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.

HP recommends Windows® 7.

Contents

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[1] 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, four or six processors, right? And that's two to six 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. 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, current 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. 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, four or six 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 multi-tasking (or multi-processing); the latter is called multi-threading.

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.

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. Multi-threading, 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.

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To display the value of adding a sufficient number of processor cores to the workstation, we configured an HP Z400 and HP Z600 identically, with the single exception that the HP Z600 has an additional processor running at the same frequency as the processor in the HP Z400. Performance was then measured across several applications spanning the CAD/CAE, finance, and digital media and entertainment (DME) market segments. The following three charts show the results. Each chart shows the average performance gain, along with the amount of daily time savings experienced by the user.

FIGURE 1

MCAE performance*

Ansys

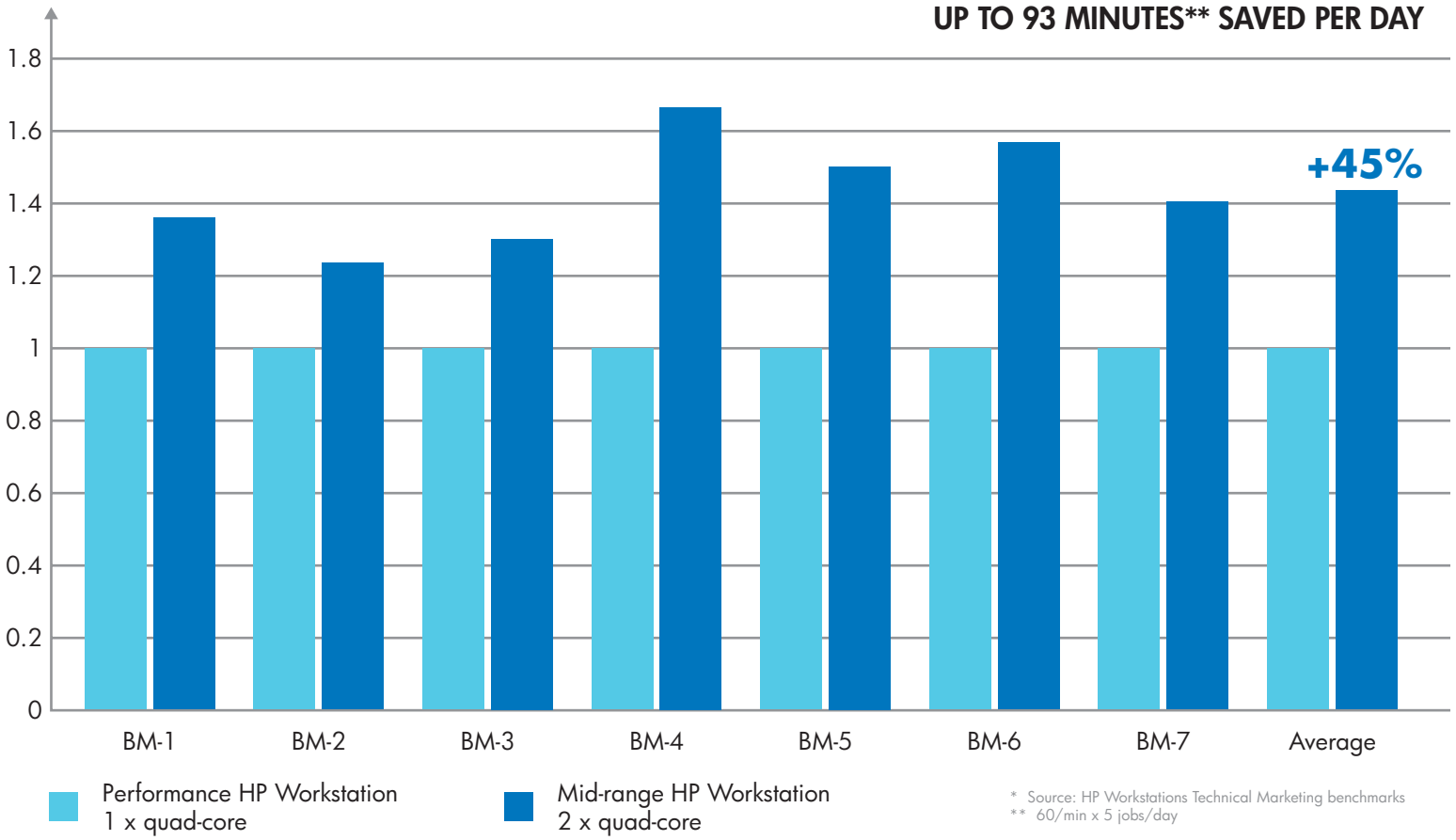


Figure 1 illustrates a Mechanical Computer Aided Engineering (MCAE) application—Ansys. Doubling the number of processor cores—moving from a single-processor HP Z400 to a dual-processor HP Z600—results in a productivity increase of 45%.

