Power Mac G5 Performance

White Paper
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Contents

World's Fastest Personal Computer

Power Mac G5 Performance Highlights

Compared with a dual 3.06GHz Xeon-based workstation, the dual 2GHz Power Mac G5:

• Scored significantly higher on industry-standard SPEC CPU2000 "rate" benchmarks for dual processing systems.[1]
• Ran 45 Adobe Photoshop filters nearly two times faster.[2]
• Played nearly 50 percent more simultaneous audio plug-ins.
• Executed BLAST word searches up to four times faster.

Apple's Power Mac G5 is a revolutionary 64-bit desktop system designed to meet the high-performance, no-compromise requirements of the creative professional. With 64-bit power and a high-bandwidth architecture, this groundbreaking new system alleviates the limitations and bottlenecks of the traditional PC—opening up a wealth of possibilities for 2D and 3D designers, video and audio producers, scientists and researchers, and game programmers and players.

All this performance begins with the 64-bit PowerPC G5 processor. Developed in collaboration with IBM and produced using state-of-the-art process technology, the PowerPC G5 yields clock speeds up to 2GHz. This breakthrough processing power combines with the industry's fastest frontside bus, a point-to-point architecture, high-speed memory, and the latest I/O technologies. The result? The world's fastest personal computer.[3]

How fast is it? Apple put the Power Mac G5 to the test against two top-of-the-line competitive systems. The Dell Dimension 8300, equipped with the latest 3GHz Pentium 4, provided a baseline for most of the tests. We also tested the Dell Precision Workstation 650 with dual 3.06GHz Xeon processors. Although the Power Mac G5 supports more memory than either of the Dell systems, all systems in each test were configured with equal amounts of memory.

For overall system performance, Apple relied on SPEC CPU2000, the most respected benchmark suite in the industry. For real-world performance, we tested popular applications for creative professionals, including Adobe Photoshop and Logic Platinum from Emagic. All Mac systems used Mac OS X v10.2 "Jaguar"; unless otherwise noted, the competitive systems used Windows XP Professional Service Pack 1.

Test results clearly demonstrate the superior processing performance of the Power Mac G5, as well as faster performance in key application categories. We invite you to learn more about the capabilities of the Power Mac G5 with the 64-bit PowerPC G5 processor.

System Performance

The PowerPC G5 processor

The groundbreaking Power Mac G5 sets a new standard for desktop computing. It's the industry's first 64-bit personal computer, with the industry's fastest frontside bus and the latest I/O technologies—including up to 500GB of internal Serial ATA storage[4] and FireWire 800 for connecting high-performance devices.

Processor

The PowerPC G5 features an entirely new superscalar, superpipelined execution core based on the architecture of the IBM POWER4 server processor. It has 12 discrete processing units that execute various types of calculations in parallel: an optimized Velocity Engine, two floating-point units, two integer units, two load/store units, and a unique three-component branch prediction unit. By arranging internal operations using an efficient group-tracking scheme, the PowerPC G5 can manage up to 215 in-flight instructions simultaneously, 70 percent more than the 126 instructions in the Pentium 4.

Data bandwidth is further optimized thanks to a frontside bus—one on each processor in dual processor systems—running at up to 1GHz. This superfast interface provides 8-GBps throughput between each processor and the rest of the system, for an aggregate 16-GBps throughput in dual processor Power Mac G5 systems.
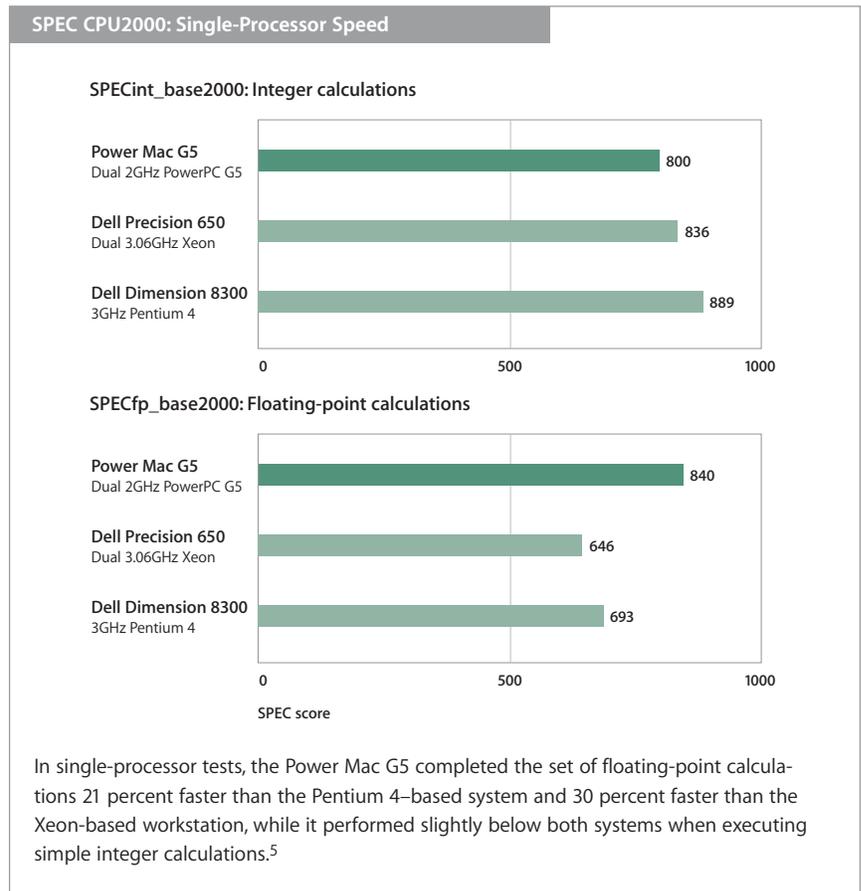
SPEC CPU2000
The Standard Performance Evaluation Corporation (SPEC) CPU2000 benchmark suite is the recognized industry standard for assessing processing performance. SPEC is a nonprofit organization of hardware and software vendors, universities, and consultants. They developed the SPEC CPU2000 benchmarks based on actual end-user applications. These tests depend on processor, memory subsystem, and compiler performance when executing integer and floating-point computations. For more information on the benchmarks, see www.spec.org.

