller detects the error and triggers a system notification to prevent bad data from corrupting further operations.

For additional protection, the ECC modules on the DIMMs integrate with Server Monitor software. If error rates exceed a defined threshold, which typically indicates a hardware problem, Server Monitor can alert the administrator for fast resolution.

High-Performance PCI-X Expansion

PCI expansion options

Built-to-order Xserve G5 configurations can include the following:
- Apple Fibre Channel PCI Card
- Hardware RAID PCI card
- Apple PCI-X Gigabit Ethernet Card
- Dual-channel Ultra320 SCSI PCI-X card
- VGA video card

Xserve G5 features the latest 133MHz PCI-X expansion protocol with throughput of up to 1GB/s. PCI-X operates more efficiently than PCI, resulting in more usable bandwidth at any PCI-X bus speed—ideal for connecting to high-performance networking, storage, and backup devices using optional SCSI and Fibre Channel cards. For fast data access, the PCI-X bus connects to the system controller using a high-speed, dual-channel HyperTransport bus with a throughput of up to 4.8GB/s (2.4GB/s each way).

Two open 64-bit PCI-X slots allow you to add one card running at up to 133MHz or two cards running at up to 100MHz. The PCI-X specification is designed to support 3.3V signaling and is compatible with Universal 33MHz and 66MHz PCI cards.[6]

Dual Onboard Gigabit Ethernet

Apple extends the networking performance of Xserve G5 with a high-performance Ethernet controller on the main logic board. This advanced controller includes two independent 10/100/1000BASE-T Ethernet interfaces, each with its own interrupt, on a dedicated 64-bit, 133MHz PCI-X bus. The result is tremendous networking bandwidth and no contention for data with the I/O subsystems.

In addition, the Gigabit Ethernet controller provides these networking features:

- Hardware-generated TCP, IP, and UDP checksum detects packet corruption and transmission errors.

- 802.1q VLAN (Virtual LAN) tags allow Xserve G5 to be a member of multiple virtual networks and to provide unique network services to each one.

- A large 64K packet buffer per interface supports jumbo frames, or packets up to 9K, to reduce system overhead and increase throughput of all network activities.

Dual Gigabit Ethernet ports deliver near-line-rate throughput of up to 980Mb/s per port, alleviating bottlenecks even with very large files and expediting mail, web, file, and printer sharing services. Together with the multihoming function in Mac OS X Server, dual network ports enable Xserve G5 to serve more client systems; provide redundant links; or support an isolated management network that is independent of a client services network. Dual Gigabit Ethernet also enables the high-speed network interconnect required by many computational cluster deployments.

Additional Connectivity

The Xserve G5 architecture uses the HyperTransport protocol to connect the I/O controller to the system controller. The Serial ATA controller, optical drive, and FireWire, USB 2.0, and serial ports are all integrated through a bidirectional 800MHz HyperTransport interconnect for a maximum throughput of 1.6GB/s.

Xserve G5 offers industry-standard interfaces for connecting I/O devices:

· **Dual FireWire 800 ports.** Two FireWire 800 ports on the back panel and one FireWire 400 port on the front panel connect to high-bandwidth FireWire (IEEE 1394) devices, such as storage devices and audio and video input devices. In addition, TCP/IP over FireWire can be used to create small clusters, and FireWire Target Disk Mode allows easy cloning of system configurations.

· **DB-9 serial port.** An industry-standard 9-pin serial port allows for system access through a serial console session.

· **Two USB 2.0 ports.** USB ports on the back panel connect to keyboards, mice, speakers, and other industry-standard peripheral devices.

· **Optical drive.** For software installation and recovery, a slot-loading 24x-speed CD-ROM drive comes standard on server configurations. A Combo drive (DVD-ROM/CD-RW) is available as an alternative for customers who need to read DVD data and back up data on CDs.

Affordable, Scalable Storage

Up to 750GB of storage
Each Xserve G5 has three drive bays for
up to three hot-plug Apple Drive Modules.[4]

Exponential growth in the creation and distribution of digital content is driving the
need for high-capacity storage in business and education. Large databases, digital
video footage, immense scientific data sets, and uncompressed audio all place
enormous demands on server storage resources.

Xserve G5 addresses these growing requirements by providing up to 750GB of afford-
able internal storage capacity.[1] With each Apple Drive Module on an independent
Serial ATA (SATA) drive channel and connected to a high-speed I/O system, the Xserve
storage subsystem scales without compromising performance. This unique architecture
delivers the best balance of performance, reliability, capacity, and price.