FIGURE 2

Financial Services performance*

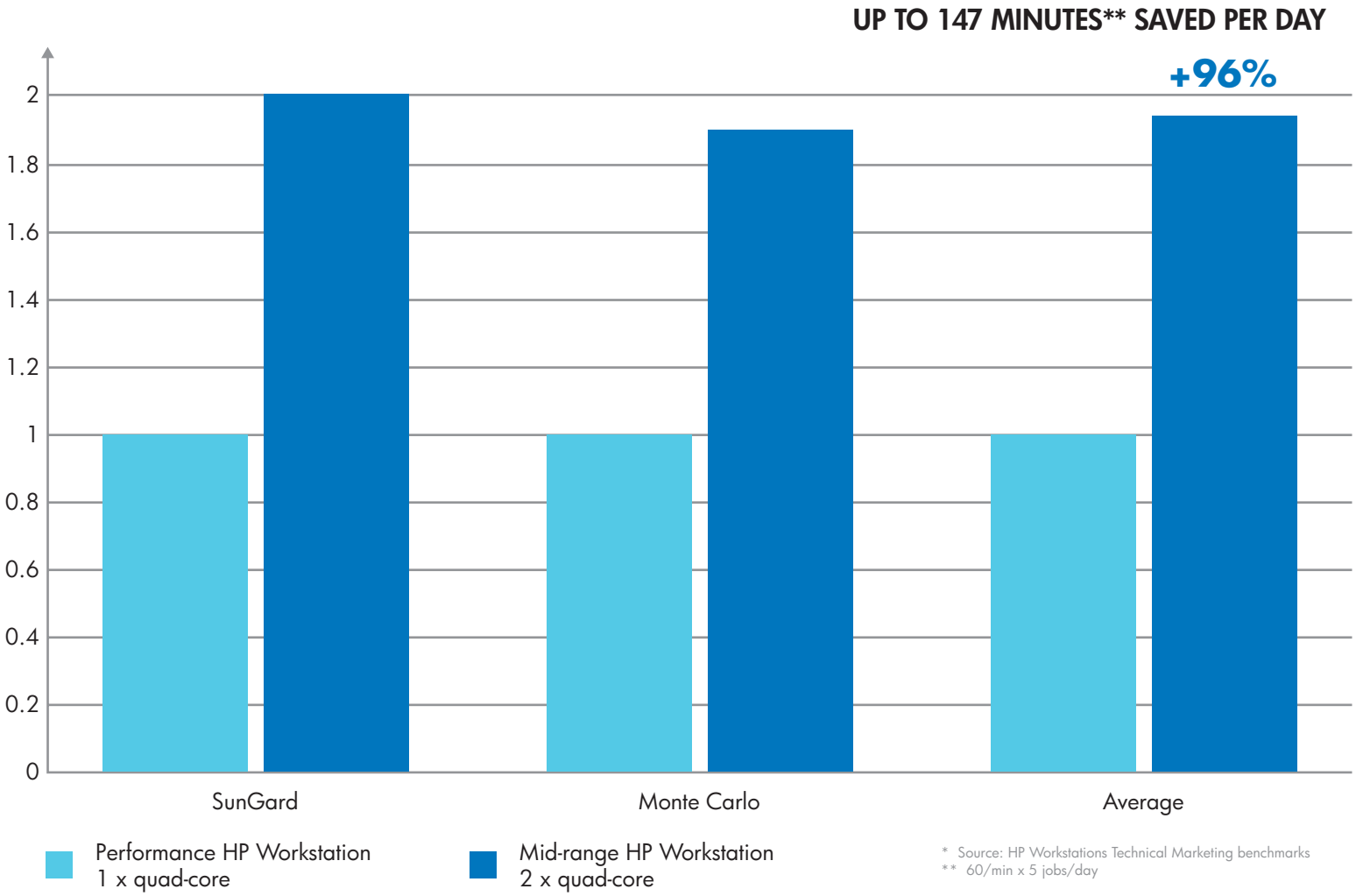


Figure 2 illustrates two financial modeling/analysis workflows, which are highly efficient at utilizing available processor cores. Doubling the number of processor cores—moving from a single-processor HP Z400 to a dual-processor HP Z600—results in a productivity increase of 96%.