Apple hired an independent laboratory, VeriTest, to conduct the SPEC CPU2000 benchmark tests and provide documented results. Since SPEC CPU2000 measures the performance of both the hardware and the compiler, VeriTest normalized the compiler on both platforms to allow for a direct comparison of hardware performance alone. VeriTest used GCC—an open source compiler popular with programmers around the world—with similar settings on all systems. (Even though GCC cannot automatically generate Velocity Engine code for the PowerPC G5, settings included automatic generation of optimized SSE/SSE2 code for the Pentium 4 and the Xeon.) The Power Mac G5 used Mac OS X v10.2.7 (G5), and the Intel-based systems used Red Hat Linux 9.0.

The SPEC CPU2000 benchmark suite comprises four metrics—SPECint_base2000, SPECfp_base2000, SPECint_rate_base2000, and SPECfp_rate_base2000—to represent different performance characteristics of the system.

SPECint_base2000 and SPECfp_base2000 measure the speed of a single task—either an integer calculation or a floating-point calculation—executing on a single processor. Each test measures how long the processor takes to complete the benchmark set of single tasks relative to a SPEC-defined baseline score. SPECint_base2000 is composed of eleven C and one C++ benchmark applications, including a chess program, a data compression utility, and a place-and-route simulator. SPECfp_base2000 consists of six Fortran-77, four Fortran-90, and four C benchmark applications, including shallow-water modeling, neural-network simulation, and computational chemistry.

SPEC CPU2000: Single-Processor Speed

SPECint_base2000: Integer calculations

System	Score
Power Mac G5 Dual 2GHz PowerPC G5	800
Dell Precision 650 Dual 3.06GHz Xeon	836
Dell Dimension 8300 3GHz Pentium 4	889

(scale: 0 — 500 — 1000)

SPECfp_base2000: Floating-point calculations

System	Score
Power Mac G5 Dual 2GHz PowerPC G5	840
Dell Precision 650 Dual 3.06GHz Xeon	646
Dell Dimension 8300 3GHz Pentium 4	693

(scale: 0 — 500 — 1000)

SPEC score

In single-processor tests, the Power Mac G5 completed the set of floating-point calculations 21 percent faster than the Pentium 4–based system and 30 percent faster than the Xeon-based workstation, while it performed slightly below both systems when executing simple integer calculations.[5]

For comparisons that more accurately demonstrate the performance of a dual proces-
sor system, VeriTest used the "SPEC rate" metrics, which recognize multiple processors.
With SPECint_rate_base2000 and SPECfp_rate_base2000, the benchmark code is
compiled and multiple copies are run concurrently, allowing both processors to work
in parallel. SPEC rate tests determine the number of times a system can complete the
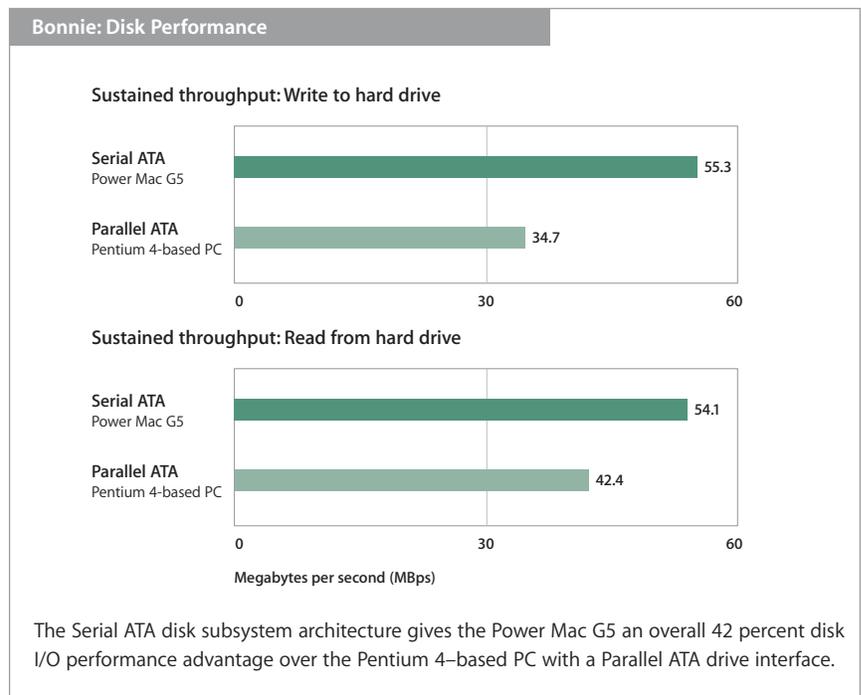benchmark per hour, also referred to as system throughput.