Internal storage comparison

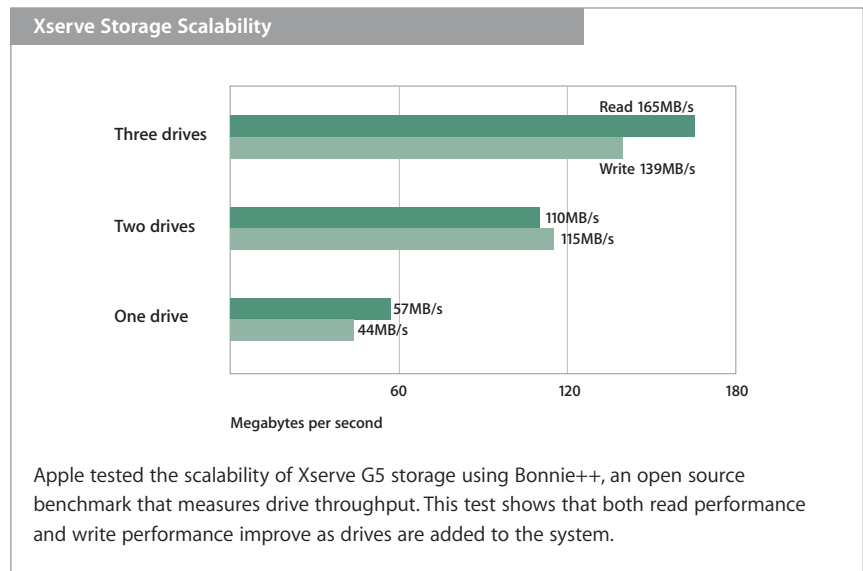| Server	Apple Xserve G5	Dell PowerEdge 1750	IBM eServer x335	Sun Sun Fire V60x
Maximum internal storage capacity	750GB (three 250GB drives)	438GB (three 146GB drives)	292GB (two 146GB drives)	219GB (three 73GB drives)
Onboard disk controller for internal drives	Three independent SATA	Ultra320 SCSI	Ultra320 SCSI	Ultra320 SCSI
Hot-plug drives	Yes	Yes	Yes	No
Cost of additional drives*	$499 (250GB)	$699 (146GB)	$899 (146GB)	$500 (73GB)
Cost per GB	$2.00	$4.79	$6.16	$6.85

* Based on suggested retail prices published on manufacturers' websites as of December 21, 2003.

Xserve G5 offers affordable internal storage that scales to nearly twice the capacity of most other
1U servers on the market.

SATA Drive Technology

Xserve G5 features sophisticated 150MB/s SATA drive controllers, each with a dedicated
SATA bus to a single Apple Drive Module. In the original Xserve—and before Serial
ATA became available—Apple pioneered a point-to-point storage architecture using
Parallel ATA. This innovative design eliminated the single-threaded operation of the
typical ATA master/slave configuration and delivered superior performance at a much
lower cost than that of SCSI-based systems.

Xserve G5 advances to a SATA-based storage subsystem that provides the same multi-
threaded system operation. Multithreading enables the system to send commands to
multiple drives at once for the fastest possible throughput. An independent drive
architecture also isolates the drives electrically, preventing a single drive failure from
causing unavailability or performance degradation of the surviving drives—a common
problem with multidrive SCSI implementations.

Xserve Storage Scalability

Three drives — Read 165MB/s — Write 139MB/s

Two drives — 110MB/s — 115MB/s

One drive — 57MB/s — 44MB/s

60   120   180

Megabytes per second

Apple tested the scalability of Xserve G5 storage using Bonnie++, an open source benchmark that measures drive throughput. This test shows that both read performance and write performance improve as drives are added to the system.

Apple Drive Module
Xserve G5 uses reliable, high-performance Apple Drive Modules to provide cost-effective, high-capacity system storage.

Hot-plug Apple Drive Modules

The three Xserve drive bays[4] provide affordable storage expansion using 80GB or 250GB SATA Apple Drive Modules.[1] Apple Drive Modules feature robust hot-plug connectors called Single Connector Attachment (SCA) II that protect the connecting pins from bending when drives are inserted or removed. Hot plugging allows administrators to add storage without bringing down the server: Insert a new Apple Drive Module at any time and it's instantly available to the server. This flexibility is made possible by tight integration between system hardware and software. The three independent drive controllers detect when a drive is unplugged, so removing the drive doesn't mean risking data loss or a system crash. When the drive is plugged back in, its controller instantly recognizes that it's back online—without requiring cycles or resets to reinitiate communication between the drive and the controller, as in other storage architectures.

Apple Drive Modules feature a unique handle design for fast, easy installation and a positive locking mechanism to hold them tightly in place after insertion. The new drive carrier employs a drive mounting technique that increases drive isolation and reduces vibration. Carefully tested and qualified to ensure maximum performance and reliability, Apple Drive Modules work seamlessly with the sophisticated Xserve monitoring sensors and Server Monitor remote monitoring software.

Monitoring of drive health

Xserve hardware and software work together to provide industry-leading remote monitoring and alert capabilities. The server operating system reads Self-Monitoring, Analysis, and Reporting Technology (SMART) data from each hard drive. SMART data allows the drive to report its health and enables Server Monitor software to warn the administrator of a prefailure condition—providing the opportunity to back up critical data and replace the hard drive before a failure occurs. For local monitoring, each Apple Drive Module has two LEDs, one for drive activity and one for drive health.