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.

FIGURE 3

DME performance*

3D animation and video editing

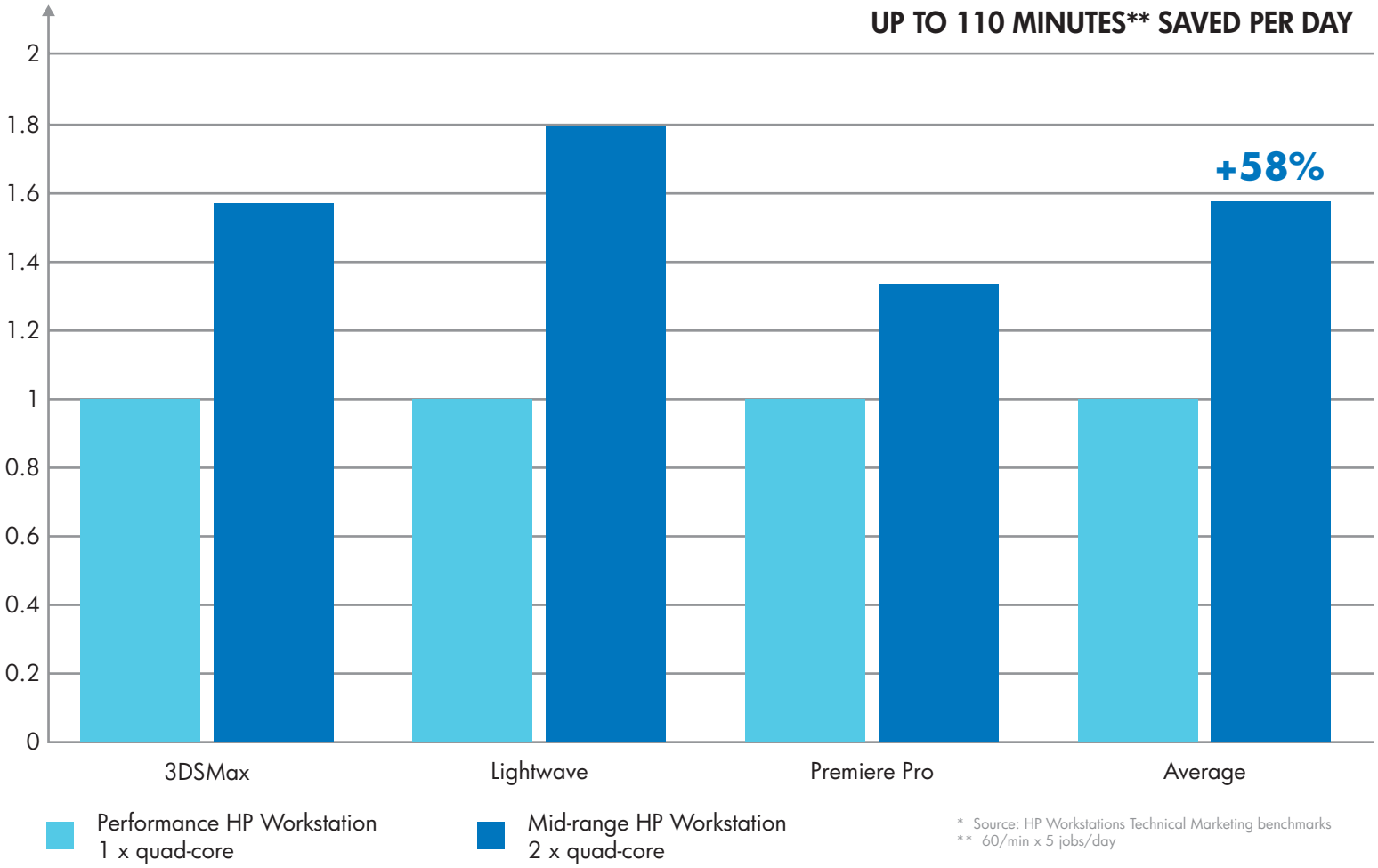


Figure 3 illustrates the increased performance of several digital media applications. Since rendering is a parallel operation, frames can be rendered independently, and theoretically the application could use as many processors as are available (with a commensurate reduction in rendering times). Doubling the number of processor cores—moving from a single-processor HP Z400 to a dual-processor HP Z600—results in a productivity increase of 58%.