SPEC CPU2000: Dual Processor System Throughput

SPECint_rate_base2000: Integer calculations

System	Score
Power Mac G5 Dual 2GHz PowerPC G5	17.2
Dell Precision 650 Dual 3.06GHz Xeon	16.7
Dell Dimension 8300 3GHz Pentium 4	10.3

0   10   20

SPECfp_rate_base2000: Floating-point calculations

System	Score
Power Mac G5 Dual 2GHz PowerPC G5	15.7
Dell Precision 650 Dual 3.06GHz Xeon	11.1
Dell Dimension 8300 3GHz Pentium 4	8.1

0   10   20

SPEC score

These results clearly demonstrate the benefits of the dual processor Power Mac G5. With
full support for symmetric multiprocessing, dual independent 1GHz frontside buses, and
two floating-point units per processor, the dual 2GHz Power Mac G5 completed the set
of floating-point calculations 95 percent faster than the Pentium 4–based system and
42 percent faster than the dual Xeon-based workstation. Integer performance was also
far superior to the Pentium 4–based system and on par with the dual Xeon-based system.[5]

For a detailed report of SPEC CPU2000 test results, see www.veritest.com.

Serial ATA

Serial ATA is the next-generation industry-standard storage interface, replacing the Parallel ATA interface. Designed to keep pace with the demands of digital video creation and editing, audio storage and playback, and other data-intensive applications, Serial ATA supports a data rate of 150 MBps, removing the storage interface as a bottleneck. The Power Mac G5 features two internal Serial ATA drives, each on an independent bus—so there is no competition for drive performance, as with Parallel ATA.
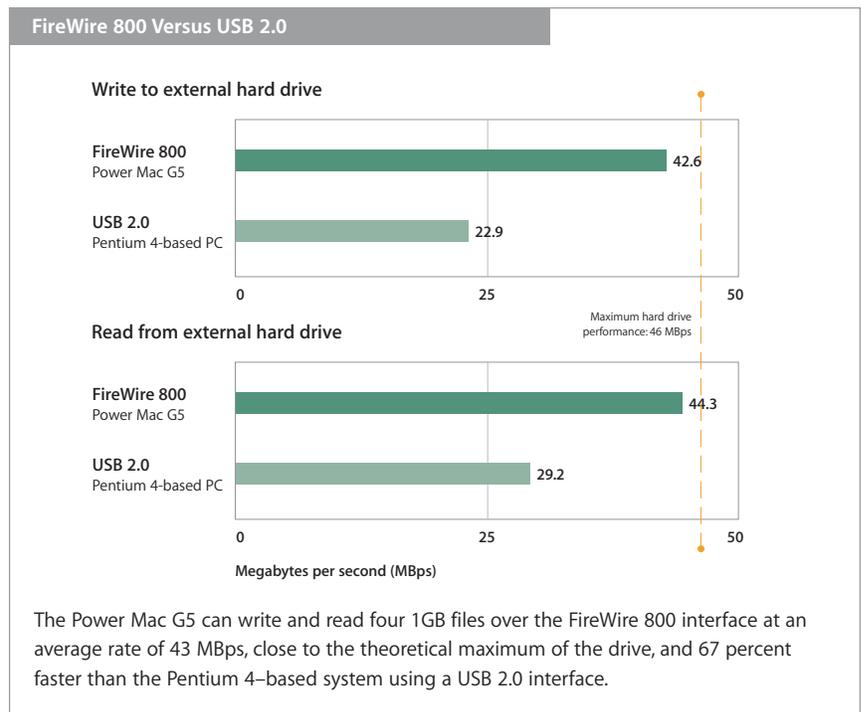
Apple tested storage performance using Bonnie, an open source benchmark, ported to Mac OS X by Apple. Bonnie measures the throughput of drive systems by writing to and reading from the disks using standard UNIX system calls, reporting results as maximum block read and write performance. A file-size setting of 2GB was used to ensure that the data was written to the disks and not only to the drive cache or to the system's physical memory.

Bonnie: Disk Performance

Sustained throughput: Write to hard drive

	MBps
Serial ATA Power Mac G5	55.3
Parallel ATA Pentium 4-based PC	34.7

0   30   60

Sustained throughput: Read from hard drive

	MBps
Serial ATA Power Mac G5	54.1
Parallel ATA Pentium 4-based PC	42.4

0   30   60

Megabytes per second (MBps)

The Serial ATA disk subsystem architecture gives the Power Mac G5 an overall 42 percent disk I/O performance advantage over the Pentium 4–based PC with a Parallel ATA drive interface.

FireWire 800

FireWire is a powerful I/O interface with a theoretical maximum throughput of 800 Mbps.[6] FireWire is ideal for transferring large quantities of data to and from external devices, such as hard drives, DV cameras, and scanners. The Power Mac G5 features one FireWire 800 and two FireWire 400 ports for easy connection to these high-performance peripherals.

