

Increasing productivity by selecting a multi-processor workstation

With the advent of multi-core processing, workstation users might be tempted to think that a single processor, multi-core workstation is sufficient. However, multiple processors—and thus more cores—can provide increased productivity in a variety of ways, and can provide better value over the life of the workstation.



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Introduction

Today's workstation vendors provide IT managers a choice of products, from low-cost entry-level to higher-performing and more capable mid- to high-end systems. Given the current availability of multi-core processors we might be tempted to select a workstation with a single processor socket and leave it at that. After all, within that single socket, there are really *two* or *four* processors, right? And that's two or four times the processing power we used to get in a personal workstation, right?

Yes, there are more processor cores available today in a single-socket workstation, and yes, they can give users more processing power.¹ However, advancements in processor performance easily extend into the dual-socket workstations by providing increased end-user productivity over single-socket workstations.

There are several ways to leverage additional processor cores in a personal workstation, and all of them can increase productivity by increasing the available problem-solving power. Additionally, today's operating systems use multiple cores to overlap many internal operations—improving the workstation's responsiveness and reducing frustration due to slow response times.

Today many professional applications employ a "divide and conquer" technique by splitting parts of the application up and spreading the parts across available processor cores. This technique reduces time-to-solution by reducing runtime for single, larger problems. Additionally, more processing elements enable overlapping segments of a workflow by running multiple copies of an application or multiple applications simultaneously. Lastly, some users leverage more processing cores to solve larger problems, improving precision of an analysis and reducing the number of iterations necessary for a quality design.

In this paper, we will examine the technology behind leveraging multi-core processors and provide some examples. In addition, we'll examine the business aspects of using a dual-socket workstation where previously a single-socket system might have been employed.

Using more processor cores

The single greatest difference between entry-level workstations and their higher-end brethren is an additional processor socket. The additional socket doubles the theoretical processing power—usually adding an additional two or four processor cores. In most cases, end users can tap into this additional performance—especially with newer operating environments and the development of more multi-core-aware applications—to enhance productivity.

There are three ways of leveraging additional processing cores: multi-tasking, multi-threading, and “mega-tasking.” We’ll examine each of these below, with the goal of showing the productivity increase an end user can experience by using a dual-socket workstation.

Multi-tasking

Successfully employing multiple processors to increase performance *always* involves splitting work up across the system’s processors, whether these pieces of work are *processes* (tasks) or *threads* (portions of a single task). The former is called multitasking (or multiprocessing²); the latter is called multithreading.

Multi-tasking is easily accomplished, since no modification of applications or user workflow is required. For example, multiple copies of a user’s application, or different stages of an application’s workflow, can be executing simultaneously—automatically increase the amount of compute work accomplished in a given elapsed time.

Figure 1. Overall system performance (throughput) can be increased with more processor cores.