Mega-tasking

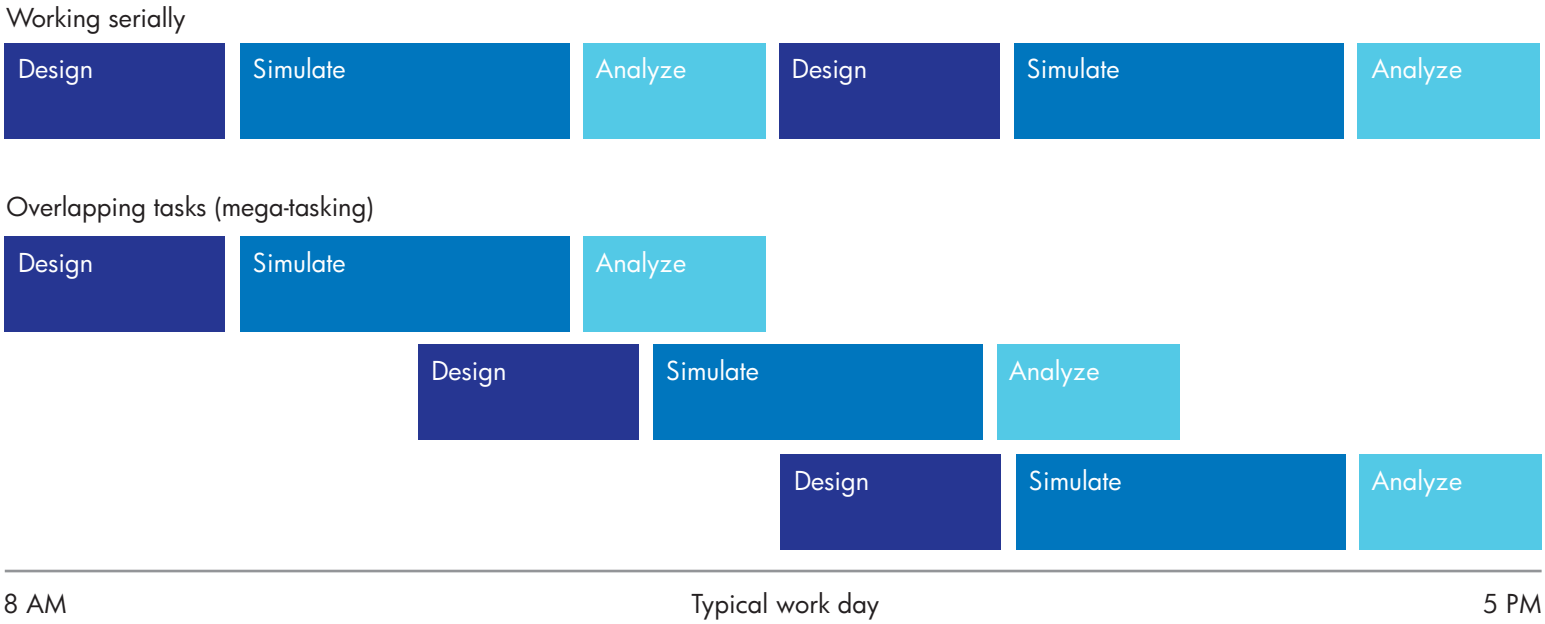
Another way of increasing overall productivity is by utilizing the concept of "mega-tasking." Mega-tasking is a term used to describe the parallelization of workflow segments. Unlike multi-tasking and multi-threading, mega-tasking involves modifying the way users work—as opposed to the workstation changing 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 4). In many cases, the design and simulation parts of the workflow can be overlapped (assuming there is sufficient computing power available).

FIGURE 4

Mega-tasking

Multiple workflows in process simultaneously can improve productivity

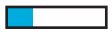
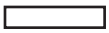
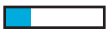
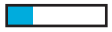
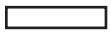


A workstation with two quad- or six-core processors is an excellent platform for mega-tasking. In many cases, engineers may not have attempted this kind of "parallel processing," since the compute power wasn't available. An entry-level, single-socket system would probably not have sufficient computing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

As shown in Figure 4, 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.