Apple compared the performance of the FireWire 800 interface on the Power Mac G5 with the performance of USB 2.0, the fastest standard I/O interface on Pentium 4–based systems. The test consisted of writing and reading four 1GB files to and from a 120GB Western Digital hard drive. With a maximum throughput of 46 MBps, this is the fastest external FireWire 800/USB 2.0 combination drive on the market.

FireWire 800 Versus USB 2.0

Write to external hard drive

FireWire 800 Power Mac G5	42.6
USB 2.0 Pentium 4-based PC	22.9

0   25   50

Maximum hard drive
performance: 46 MBps

Read from external hard drive

FireWire 800 Power Mac G5	44.3
USB 2.0 Pentium 4-based PC	29.2

0   25   50

Megabytes per second (MBps)

The Power Mac G5 can write and read four 1GB files over the FireWire 800 interface at an average rate of 43 MBps, close to the theoretical maximum of the drive, and 67 percent faster than the Pentium 4–based system using a USB 2.0 interface.

Application Performance

The success of today's creative professionals depends on their ability to crunch increasing quantities of data quickly and efficiently. They need vast amounts of RAM to handle memory-intensive applications and enormous media files. They need superfast, sophisticated graphics capabilities to visualize complex 3D models and manipulate high-resolution images. And they need comprehensive input and output options to connect to a myriad of industry-specific peripherals.

The Power Mac G5 opens up a wealth of computing opportunities. Graphic designers can manipulate Adobe Photoshop images for print, web, and animation more than two times faster than on the fastest PC.[2] Video producers can manipulate multiple streams of DV and SD content in real time. Musicians and audio producers can process an unprecedented number of audio tracks, all with complex filters and digital effects. Scientists can execute high-precision math on extremely large 64-bit numbers and return results faster than ever. Artists, game developers, architects, and researchers can model and render complex 3D visualizations at remarkable speeds.
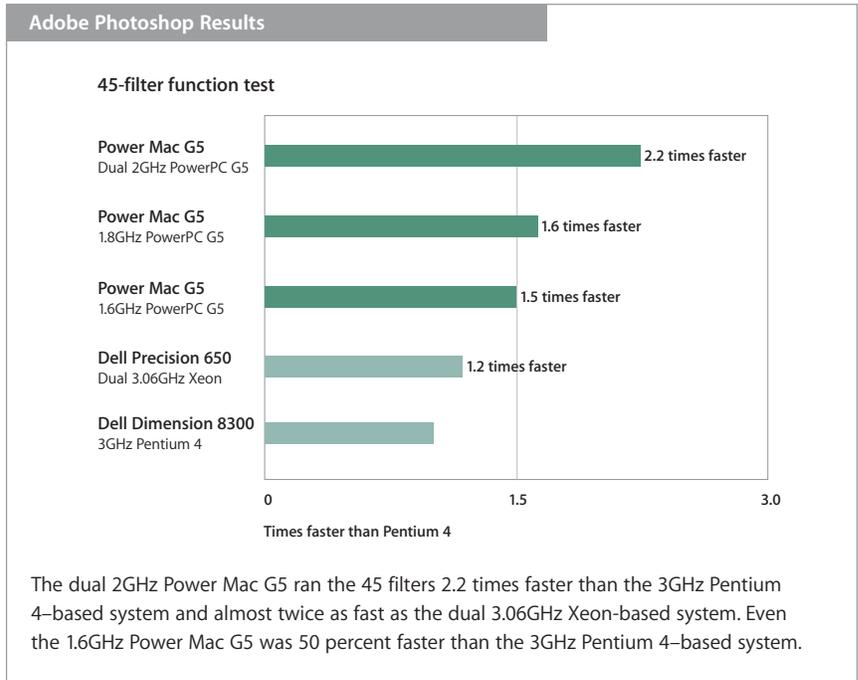
Design and Graphics

The Power Mac G5 provides the performance leap that design and publishing professionals have been waiting for. More system memory and a faster memory architecture make it possible to manipulate massive images and layouts entirely in RAM, reducing the need to access the hard drive. And with state-of-the-art I/O technologies—Gigabit Ethernet, SuperDrive, FireWire 800, and USB 2.0—standard on all configurations, designers and digital artists have fast and easy access to the peripherals that their workflows demand.
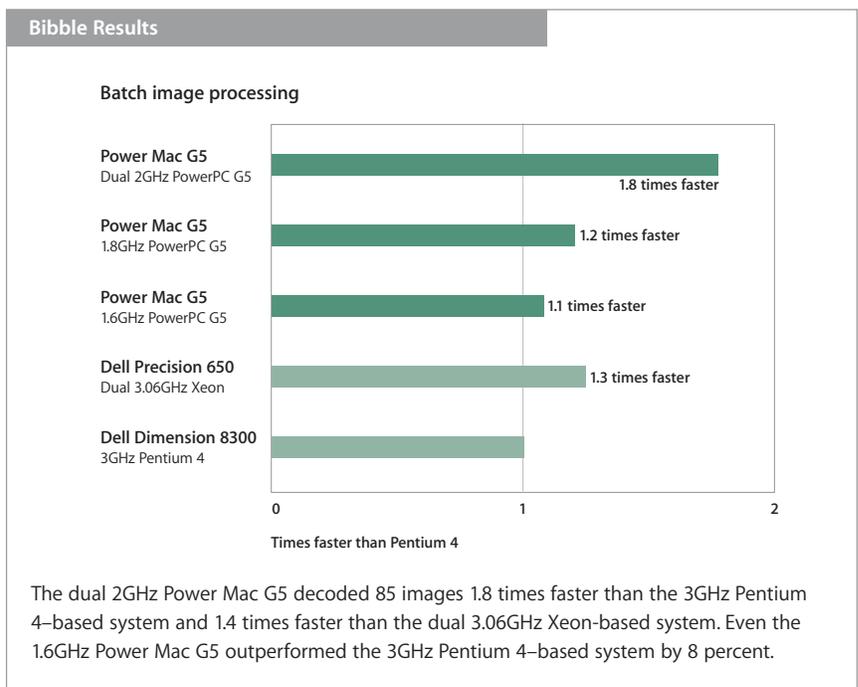
Adobe Photoshop
To demonstrate the superiority of the Power Mac G5, Apple conducted tests using Adobe Photoshop, the most popular application among creative professionals. Photoshop is an effective cross-platform measure of system performance because it has been optimized for both Macintosh and Windows platforms. It even takes advantage of the latest processor technologies on both platforms: SSE2 in the Pentium 4 and the Xeon, and Velocity Engine in the PowerPC G5.