Software and Hardware RAID Options

Affordable and easy-to-install drive modules make it simple to expand Xserve systems to meet growing storage needs over time. For even greater storage capacity or to share storage among multiple servers, high-throughput PCI-X slots enable users to connect to external rackmount storage and backup systems, including SCSI devices and Apple's Xserve RAID.
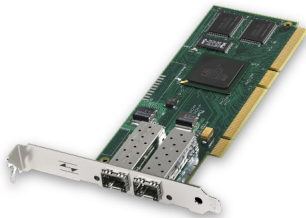
Software RAID in Mac OS X Server
Using software RAID built into Mac OS X Server, the three Apple Drive Modules can be striped or mirrored for improved performance or data redundancy.[4]

· **RAID 0, or striping.** Increases storage performance dramatically by distributing data across two or three Apple Drive Modules and enabling the drives to read and write data concurrently. Drive striping takes full advantage of the three independent drive channels and utilizes the I/O capabilities of Mac OS X Server.

· **RAID 1, or mirroring.** Provides a high level of data protection by creating a real-time exact duplicate of the contents of one Apple Drive Module on a second drive. With the new volume promotion feature in Mac OS X Server v10.3, you can upgrade a single drive to a RAID 1 mirror without needing to back up and reformat the drive. If a mirrored drive fails, the system can rebuild the array in the background, while continuing to serve data. The independent drive architecture and software RAID combine to provide RAID 1 protection with no performance penalty.

For additional protection or higher performance, Mac OS X Server on Xserve can boot from a mirrored or striped volume.

Optional hardware RAID PCI card
For enhanced storage performance and data protection, the hardware RAID PCI card provides RAID levels 0, 1, and 5 using a hardware RAID controller and 64MB of battery-backed, ECC cache memory. When Xserve is configured with three 250GB Apple Drive Modules and the hardware RAID PCI card, it offers half a terabyte of internal, RAID 5–protected storage in a 1U form factor—unmatched in the industry. This compact solution provides affordable protected RAID storage for small to medium-size storage requirements.

Xserve RAID storage solution
For massive capacity and advanced data protection and availability features, Xserve connects to the Xserve RAID storage system using the Apple Fibre Channel PCI Card. Xserve RAID holds up to 14 hot-swap Apple Drive Modules, for up to 3.5TB[1] of storage in a rack-optimized 3U enclosure. The innovative Apple-designed architecture combines affordable, high-capacity ATA drive technology with a dual 2Gb Fibre Channel SFP interface for fast, reliable data access, even at distances of up to 500 meters. Redundant components further increase data protection and system availability. With easy-to-use tools for remote setup and management, this powerful RAID system provides a cost-effective answer to the growing storage requirements of businesses and institutions.

Apple Fibre Channel PCI Card
Xserve RAID connects to a host Xserve G5 system using the dual-port 2Gb Apple Fibre Channel PCI Card (sold separately), for easy integration into copper or optical infrastructures.

Integrated Hardware Monitoring

Remote monitoring
Server Monitor allows administrators to review information on hundreds of Xserve systems from any Internet-connected Mac OS X system.

Xserve G5 includes built-in remote monitoring capabilities that enable network administrators to stay in touch with their Xserve systems from anywhere on the network or over the Internet. Xserve monitoring tools run over TCP/IP using robust password authentication to protect management data and server deployments from unauthorized access.

With 38 sensors in the enclosure, Xserve G5 is the most instrumented server in its class. Embedded hardware sensors integrate with Apple's sophisticated Server Monitor software to check the condition of all critical subsystems, such as memory, fans, power supplies, and Ethernet links. Temperature measurements for hard drives, processors, memory, PCI, power supply, and incoming ambient temperature are processed using three dedicated microcontrollers and three dedicated communication buses on the logic board.