		Applicable multi-core technologies MT = Multi-tasking MD = Multi-threading MG = Mega-tasking			**Overall benefits of more cores in this industry/ application**
Application segment	**Characteristics**	**MT**	**MD**	**MG**	**Lowest / Highest**
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, and 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 users who 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.				
DME 2D animation/ imaging	Users perform image manipulation and 2D animation. Applications are often multi-threaded.				
DME 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 these users. NLE can generally take advantage of multiple processors in rendering and real-time compression/ decompression.				
Financial services	Traders 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 Workstation family

For over 25 years, scientists, engineers, designers, financial analysts, and artists have used HP Workstations to improve their efficiency of work and the quality of products they create. They count on HP developers to employ first-to-market advances in processors, packaging, graphics, and I/O subsystems to create platforms that improve their competitiveness in the industry. HP Z Workstations (Figure 5) provide an extremely broad product portfolio, offering end users a completely revamped system architecture that provides greater power, reliability, and serviceability for users in all workstation industries.

FIGURE 5

The HP Workstation family

HP Z800—The ultimate in power and expandability
Streamlined chassis 35% smaller than competitive products

- Genuine Windows® 7 Ultimate or other editions available
- Intel® Xeon® Processor 5600 Series[2,3]
- Storage up to 10 TB[4]
- Graphics up to 8 displays or dual NVIDIA Quadro 6000

HP Z600—Massive performance in a small footprint
Sleek tool-less chassis with integrated handles and visually cable-less design

- Genuine Windows® 7 Ultimate or other editions available
- Intel® Xeon® Processor 5600 Series[2,3]
- Storage up to 6 TB[4]
- Graphics up to 8 displays or dual NVIDIA Quadro 2000 or AMD FirePro V5900

HP Z400—Breakthrough price and performance
Redefines the power users expect from a PC

- Genuine Windows® 7 Ultimate or other editions available
- Intel® Xeon® Processor 3500 and 3600 Series[2,3]
- Storage up to 8 TB[4]
- Graphics up to 8 displays or dual NVIDIA Quadro 2000 or AMD FirePro V5900

HP Z210 CMT—Low-cost, high-performance mainstream entry workstation
Workstation-class productivity on a PC budget

- Genuine Windows® 7 Ultimate or other editions available
- 2nd Generation Intel® Core™ i3, i5, and i7 Processors and Intel® Xeon® Processor E3 Series[2,3]
- Storage up to 4.5 TB[4]
- Graphics up to NVIDIA Quadro 2000 or AMD FirePro V5900

HP Z210 SFF—Small size, great value, and rock-solid application performance
65% smaller than the HP Z200 convertible mini-tower

- Genuine Windows® 7 Ultimate or other editions available
- 2nd Generation Intel® Core™ i3, i5, and i7 Processors and Intel® Xeon® Processor E3 Series[2,3]
- Storage up to 2 TB[4]
- Graphics up to NVIDIA Quadro FX 380 LP or ATI FirePro V3800

The HP Workstation family continued

The HP Z210s are great systems for light desktop use and OEMs while the HP Z400 is the starting point workstation for mainstream CAD, CAE, video editing, and AEC applications. We will examine these systems in detail, and highlight some of the benefits of choosing an HP Z600 Workstation as a productivity enhancement over the entry-level HP Z400 Workstation.

- **The HP Z210 Workstations**—The new HP Z210 Convertible Minitower (CMT) and Small Form Factor (SFF) Workstations are single processor-socket workstations that feature Genuine Windows® 7 Ultimate or other editions available and the next generation Intel® Xeon® Processor E3-1200 Family including the high performance 3.5GHz Intel® Xeon® E3-1280, or 2nd generation Intel® Core™ i3/i5/i7 processors.[1,2] They support the new Intel® HD Graphics P3000/2000 and 2D and 3D professional graphics options from NVIDIA and AMD interfaces, and up to 16 GB ECC memory.
- **The HP Z400 Workstation**—This single processor-socket workstation features Genuine Windows® 7 Ultimate or other editions available, and is based on the Intel® X58 Express performance chipset, and supports one dual-, quad- or six-core Intel® Xeon® up to 3.46 GHz[1,2]. It supports a dual PCIe x16 graphics interface and up to 24 GB of memory.
- **The HP Z600 Workstation**—This dual processor-socket workstation features Genuine Windows® 7 Ultimate or other editions available, and is based on the Intel® 5520 chipset, and supports two quad- or six-core Intel® Xeon® processors up to 3.06 GHz[1,2]. It supports a dual PCIe x16 graphics interface and up to 48 GB of memory.
- **The HP Z800 Workstation**—This dual processor-socket workstation features Genuine Windows® 7 Ultimate or other editions available, and is based on the Intel® 5520 chipset, and supports two quad- or six-core Intel® Xeon® processors up to 3.46 GHz[1,2]. It supports up to two dual PCIe x16 graphics interfaces and supports up to 192 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 working on a workstation. The following 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 Z400 Workstation with the mid-range HP Z600 Workstation. 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 6).