Apple ran the Adobe Photoshop tests using a 600MB Photoshop file and a suite of 45 commonly used Photoshop actions, including file saving, image adjustments, mode changes, and filters. (See "Test Details" for a complete list.) We measured the time to execute each filter or function and compared the performance of all actions using an indexed score.[2]

Adobe Photoshop Results

45-filter function test

System	
Power Mac G5 Dual 2GHz PowerPC G5	2.2 times faster
Power Mac G5 1.8GHz PowerPC G5	1.6 times faster
Power Mac G5 1.6GHz PowerPC G5	1.5 times faster
Dell Precision 650 Dual 3.06GHz Xeon	1.2 times faster
Dell Dimension 8300 3GHz Pentium 4	

0   1.5   3.0

Times faster than Pentium 4

The dual 2GHz Power Mac G5 ran the 45 filters 2.2 times faster than the 3GHz Pentium 4–based system and almost twice as fast as the dual 3.06GHz Xeon-based system. Even the 1.6GHz Power Mac G5 was 50 percent faster than the 3GHz Pentium 4–based system.

Bibble

Bibble is a powerful batch image processing application used by professional photographers for decoding files from native digital camera formats, such as Nikon's .nef, into industry-standard formats, such as .tif. Bibble is a processor-intensive, multiprocessor-aware application that uses symmetric multiprocessing on the Mac and Hyper-Threading on the PC to enhance performance. Apple compared the performance of the Power Mac G5 running MacBibble 3.1a with Intel-based systems running Bibble 3.1a. The test consisted of batch-converting 85 images from .nef to a 16-bit .tif format and measuring how long each system took to complete the task.[2]

Bibble Results

Batch image processing

System	
Power Mac G5 Dual 2GHz PowerPC G5	1.8 times faster
Power Mac G5 1.8GHz PowerPC G5	1.2 times faster
Power Mac G5 1.6GHz PowerPC G5	1.1 times faster
Dell Precision 650 Dual 3.06GHz Xeon	1.3 times faster
Dell Dimension 8300 3GHz Pentium 4	

0   1   2

Times faster than Pentium 4

The dual 2GHz Power Mac G5 decoded 85 images 1.8 times faster than the 3GHz Pentium 4–based system and 1.4 times faster than the dual 3.06GHz Xeon-based system. Even the 1.6GHz Power Mac G5 outperformed the 3GHz Pentium 4–based system by 8 percent.
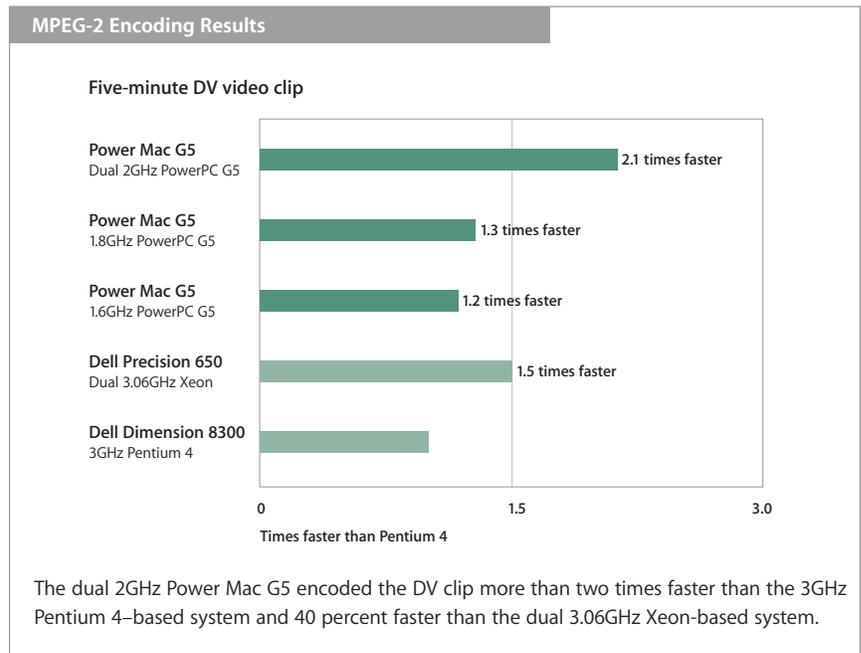
Film and Video

With its 64-bit processor and high-bandwidth architecture, the Power Mac G5 is the ultimate professional video workstation. Dual processors, outstanding floating-point performance, up to 8GB of main memory, and PCI-X expansion provide huge advances for video editing, 3D content creation, compositing, and special effects on the desktop.