To maximize server uptime, Server Monitor aids in the early identification and easy diagnosis of system problems. This powerful application uses data from the hardware sensors to continuously report on the status of all Xserve subsystems, for all servers on the network. If operating conditions for any component exceed predefined thresholds, Server Monitor can instantly send notification via email or email-capable pager, so network administrators can respond quickly to prevent or repair the problem.
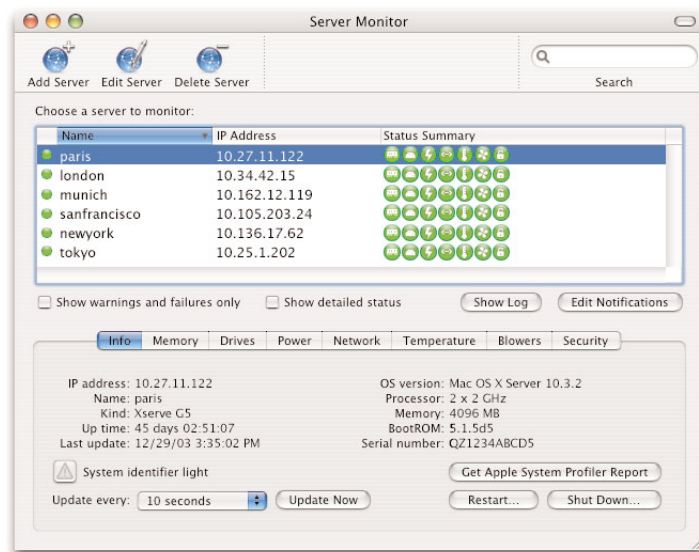
Server Monitor can monitor hundreds of servers using a single, intuitive interface. Each server is identified by name and IP address (or DNS host name), and at-a-glance summary information (green—OK, yellow—warning, red—error) indicates the status of individual components. A click on any icon displays detailed status and performance information.
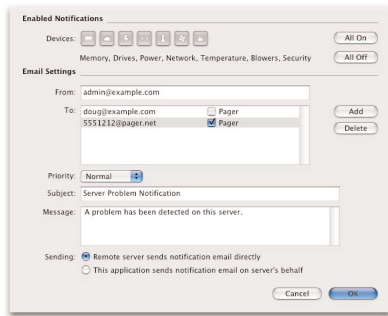
Automatic notifications
Server Monitor can send a customized email to alert specified individuals when operating conditions exceed predefined thresholds. Short text messages can be sent to email-capable pagers, cell phones, or PDAs; full-text details can be sent to email clients or full-function PDAs.

Xserve Remote Diagnostics
Xserve G5 includes a new set of server-class diagnostic tools that support hardware profiling and advanced diagnostics, as well as remote, headless operation.

Server Monitor provides instant access to status and performance details, including these individual server attributes, subsystems, and system variables:

- **Info.** Lists key attributes of the server: name, IP address, device kind, operating system version, processor type, amount of memory, firmware version, uptime, last monitoring update, and hardware serial number.

- **Memory.** Displays the size, speed, and type of memory installed in each system, as well as ECC error counts.

- **Drives.** Provides the status of each of the server's hard drives, including SMART data for predictive failure notification.

- **Power.** Shows the current, voltage, and processor power, as well as a historical line graph for each supply rail. It also provides Uninterruptible Power Supply (UPS) information and status when available.

- **Network.** Indicates the status of active network links, network stack, and link settings and provides a historical line graph for each link.
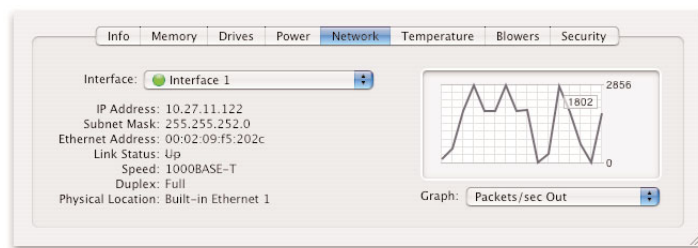
- **Temperature.** Provides the values of the ten enclosure and processor temperature sensors, as well as a historical line graph for each sensor reading.

- **Blowers.** Shows the revolutions per minute and status of the eight fans, including a historical line graph for each one. In the case of a single blower failure, the other fans speed up to compensate, allowing the server to continue to run, while also notifying the system administrator.
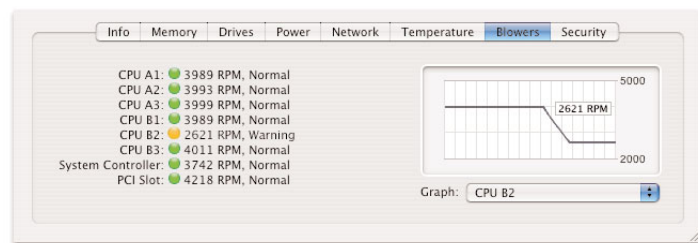
- **Security.** Displays the security status of the Xserve enclosure. Xserve G5 features a hardware enclosure lock that prevents drives from being removed, as well as software-based I/O port security that allows administrators to disable CD mounting, removal of hard drives, or use of USB and FireWire devices.

In addition, Server Monitor records a log of activities and messages for each monitored Xserve. The log provides the times Server Monitor attempted to contact the server and whether a connection was successful. It also shows changes in server status. For asset tracking or support logging, a System Profiler report can be saved for a selected server or multiple servers.