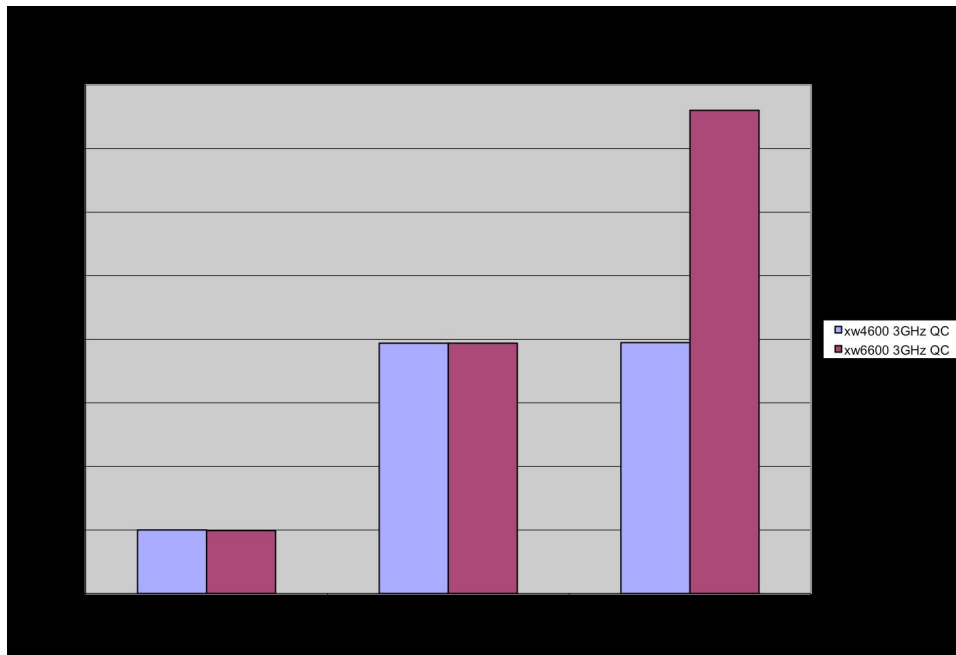


Figure 1 illustrates the near-linear performance improvement obtained by a popular financial services industry benchmark, the SunGard Adaptiv Credit Risk (ACR) benchmark, when an additional processor socket (and four additional cores) is available. Per SunGard,³ “SunGard Adaptiv Credit Risk (ACR) provides a total, real-time credit risk solution for counterparty credit exposure aggregation,

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global limit management, credit risk analytics and collateral management." The ACR benchmark runs multiple copies of a series of applications, much like a typical workstation environment handling multiple tasks simultaneously.

Modern operating systems heavily employ multi-tasking, providing overlapped system services and improve end-user responsiveness. For example, network activity, routine file system maintenance tasks like virus checking or backups, and background printing can all be executing at the same time the user's core application is running unimpeded on its "own" processing core(s). Multi-tasking allows an operating system to respond more quickly to user requests, improving responsiveness and reducing frustration caused from sluggish response times.

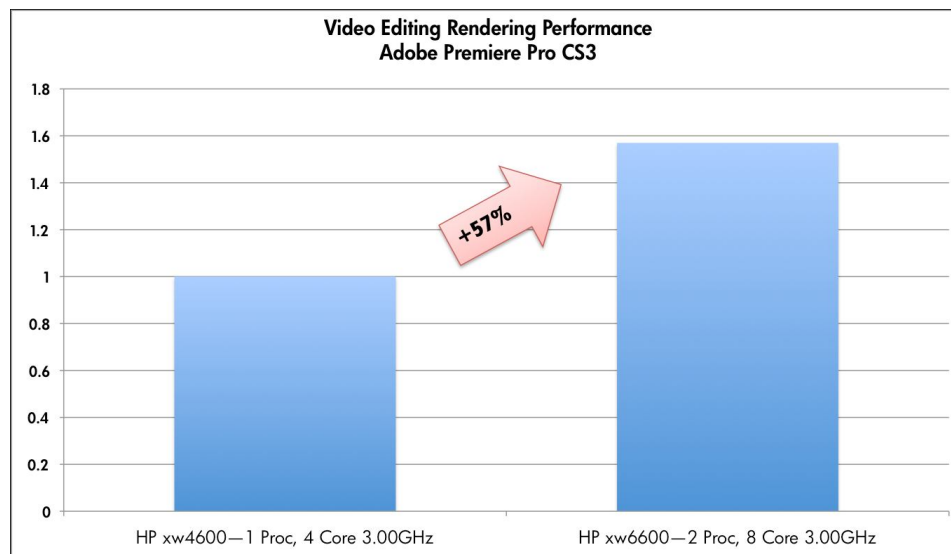
Multi-threading

Multi-threading is another method of increasing performance by employing all available processing cores to reduce the time-to-solution for a single application. Multithreading, also called parallelization, involves breaking the application into pieces and spreading the pieces over multiple processor cores

Multi-threading requires support from the application, and some applications have not been modified to take advantage multi-threading. However, as multi-core workstations and servers become more prevalent, software vendors are rapidly modifying their applications to utilize multiple cores. For example, key operations in many compute-intensive applications such as CAE and CAD have been multi-threaded to improve their performance.

Figure 2 illustrates increased performance of a rendering sequence using Adobe's Premiere Pro CS3 video editing application. Since rendering video sequences is a parallel operation frames can be rendered independently, and theoretically the application could use as many processors as are available (with a commensurate reduction in rendering times).