Video encoding

For an initial look at video performance on the Power Mac G5, Apple tested video encoding, the most time-consuming part of burning a DVD. The test consisted of converting DV, the format generated by most standard digital video cameras, to MPEG-2, the format used for high-quality television display by consumer DVD players.

We compared Power Mac G5 systems running Compressor, Apple's professional-level encoding software, with Intel-based systems running Canopus ProCoder professional transcoding software, a popular Windows-based DVD authoring solution. We measured the time it took each system to encode a five-minute DV clip using the high-quality MPEG-2 encoding setting.[2]

MPEG-2 Encoding Results

Five-minute DV video clip

Power Mac G5 Dual 2GHz PowerPC G5	2.1 times faster
Power Mac G5 1.8GHz PowerPC G5	1.3 times faster
Power Mac G5 1.6GHz PowerPC G5	1.2 times faster
Dell Precision 650 Dual 3.06GHz Xeon	1.5 times faster
Dell Dimension 8300 3GHz Pentium 4	

0   1.5   3.0

Times faster than Pentium 4

The dual 2GHz Power Mac G5 encoded the DV clip more than two times faster than the 3GHz Pentium 4–based system and 40 percent faster than the dual 3.06GHz Xeon-based system.

Audio Production

As digital audio rendering becomes more sophisticated, processing performance gains are paramount to the success of professional audio producers. The 64-bit G5 processor provides the computing power and the Power Mac G5 system architecture provides the bandwidth to support more simultaneous channels, plug-ins, and polyphony than ever before. FireWire 800 and USB 2.0 ports connect to high-performance MIDI and multichannel audio devices, and optical digital audio input and output ports connect to professional production equipment, as well as to traditional analog devices.

Logic versus Cubase

To quantify the performance advantages of the Power Mac G5 for audio production, Apple tested two of the industry leaders in professional audio software: Emagic's Logic Platinum for the Macintosh and Steinberg's Cubase SX 1.051 for the PC. We created a processor-intensive workload of projects containing multiple unique audio tracks; assigned five default reverb plug-ins to each of the audio tracks; and tested each platform to see which could play more plug-ins.[2]

Logic Versus Cubase

Simultaneous reverb plug-ins

System	Plug-ins
Power Mac G5 Dual 2GHz PowerPC G5	115 plug-ins
Power Mac G5 1.8GHz PowerPC G5	59 plug-ins
Power Mac G5 1.6GHz PowerPC G5	52 plug-ins
Dell Precision 650 Dual 3.06GHz Xeon	81 plug-ins
Dell Dimension 8300 3GHz Pentium 4	35 plug-ins

Maximum number of plug-ins (0, 75, 150)

The dual 2GHz Power Mac G5 can play 115 plug-ins, compared with a maximum of 35 plug-ins on the Dell Dimension 8300 and 81 plug-ins on the Dell Precision 650. More impressively, the 1.6GHz Power Mac G5 played almost 50 percent more plug-ins than the 3GHz Pentium 4–based system.

Scientific and Technical Computing

The typical researcher's desktop has two or more computers: a UNIX workstation for research and analysis applications; and a PC or a Mac for mainstream applications such as writing, budgeting, and presentations. The Power Mac G5 makes it possible for a researcher to run both productivity applications and high-performance UNIX applications on a single system. In fact, the impressive floating-point performance of the PowerPC G5 processor enables Power Mac G5 systems to outperform many UNIX workstations. The PowerPC G5 also significantly accelerates vector processing with the Velocity Engine—making the Power Mac G5 ideal for users in the life sciences, physical sciences, and other technical computing disciplines.

A/G BLAST

A/G BLAST is an optimized 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. Before A/G BLAST on the Power Mac, this kind of search was impractical, because it required an enormous amount of time.

BLAST

To demonstrate the performance advantages of the Power Mac 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—a highly processor-intensive task.

BLAST searches are based on word size, or the number of nucleotide pairs specified by the researcher to register as a match. For example, a word size of 40 means that two sets of genetic code have 40 nucleotides in common. 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 example, comparing DNA samples from two different mice. For short-word-size searches (fewer than 11), the researcher is comparing more distantly related sequences, such as mouse DNA versus human DNA. These searches require high resolution in order to find the small matches between dissimilar sequences.