Mac OS X Server Version 10.3

New in Mac OS X Server version 10.3
The latest release of Mac OS X Server has more than 150 new features, including:
• PowerPC G5–optimized kernel and numerical libraries
• Automatic Setup for configuring multiple servers
• Server Admin application for easy setup and monitoring of services
• Open Directory 2 for delivering enterprise directory and authentication services
• Single sign-on using Kerberos v5
• Samba 3 for supporting Windows users
• Postfix mail server for Mac and Windows users
• VPN server for Mac and Windows users
• JBoss application server for running J2EE-based applications

New in Mac OS X Server for Xserve G5
• 802.1q VLAN support
• Background rebuilding of software RAID mirrors
• RAID volume promotion
• Enhanced UPS support
• Enhanced Server Monitor
• Customizable keyboard and mouse security options
• Xserve Remote Diagnostics

Xserve G5 ships with Mac OS X Server version 10.3, the fourth major release of Apple's award-winning server operating system. Mac OS X Server provides open source, standards-based workgroup and Internet services without the complexity inherent in Linux and other UNIX-based solutions. Hardware and software work together to deliver powerful, scalable solutions for supporting Mac, Windows, and Linux workgroups; deploying powerful Internet services; and hosting enterprise applications—all with an ease of use that is uniquely Macintosh. And with the unlimited-client license, there are no additional per-seat fees for connecting more users.[4] This kind of power has never been easier to put to work—or easier to integrate into your organization.

Optimized for the PowerPC G5

On all systems, Mac OS X Server features a high-performance 64-bit file system that supports HFS+ (and HFS+ journaled) file systems up to 16TB, so you can create very large, single file systems for massive databases, image archives, and digital video storage. In addition, Apple has written version 10.3 to take maximum advantage of the PowerPC G5, enabling current 32-bit applications to benefit immediately from the key advances of 64-bit processing. On PowerPC G5–based systems, Mac OS X Server can utilize the processor's 64-bit instructions and registers. It also includes 64-bit math and vector libraries that accelerate audio, video, and image processing, as well as large number operations—so existing applications that use these built-in libraries get an automatic performance boost.

Mac OS X Server v10.3 can address the 4TB of physical memory supported by the PowerPC G5. To ensure binary compatibility with existing 32-bit applications, Mac OS X manages access to the 64-bit physical memory space using a 32-bit virtual memory manager. This enables each Mac OS X application to access 4GB of address space, allowing multiple memory-intensive applications to run concurrently. For improved performance, data-intensive applications that require more than 4GB of memory can map pages of memory using the built-in mmap function.

Performance gains are even more dramatic when applications, particularly compute-intensive applications, are recompiled for the PowerPC G5. Using Xcode and GCC (GNU Compiler Collection) version 3.3, developers can get improved code generation that keeps the processor's integer and floating-point units constantly fed with instructions.

Built-In Network Services

Mac OS X Server includes a complete suite of robust solutions for file and print, Internet and web, networking, workgroup management, and directory services. Apple has integrated and tested the latest open source technologies—such as OpenLDAP, Postfix, Apache, and JBoss—making them easy to deploy right out of the box.

Built on open standards, Mac OS X Server is compatible with existing network and computing infrastructures. Samba 3, the new version of the popular open source SMB/CIFS server, provides reliable file and printer sharing for Windows clients, as well as support for NT Domain services. The built-in directory services architecture is based on LDAPv3, allowing Mac OS X Server systems to host LDAP directory services or integrate with any network that uses LDAP directory services. In addition, Mac OS X Server includes compatibility with legacy directory service solutions such as NIS, as well as proprietary solutions such as Active Directory. What's more, the open source UNIX-based foundation makes it easy to port and deploy existing tools to Mac OS X Server.

Innovative Remote Management

Mac OS X Server comes with innovative remote management tools that provide a consistent, unified interface for setting up and managing the built-in services. The new Server Admin application enables network administrators to securely manage services on multiple servers at the same time—all from the same easy-to-use application.
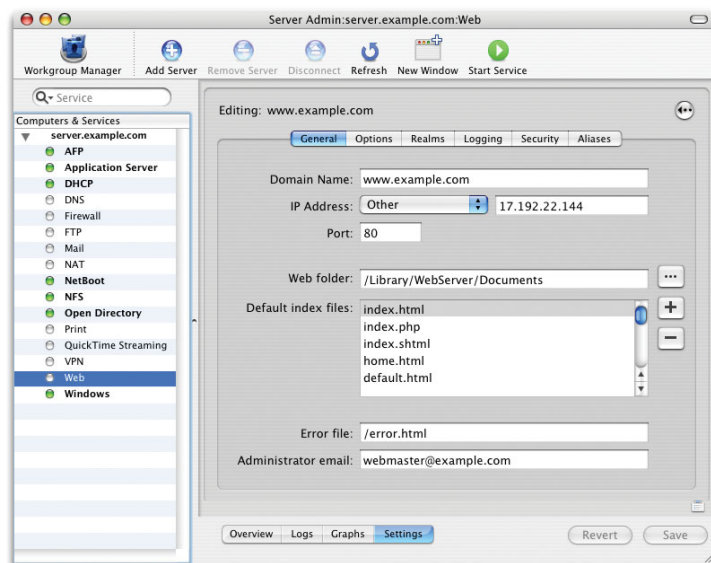
Administrators can use Server Admin on any Internet-connected Mac OS X computer to install software updates (including system software), set preferences, and configure workgroup and Internet services—such as Samba 3, Apache, DHCP, Postfix, and QuickTime Streaming Server.