Figure 2. Performance of a single application can be accelerated by multithreading (parallelism).



In a similar fashion, much of video editing on workstations is compressed high-definition (HD) format. Such compressed formats requires decompression "on the fly" during any editing or timeline scrubbing of the video. The real-time decompression can be distributed across all of the available cores, improving response time and allowing real-time previews of edits. In an industry where time

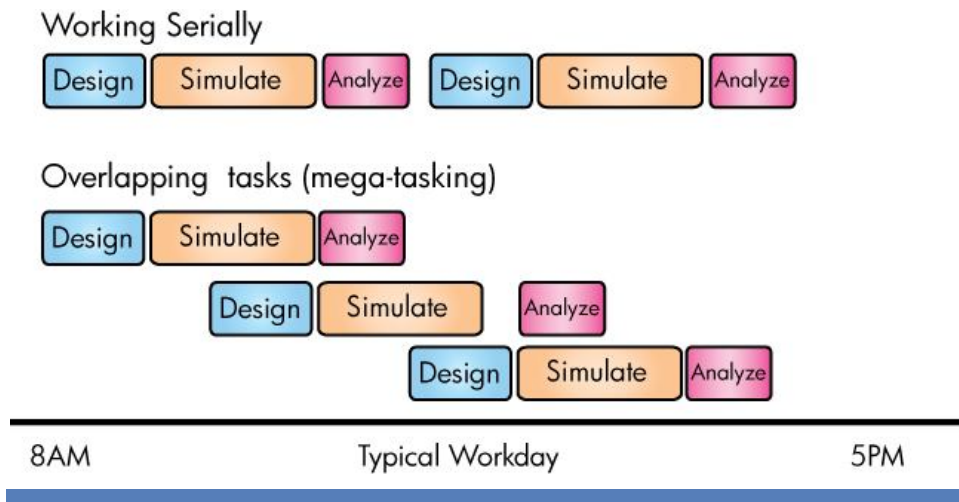
translates directly to money, the advantage of reducing rendering and editing time becomes immediately apparent.

Mega-tasking

Another way of increasing overall productivity is by utilizing the concept of “mega-tasking.” Mega-tasking is a term used to describe the parallelization of workflow segments. Unlike multi-tasking and multi-threading, mega-tasking involves modifying the way *users* work—as opposed to the workstation changing the way *it* works.

Mega-tasking involves breaking up the user’s workflow into smaller independent pieces and distributing these workflow segments across available processor cores. For example, in a typical serial CAE/CAD workflow, an engineer develops a design, performs some kind of simulation (structural analysis, fluid flow, etc.), and then observes the results (Figure 3). In many cases, the design and simulation parts of the workflow can be overlapped (assuming there is sufficient computing power available).

Figure 3. Mega-tasking—having multiple workflows in process simultaneously—can improve productivity.

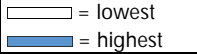






















































A workstation with two quad-core processors is an excellent platform for mega-tasking. In many cases, engineers may not have attempted this kind of “parallel processing,” since the compute power wasn’t available. An entry-level, single-socket system would probably not have sufficient computing capabilities to run several simulations at once; a more capable system is needed.

As shown in Figure 3, a designer can be much more productive and, in this case, more compute power enables the engineer to complete three work cycles compared to the time it previously took to complete two (a 50% gain in productivity).

How applications use more power

Now that we've discussed the productivity benefits behind using more processing cores, let's examine how more cores can be used for various application segments (see Table below). While we necessarily have to make some generalizations, the characteristics of applications within a particular segment are fairly similar in their use of increased processing power.⁴

Application segment	Characteristics	Applicable multi-core technologies			Overall benefits of more cores in this industry/application
		MT=Multi-tasking	MD=Multi-threaded	MG=Mega-tasking	
					