Apple compared the performance of the dual 2GHz Power Mac G5 running A/G BLAST with a 3GHz Pentium 4–based system and a dual 3.06GHz Xeon-based system, both running Red Hat Linux 9.0 and NCBI BLAST.[2]
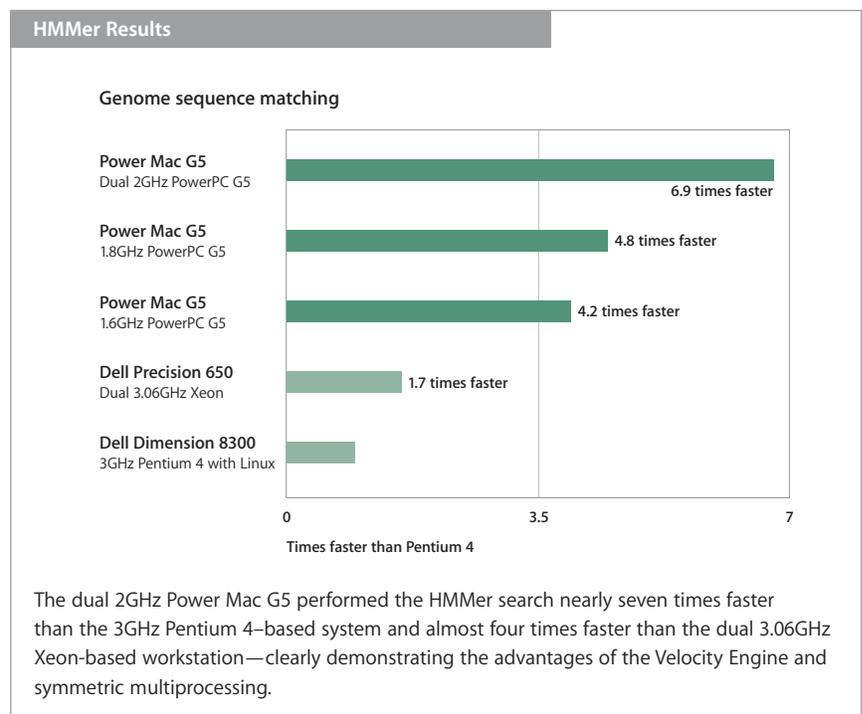

BLAST Results

DNA sequence matching

In common searches using a word size of more than 11, the Power Mac G5 far outperformed the Pentium 4–based system and the dual Xeon-based system.
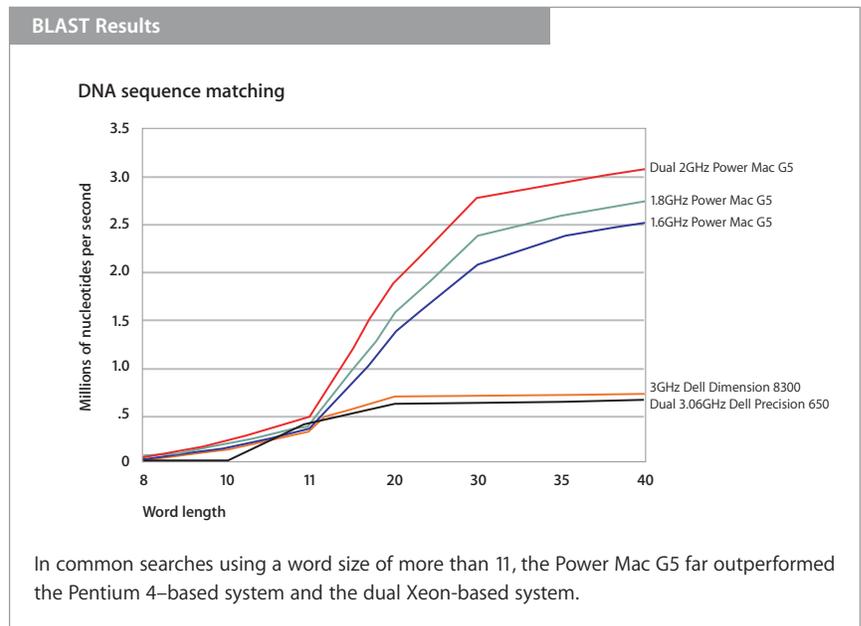
HMMer

HMMer is another application that demonstrates the performance advantages of the Power Mac 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—a critical task in areas such as speech recognition and protein and DNA sequence analysis. By representing the properties of a sequence family as a statistic, an HMM makes it possible to perform highly sensitive database searches.

Erik Lindahl of Stanford University has optimized the standard HMMer source code for the Velocity Engine. The core routines of HMMer repeatedly perform the same operation on large amounts of data. Utilizing single-instruction, multiple-data (SIMD) technology, the Velocity Engine enables the application to perform the same opera-tion on four pieces of data in a single clock cycle. With Lindahl's optimized code, the performance of a HMMer search is now seven to eleven times faster.

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. The Power Mac G5 used Mac OS X v10.2.7 (G5), and the Intel-based systems used Red Hat Linux 9.0.[2]

HMMer Results

Genome sequence matching

System		Result
Power Mac G5 Dual 2GHz PowerPC G5		6.9 times faster
Power Mac G5 1.8GHz PowerPC G5		4.8 times faster
Power Mac G5 1.6GHz PowerPC G5		4.2 times faster
Dell Precision 650 Dual 3.06GHz Xeon		1.7 times faster
Dell Dimension 8300 3GHz Pentium 4 with Linux		

0   3.5   7

Times faster than Pentium 4

The dual 2GHz Power Mac G5 performed the HMMer search nearly seven times faster than the 3GHz Pentium 4–based system and almost four times faster than the dual 3.06GHz Xeon-based workstation—clearly demonstrating the advantages of the Velocity Engine and symmetric multiprocessing.