FIGURE 6

Workstation comparison

Entry-level and mid-range workstations comparably equipped and their list price.

HP Z400 Workstation with (1) processor, (4) cores	HP Z600 Workstation with (2) processors, (8) cores
• HP Z400 Workstation	• HP Z600 Workstation
• Genuine Windows® 7 Professional 64-bit[5]	• Genuine Windows® 7 Professional 64-bit[5]
• 475 W 85% efficient power supply	• 650 W 85% efficient power supply
• One quad-core Intel® Xeon® W3520 processor 2.66 GHz 8 MB/1066 Mhz[1,2,3]	• Two quad-core Intel® Xeon® E5640 processors 2.66 GHz 12 MB/1066 Mhz[1,2,3]
• NVIDIA Quadro FX 1800 768 MB	• NVIDIA Quadro FX 1800 768 MB
• HP 12 GB (6 x 2 GB) DDR3-1333 MHz ECC RAM[6]	• HP 12 GB (6 x 2 GB) DDR3-1333 MHz ECC 2-CPU RAM[6]
• HP 250 GB SATA 7200 1st HDD[4,7]	• HP 250 GB SATA 7200 1st HDD[4,7]
• HP 16X DVD +-RW/SuperMulti SATA[8]	• HP 16X DVD +-RW/SuperMulti SATA[8]
• No floppy disk option	• No floppy disk option
• HP PS/2 Standard Keyboard	• HP PS/2 Standard Keyboard
• HP PS/2 Optical Scroll Mouse	• HP PS/2 Optical Scroll Mouse
• 3 years parts, labor, and onsite service (3/3/3) standard warranty. Certain restrictions and exclusions apply.	• 3 years parts, labor, and onsite service (3/3/3) standard warranty. Certain restrictions and exclusions apply.
• $2,783.00	• $5,596.00

As shown in Figure 6, the incremental price difference of a two-processor, eight-core system over a one-processor, quad-core system is $2,813 ($5,596 - $2,783).

Pulling all this performance and investment information together, we arrive at the chart depicted in Figure 7 below, which shows the time necessary to recover the incremental investment in a dual-socket workstation. The horizontal red line represents the $2,813 incremental investment needed to move from an HP Z400 to an HP Z600 configured as shown in the previous section. This chart shows several lines representing varying increases in productivity. Recall that the performance charts previously shown depict performance increases of 45% to 96%; thus the numbers shown below are very conservative. As you can see, the investment is recovered in a very short period of time.