High-availability services
To minimize downtime and maximize data protection, Mac OS X Server includes high-availability features such as software RAID, directory replication, file system journaling, a two-node IP failover service, and "watchdog" features such as automatic restart of the server and individual services.

Mac OS X Server also makes it easy to monitor services remotely. Server Admin displays the current status of all services running on Xserve systems. Administrators can read access and error logs, view charts of traffic patterns, and graph the performance of individual network services and file throughput—providing valuable information for planning and allocating network resources.

For administrators who prefer to manage from a terminal, Mac OS X Server includes Secure Shell (SSH2) technology for encrypted and authenticated login. Xserve G5 is equipped with a DB-9 (9-pin) serial port, giving UNIX-savvy administrators a way to access the system through a serial console session even when network services are down. Command-line tools allow administrators to remotely install software, run Software Update, or set system and network preferences. In addition, Mac OS X Server supports industry-standard Simple Network Management Protocol (SNMP) for integrating with third-party products, such as HP OpenView.

Service, Support, and Training Options

Every Xserve G5 comes with a one-year limited warranty and 90 days of up-and-running telephone support. In addition, the AppleCare website publishes in-depth product information, training on hardware and software installation and configuration, and technical resources, including the AppleCare Knowledge Base, discussions, and downloadable software on Apple's Featured Software site.
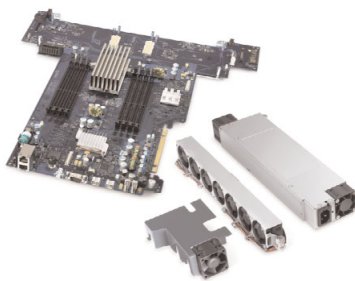
For critical server deployments, Apple also offers a comprehensive range of service and support options for Xserve hardware and Mac OS X Server software. For more information about these AppleCare products, see www.apple.com/server/support.

AppleCare Premium Service and Support Plan

This server-class support product provides up to three years of up-and-running telephone and email support and onsite hardware service. Apple technical support experts are available 24 hours a day to help you determine whether you're experiencing a hardware failure or a Mac OS X Server configuration issue. In either case, Apple will work to get systems up and running quickly. And because Apple hardware and software are uniquely integrated, there's only one vendor to call.

The AppleCare Premium Service and Support Plan delivers up-and-running telephone and email support within 30 minutes—24 hours a day, seven days a week. The hardware repair coverage provides onsite response within four hours during business hours and next-day onsite response when you contact Apple after business hours (terms apply).[7] For added peace of mind, you'll have the assurance that Apple-authorized technicians will perform repairs using genuine Apple parts.

The AppleCare Premium Service and Support Plan can be purchased at any time while Xserve G5 is still under its original one-year warranty. However, since coverage ends three years after the hardware purchase date, you'll get maximum advantage when you make both purchases at the same time.

AppleCare Service Parts Kit

Xserve G5 is designed for quick and easy swapping of crucial parts; no special tools or training certifications are needed. AppleCare Service Parts Kits let system administrators keep key components handy to address the most common hardware failures. Each kit has a logic board, a power supply, a PCI fan unit, and a fan array module. When the AppleCare Premium Service and Support Plan is combined with an AppleCare Service Parts Kit, technical support experts can often help troubleshoot and fix systems right over the phone—day or night—eliminating the need for an onsite technician.

Convenient replacement modules
Problem resolution is fast with AppleCare Service Parts Kits for Xserve G5 (sold separately).

Mac OS X Server Software Support

Apple also offers support programs for Mac OS X Server that extend beyond the up-and-running support provided by the AppleCare Premium Service and Support Plan. Apple technical support experts can provide consultative phone and email support for Mac OS X Server integration and migration issues, as well as help with command-line configuration.

Three levels of Mac OS X Server Software Support are available, depending on the number of incidents supported and desired response time. Each plan provides one year of coverage.

Mac OS X Server Maintenance Program
This subscription program makes it easy to manage software expenditures while benefiting from the latest technologies and improvements. With one easy payment, you'll receive major Mac OS X Server software upgrades for three years.

- **Select** covers up to 10 incidents with 4-hour response for priority 1 issues (server down), 12 hours a day, 7 days a week.[7] Support for additional incidents can be purchased as needed.

- **Preferred** covers an unlimited number of incidents with 2-hour response for priority 1 issues, 12 hours a day, 7 days a week,[7] and assigns a technical account manager to the organization.

- **Alliance** covers an unlimited number of incidents at multiple locations with 1-hour response for priority 1 issues, 24 hours a day, 7 days a week.[7] This plan includes an onsite review by an Apple technical support engineer.

Training and Certification Programs

Apple offers comprehensive instruction on Mac OS X and Mac OS X Server, covering such topics as client management, system troubleshooting, and cross-platform network configuration. A combination of lectures, demonstrations, and hands-on exercises, classes are taught by Apple Certified Trainers with real-world experience and dynamic presentation skills. Classes are offered at Apple Authorized Training Centers, as well as at customer locations.