AEC entry CAD	Lower processing power; low price is key issue. An entry-level solution is ideal for those who do not have larger model requirements.				
AEC mid-market CAD	Mid-range workstations are a good fit for those users that require Mid-Market AEC solutions but are cost sensitive. Applications don't require high-end/extreme 3D graphics cards.				
AEC professional CAD	Applications benefit from dual processor capability, larger memory capacity, high-end and extreme 3D graphics				
CAD entry	Combines price sensitivity with the performance needed to run 2D and 3D entry level CAD. Applications and the user environment generally benefit from multiple cores.				
CAD mid-market	Low- and mid-range workstations fit well for those users that require mid-market CAD solutions but are price sensitive.				
CAD enterprise	Applications often require large memory capacity, high-end and extreme 3D graphics, and elaborate RAID solutions.				
DCC 2D animation/imaging	Users perform image manipulation and 2D animation. Applications are often multi-threaded.				
DCC 3D animation	Requires high-end or extreme 3D graphics cards, multiple cores, and large memory capacities.				
DCC digital video/NLE	Low- and mid-range workstations fit well for those users. NLE can generally take advantage of multiple processors in rendering and real-time compression/decompression.				
Financial services	Applications use many different applications. High throughput (many separate jobs) is important.				
Power office	Users perform complicated and data-intensive office functions, including graphics, video and web design, complex linked worksheet calculations, database storage/access and spreadsheet manipulations.				
Public sector	Includes such entities as government organizations (including the military), educational institutions, and some healthcare and other not-for-profit organizations. Low cost is important.				
Software development	Involves the manipulation of many files; many concurrent tasks can run at once.				

The HP Personal Workstation family

Hewlett-Packard is a leader in personal workstation design, manufacturing, and deployment. The HP family of personal workstations (Figure 4) provides an extremely broad product portfolio, offering end users a good fit of performance and functionality to a bottom-line budget.

Figure 4. The HP Workstation family.



While the HP xw4550 is a great system for light desktop use and for OEMs, for most users the HP xw4600 is the starting point for mainstream CAD, CAE, video editing, and AEC applications. Therefore, we will examine several of these systems in detail, and highlight some of the benefits of choosing an HP xw6600 or an HP xw8600 personal workstation as a productivity enhancement over the entry-level xw4600 system.

The HP xw4600 Personal Workstation—The HP xw4600 is a single processor-socket workstation based on the Intel® X38 Express performance chipset, and supports dual- and quad-core Intel® Core™ 2 Duo processors^{5,6,7} up to 3.16 GHz. It supports a dual PCIe “x16” graphics interface⁸ and supports up to 8 GB of memory.⁹

The HP xw6600 Personal Workstation—The HP xw6600 is a dual processor-socket workstation based on the Intel 5400 chipset, and supports one or two dual- and quad-core Intel® Xeon® processors^{5,6} up to 3.33 GHz. It supports a dual PCIe “x16” graphics interface⁸ and up to 32 GB of memory.

The HP xw8600 Personal Workstation—The HP xw8600 is a dual processor-socket workstation based on the Intel 5400 chipset, and supports one or two dual- and quad-core Intel Xeon processors^{5,6} up to 3.5 GHz. It supports up to two dual PCIe “x16” graphics interfaces⁸ and up to 128 GB of memory.

The case for a mid- or high-end workstation

As we have seen, in most situations—from Architectural Engineering to CAD to power office users—more processing cores provides performance benefits in one or more ways. We’ve also seen how the increased performance can translate into higher productivity for the engineer, designer, or artist sitting in front of his/her workstation. Follows is a case study illustrating a typical situation where selecting a dual-processor system ultimately benefits a corporation.

Let’s begin by comparing similar configurations of the entry-level HP Workstation, the xw4600, and the mid-range xw6600. Each has the same amount of memory, graphics card, and storage options; the configurations are as close to equal configurations as their architectures will allow, excepting the number of processors (Figure 5).¹⁰