FIGURE 7

Time to recover investment

Additional processor assuming different productivity increase

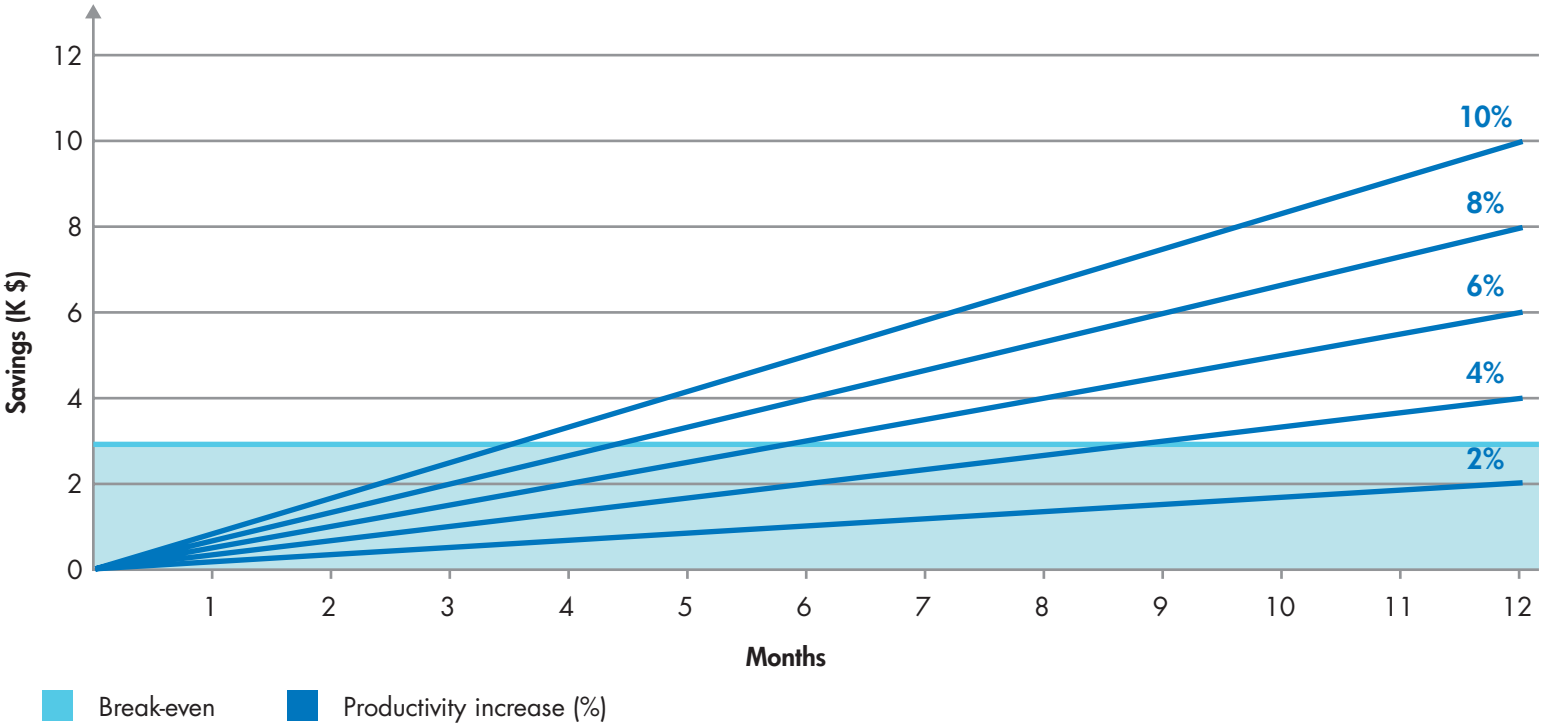


Figure 7 illustrates the time to recover the investment of an additional processor, assuming productivity increases from 2% to 10%.

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HP recommends Windows® 7.

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 can be negligible compared to the return on 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 workstation.

1 Dual-, quad- and six-core technologies are designed to improve performance of multi-threaded software products and hardware-aware multi-tasking operating systems and may require appropriate operating system software for full benefits. Not all customers or software applications will necessarily benefit from use of these technologies.

2 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.

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

4 For hard drives, 1 GB = 1 billion bytes. TB = 1 trillion bytes. Actual formatted capacity is less. Up to 8 GB of hard drive (or system disk) is reserved for the system recovery software for Windows XP and XP Pro, up to 12 GB for Windows Vista, and up to 20 GB for Windows 7.

5 Windows 7 systems may require upgraded and/or separately purchased hardware and/or a DVD drive to install the Windows software and take full advantage of Windows 7 functionality. See www.microsoft.com/windows/windows-7 for details.

6 Each processor supports up to 2 channels (HP Z210 CMT/HP Z210 SFF) or 3 channels (HP Z400/HP Z600/HP Z800) of DDR3 memory. To realize full performance at least 1 DIMM must be inserted into each channel. To get full 6 channel support, 2 processors MUST be installed.

7 SATA hardware RAID is not supported on Linux systems. The Linux kernel, with built-in software RAID, provides excellent functionality and performance. It is a good alternative to hardware-based RAID. Please visit http://h20000.www2.hp.com/bc/docs/support/SupportManual/c00060684/c00060684.pdf for RAID capabilities with Linux.

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

For more information, visit the HP Workstations home page at **http://www.hp.com/go/workstations**.

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