Once IT professionals have acquired the requisite skills, Apple certification programs provide tangible evidence of their technical expertise. For more information about Apple training and certification programs, visit www.apple.com/training.

Purchasing Information

Standard Configurations

Xserve G5 is available in three standard configurations to meet the needs of server and cluster deployments in education and business.

	Cluster node	Single-processor server	Dual processor server
Order number	M9215LL/A	M9216LL/A	M9217LL/A
Processor	Dual 2GHz PowerPC G5	2GHz PowerPC G5	Dual 2GHz PowerPC G5
Frontside bus	1GHz per processor	1GHz	1GHz per processor
PC3200 DDR memory (400MHz ECC)	512MB	512MB	1GB
Hot-plug Apple Drive Module	80GB Serial ATA[1]	80GB Serial ATA[1]	80GB Serial ATA[1]
Storage expansion	—	Three drive bays supporting up to 750GB, using 80GB and/or 250GB drives	
Optical drive	—	Slot-loading CD-ROM	Slot-loading CD-ROM
Networking	Two onboard Gigabit Ethernet interfaces (10/100/1000BASE-T)		
PCI expansion	Two open 64-bit PCI-X slots supporting one card at up to 133MHz or two cards at up to 100MHz		
Ports	Two FireWire 800, two USB 2.0, one DB-9 (back panel); one FireWire 400 (front panel)		
Mac OS X Server software	10-client edition	Unlimited-client edition	Unlimited-client edition
Also included	Mounting screws with M5 and 10/32-inch threads; caged nuts; cable management arm for four-post racks; agency-approved 12-foot power cable		
Service and support	90 days of free telephone support and one-year limited warranty; optional extended service and support products		

Build-to-Order Options

Customers can order a custom-configured Xserve G5 with the following options.

- Memory: 512MB, 1GB, 2GB, 4GB, 6GB, 8GB
- Internal storage: 80GB and 250GB Apple Drive Modules[1]
- Optical drive: Combo drive (DVD-ROM/CD-RW)
- PCI cards: Apple Fibre Channel PCI Card (includes SFP to SFP cables), hardware RAID PCI card, Apple PCI-X Gigabit Ethernet Card, dual-channel Ultra320 SCSI PCI-X card, VGA video card

Compute power with Macintosh ease of use
The Apple Workgroup Cluster for Bioinformatics enables researchers to harness the vast computational power of a PowerPC G5–based cluster.

Related Products

• Xserve RAID, available in 1TB, 1.75TB, and 3.5TB configurations[1]
• AppleCare Premium Service and Support Plan
• AppleCare Service Parts Kit
• Mac OS X Server Maintenance Program
• Third-party products, including racks, switches, and UPS devices

For up-to-date information on these and other products that enhance Xserve deployments, visit www.apple.com/store or call 800-MY-APPLE.

Apple Workgroup Cluster for Bioinformatics

Apple makes it easy for researchers to benefit from the power of computational clustering. The Apple Workgroup Cluster for Bioinformatics provides everything you need to get started: simple setup tools, more than 200 preinstalled bioinformatics applications, a web-based management interface, and a choice of two, four, eight, or 16 Xserve G5 cluster nodes. For information, visit www.apple.com/xserve/cluster.

Technical Specifications

Hardware

Processor
• Single or dual 2GHz PowerPC G5 processors
• PowerPC processor architecture with 64-bit data paths and registers
• Native support for 32-bit application code
• 512K on-chip L2 cache running at processor speed
• Parallel execution architecture supporting up to 215 simultaneous in-flight instructions
• Simultaneous issue of up to 10 out-of-order operations
• Dual-pipeline Velocity Engine for 128-bit single-instruction, multiple-data (SIMD) processing
• Two independent double-precision floating-point units
• Two integer units
• Advanced three-component branch prediction logic
• 64-bit, 1GHz DDR frontside bus per processor, each supporting up to 8GB/s data throughput
• Point-to-point system controller with support for ECC memory

Memory
• 128-bit data paths for up to 6.4GB/s memory throughput
• 512MB or 1GB of PC3200 (400MHz) DDR SDRAM
• Data protection using Error Correction Code (ECC) logic
• Eight slots supporting up to 8GB of DDR SDRAM using the following DIMMs (in pairs):
  – 256MB DIMMs (128-bit-wide, 128- or 256-Mbit technology)
  – 512MB DIMMs (64-bit-wide, 256-Mbit technology)
  – 1GB DIMMs (64-bit-wide, 256-Mbit technology)

I/O connections
• Two open 11-inch, 64-bit PCI-X slots, running at up to 133MHz with one card installed or up to 100MHz with two cards installed; support for 32-bit or 64-bit 3.3V Universal PCI cards running at 33MHz or 66MHz[6]
• Two independent 10/100/1000BASE-T (Gigabit) RJ-45 Ethernet interfaces on the main logic board
• Two 1.2MHz HyperTransport interconnects with the following throughput:
  – Up to 4.8GB/s (2.4GB/s each way) between system controller and PCI-X
  – Up to 1.6GB/s (800MB/s each way) between system controller and I/O controller
• Two FireWire 800 ports on back panel and one FireWire 400 port on front panel; 15W total power
• Two USB 2.0 ports (480Mb/s each)
• One DB-9 serial port (RS-232)