The ATI Radeon 9800 Pro features the industry's first 8-pixel pipeline architecture and a superfast 256-bit memory interface—enabling superior 3D rendering, sophisticated real-time effects, and unsurpassed image quality. A 128MB frame buffer supports large textures in the latest games and design applications, delivering a truly cinematic visual experience.
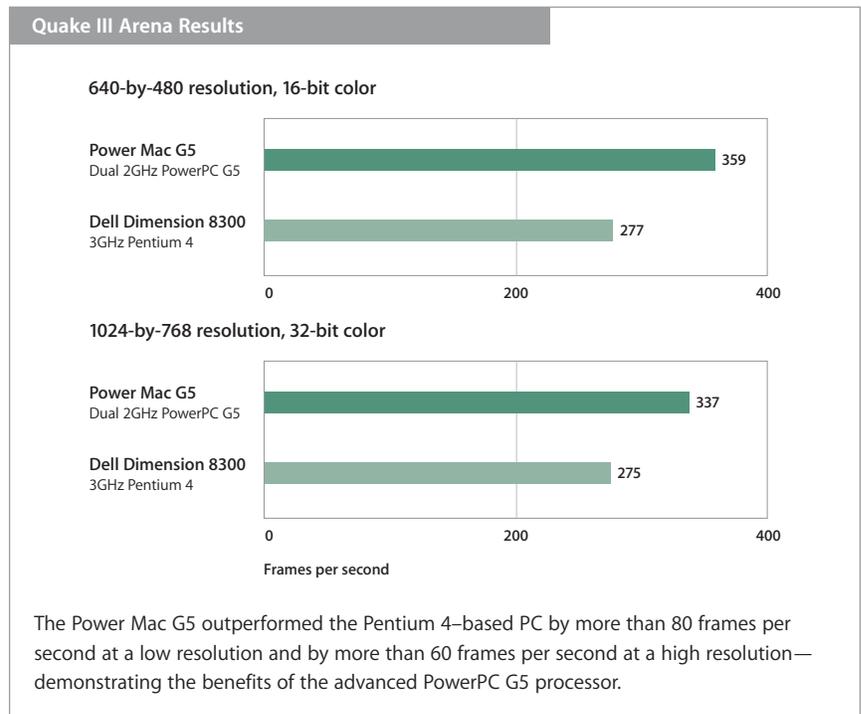
3D Gaming

3D gaming involves complex visualizations and rapid movements that require maximum processor performance and top-of-the-line graphics capabilities. The Power Mac G5 provides a robust platform that not only supports the latest in 3D technology, but also delivers a great gaming experience.

An avid gamer understands that every frame per second counts when trying to survive in the gaming arena. With the addition of the latest graphics interface, AGP 8X Pro, the Power Mac G5 doubles the maximum data transfer rate over AGP 4X, and the amount of data transferred in a single AGP bus cycle also doubles. This advanced AGP technology combines with the superfast PowerPC G5 processor to deliver more frames per second at higher resolutions and with improved complexity and texturing.

Quake III Arena
Leading games such as iD's Quake III Arena bring the benefits of the Power Mac G5 to the forefront. The de facto industry standard for 3D game benchmarking, Quake III Arena stresses the system's processor and graphics card to provide a reliable representation of graphics performance.

Apple configured both the dual 2GHz Power Mac G5 and the 3GHz Dell Dimension 8300 with the same industry-leading graphics card, the ATI Radeon 9800 Pro. We tested Quake III Arena 1.32 at two resolutions to differentiate between demands on the processor and demands on the graphics card. At low screen resolutions (640 by 480 pixels), Quake performance is more dependent on processor power; at high resolutions (1024 by 768 pixels), it depends on the capabilities of both processor and graphics card. The test was conducted with all default settings using the Demo_4 benchmark.[2]

Quake III Arena Results

640-by-480 resolution, 16-bit color

	Frames per second
Power Mac G5 Dual 2GHz PowerPC G5	359
Dell Dimension 8300 3GHz Pentium 4	277

1024-by-768 resolution, 32-bit color

	Frames per second
Power Mac G5 Dual 2GHz PowerPC G5	337
Dell Dimension 8300 3GHz Pentium 4	275

The Power Mac G5 outperformed the Pentium 4–based PC by more than 80 frames per second at a low resolution and by more than 60 frames per second at a high resolution—demonstrating the benefits of the advanced PowerPC G5 processor.

Test Details

Adobe Photoshop filters
- Save as PSD
- Save as TIFF
- Save as GIF
- Levels
- Curves
- Color Balance
- Hue/Saturation
- Desaturate
- Replace Color
- Variations
- Fill Selection
- Stroke Selection
- Transform Scale
- Transform Rotate
- Calculations
- Image Size
- Canvas Size
- Rotate
- Flip Canvas Horizontal
- Flip Canvas Vertical
- Blur More
- Gaussian Blur
- Motion Blur
- Add Noise Uniform
- Despeckle
- Dust & Scratches
- Sharpen
- Sharpen Edges
- Unsharp Mask
- Find Edges
- High Pass
- Normal Blend
- Multiply Blend
- Screen Blend
- Darken Blend
- Lighten Blend
- Saturation Blend
- Make Path
- Make Selection (from Path)
- Fill Path
- Flatten Image
- RGB to Grayscale
- RGB to Indexed
- RGB to Lab
- RGB to CMYK

For More Information

For more information about the Power Mac G5, visit www.apple.com/powermac.