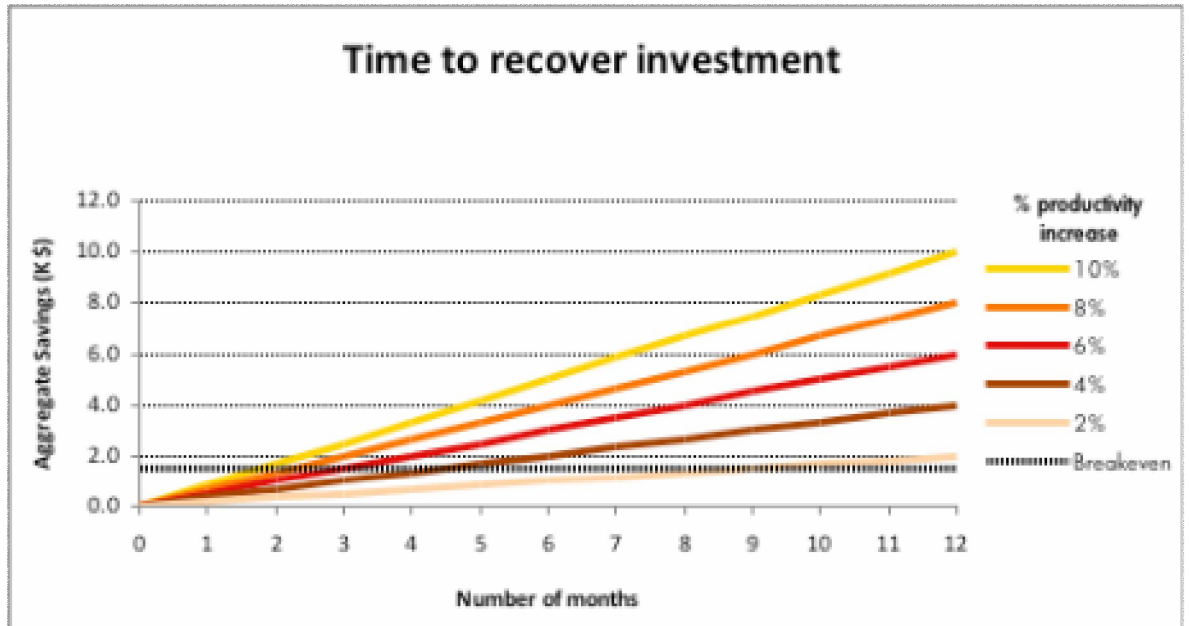
Figure 5. Comparably equipped entry-level and mid-range workstations and their list price.

HP Workstation xw4600 with (1) processor, (4) cores	HP Workstation xw6600 with (2) processors, (8) cores
<ul style="list-style-type: none"> • HP xw4600 Workstation • Genuine Windows Vista® Business 32-bit with downgrade to Windows XP Professional 32-bit custom installed* • 80 PLUS Energy Efficient Chassis • Intel® Core™ 2^{5,6,7} Quad Q9300¹¹ 2.50 GHz 6M/1333 CPU • NVIDIA Quadro NVS 290 256MB PCIe⁸ • HP 4 GB⁹(4 x1 GB) DDR2-800¹² ECC RAM (E-STAR=M) • HP 80 GB¹³ SATA 3Gb/s NCQ 7200 1st HDD • HP 16X/48X DVD-ROM SATA¹⁴ • No floppy disk option • No keyboard option • No mouse • Integrated High Definition audio • 3 years parts, labor and onsite service (3/3/3) standard warranty. Certain restrictions and exclusions apply. • \$1,526.00 	<ul style="list-style-type: none"> • HP xw6600 Workstation • Genuine Windows Vista® Business 32-bit with downgrade to Windows XP Professional 32-bit custom installed* • 650W 80 PLUS Energy Efficient Chassis • Intel® Xeon® E5420^{4,5,11} 2.50 GHz 12M/1333 QC 1st CPU • Intel® Xeon® E5420^{4,5,11} 2.50 GHz 12M/1333 QC 2nd CPU • NVIDIA Quadro NVS 290 256MB PCIe⁸ • HP 4 GB⁹ (2 x 2 GB) DDR2-667 ECC FBD RAM • HP 80 GB¹³ SATA 3Gb/s 7200 1st HDD • HP 16X/48X DVD-ROM SATA¹⁴ • No floppy disk option • No keyboard • No mouse • Integrated High Definition audio • 3 years parts, labor and onsite service (3/3/3) standard warranty. Certain restrictions and exclusions apply. • \$3,174.00

As shown in Figure 5, the difference in the list prices of the configuration is (\$3,174-\$1,526), or \$1,648, the incremental price difference of a 2-processor, 8-core system over a 1-processor, 4-core system.