Storage
- Three internal drive bays on independent 150MB/s SATA channels (server configurations); or one internal drive bay on 150MB/s SATA channel (cluster node configuration)
- One bay filled with 80GB 7200-rpm SATA Apple Drive Module; empty drive bays on server configurations contain blank modules
- Up to 750GB of internal storage[1] using hot-plug Apple Drive Modules (server configurations), available in the following capacities:
  – 80GB 7200-rpm SATA with 8MB disk cache
  – 250GB 7200-rpm SATA with 8MB disk cache
- Support for reading SMART data from Apple Drive Modules for prefailure notification
- Slot-loading 24x-speed CD-ROM drive or optional DVD-ROM/CD-RW Combo drive (server configurations)

Rack support
- Fits EIA-310-D–compliant, industry-standard 19-inch-wide racks, including:
  – Four-post racks: 24 inches, 26 inches, and from 29 to 36 inches deep
  – Two-post telco racks (center-mount brackets included)
- Cable management arm for four-post rack
- Front-to-back cooling for rack enclosure

Electrical requirements
- Line voltage: universal input (90V to 264V AC), power factor corrected
- Maximum input current: 5.5A (90V to 132V) or 2.75A (180V to 264V)
- Frequency: 47Hz to 63Hz, single phase
- Output power: 400W

Environmental requirements and approvals
- Operating temperature: 50° to 95° F (10° to 35° C)
- Storage temperature: –40° to 116° F (–40° to 47° C)
- Relative humidity: 5% to 95% noncondensing
- Maximum altitude: 10,000 feet
- FCC Class A approved

Size and weight
- Height: 1.73 inches (4.4 cm)
- Width: 17.6 inches (44.7 cm) for mounting in standard 19-inch rack
- Depth: 28 inches (71.1 cm)
- Weight: 33.3 pounds (15.11 kg); 36.6 pounds (16.62 kg) with three Apple Drive Modules[8]

Software

Mac OS X Server
· Unlimited-client edition (server configurations); or 10-client edition (cluster node configuration)

Included services
· File and printer sharing: Macintosh (AFP, AppleTalk PAP), Windows (SMB/CIFS), UNIX and Linux (NFS, LPR/LPD), Internet (FTP, WebDAV)
· Directory services: Open Directory 2 (OpenLDAP, Kerberos, SASL), NT Domain Controller (Samba 3)
· Networking and security: DNS server (BIND 9), DHCP server, NTP server, Firewall (IPFW), WINS, VPN server (L2TP, PPTP)
· Mail services: SMTP (Postfix), POP and IMAP (Cyrus), Berkeley DB for indexing, SSL/TLS encryption (OpenSSL), mailing lists (Mailman), webmail (SquirrelMail)
· Web hosting: Apache web server, SSL/TLS (OpenSSL), WebDAV, server-side includes (SSIs), PHP, Perl, Ruby, Python, MySQL 4
· Application services: JBoss application server (EJB), Apache Tomcat (JavaServer Pages, Java Servlets), Java virtual machine (J2SE), Apache Axis (SOAP, WSDL Web Services), WebObjects 5.2 Deployment
· Media streaming: QuickTime Streaming Server (MPEG-4, MP3, AAC, RTP/RTSP), QuickTime Broadcaster, QuickTime Streaming Server Publisher, unicast and multicast
· Workgroup management: Workgroup Manager, NetBoot, Network Install
· Remote management: Server Monitor, Server Admin, SNMPv3, command-line tools

For More Information

For more information about Xserve G5 and other Apple server solutions, visit www.apple.com/server.

[1]For hard drive capacity measurements, 1GB = 1 billion bytes and 1TB = 1 trillion bytes; actual formatted capacity less. Maximum capacity of 750GB achieved through use of three 250GB Apple Drive Modules (server configurations only). [2]"Third most powerful" based on TOP500 List of Supercomputer Sites, November 2003. [3]Based on LINPACK tests conducted by Apple in January 2004 using preproduction dual 2GHz Xserve G5 units; all other systems tested were shipping units. [4]The cluster node configuration has one drive bay and no optical drive and includes a 10-client license for Mac OS X Server. [5]Based on U.S. MSRP $2799 and LINPACK performance of 9 gigaflops. [6]Check with manufacturer for compatibility. [7]A separate AppleCare Premium Service and Support Plan must be purchased for each Xserve RAID system to be covered. To qualify, systems must be within the one-year hardware warranty. Coverage ends three years after date of Xserve RAID purchase. Actual onsite response time and availability of onsite service depend on location; see www.apple.com/support/products/premium for details. Local telephone fees may apply; telephone numbers may vary and are subject to change. [8]Weight varies by configuration and manufacturing process.