Using that amount as an investment, and examining various conservative improvements in productivity for an engineer that costs an organization \$100,000/year produces a “time to recover investment” chart as shown in Figure 6.¹⁵

Figure 6. The time to recover the investment of an additional processor assuming different productivity increases.



Obviously, even a small improvement in productivity provides a positive return. Given the previous analysis of performance improvements caused by additional processing cores, even a 10 percent improvement might be conservative.

Summary

It should be clear that there is a productivity improvement when using more processor cores. The decision becomes "is the increased productivity worth the incremental price for stepping up to the next workstation level?" We contend that the answer is almost always yes, for a variety of reasons:

- The initial purchase price is can be negligible compared to the return on investment.
- The benefits of additional processing are for the lifecycle of the workstation; the acquisition costs are a one-time investment.
- The number of opportunities for leveraging a multi-processor system will only increase in coming years.

Most of these benefits come from the fact that the initial purchase price is often small compared to the return on investment (depending upon the productivity increases seen), and that the additional productivity benefits occur across the lifetime of the workstation.

Further, application developers continue to improve applications' ability to take advantage of multiple processing cores. As technology and techniques improve, more and more applications will be multi-threaded, making a dual-processor workstation a highly attractive alternative to a single-processor entry-level system.

End users and OEMs that are considering a workstation with the lowest possible acquisition cost should consider the total cost of ownership and improvements in end user productivity that are potentially available from dual-processor personal workstations.

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For more information

<http://www.hp.com/go/workstations>

The HP Workstations home page

Notes

*Certain Windows Vista product features require advanced or additional hardware. See www.microsoft.com/windowsvista/getready/hardwarereqs.aspx and www.microsoft.com/windowsvista/getready/capable.aspx for details. Windows Vista Upgrade Advisor can help you determine which features of Windows Vista will run on your computer. To download the tool, visit www.windowsvista.com/upgradeadvisor. Windows Vista Business disk also included for future upgrade if desired. To qualify for this downgrade an end user must be a business (including governmental or educational institutions) and is expected to order at least 25 customer systems with the same custom image.

¹ Benchmark performance determined by HP.

² The terms multitasking and multiprocessing are used synonymously in this paper.

³ See www.sungard.com.

⁴ Based on performance improvements of popular applications in their respective market segment. Actual benefits may vary.

⁵ Quad-Core and Dual-Core are designed to improve performance of multithreaded software products and hardware-aware multitasking operating systems and may require appropriate operating system software for full benefits; check with software provider to determine suitability; Not all customers or software applications will necessarily benefit from use of these technologies.

⁶ 64-bit computing on Intel architecture requires a computer system with a processor, chipset, BIOS, operating system, device drivers and applications enabled for Intel® 64 architecture. Processors will not operate (including 32-bit operation) without an Intel 64 architecture-enabled BIOS. Performance will vary depending on your hardware and software configurations. See www.intel.com/info/em64t for more information

⁷ This workstation does not support the Intel Core 2 Extreme processor over-clocking feature.

⁸ I/O card must also be Gen2 in order to realize PCI Express® Base 2.0 Specification (also known as PCIe Gen2) graphics performance.

⁹ Maximum memory capacities assume 64-bit operating systems. Microsoft® Windows® XP (32-bit) supports 4 GB (with Microsoft 32-bit, the amount of usable memory will be dependent upon your system configuration. It may be less than 4 GB); 32-bit Linux can support up to 8 GB.

¹⁰ List prices and configuration information taken from HP configuration tool at www.hp.com in September 2008. Some changes made for formatting.

¹¹ Intel's numbering is not a measurement of higher performance.

¹² Dual Channel is only supported when the system is configured with DDR2 symmetric memory (i.e. 2 x 256).

¹³ 1 GB=1 billion bytes. Actual formatted capacity is less. Up to 8 GB of hard drive (or system disk) is reserved for the system recovery software (XP and XP Pro). Up to 12 GB of system disk is reserved for system recovery software. (Vista).

¹⁴ Actual speeds may vary. Does not permit copying of commercially available DVD movies or other copy-right protected materials. Intended for creation and storage of your original material and other lawful uses.

¹⁵ Productivity improvements are based on performance increases of popular applications in their respective market segment. Actual productivity improvements may vary.

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