CSA Special Report

PC Performance Levels Required to Run the Next Generation of Desktop Operating Systems

Introduction – Why This Report?

As the release of Windows 2000 approaches, IT organizations everywhere are struggling to understand the impact that this next generation desktop operating system will have on their installed base of Personal Computers. In order for these organizations to effectively plan future PC purchases, they need to know today what the real world hardware requirements will be for a Windows desktop 18-24 months down the road. Only then can they make intelligent choices regarding new hardware platform selection and minimum processor performance levels.

In an effort to shed light on this decision making process, CSA performed comprehensive benchmark testing across a variety of current and projected future Windows PC environments. It was our intent to prove that, despite Moore's law (which stipulates that PC performance effectively doubles every 18-24 months), the pace of desktop operating system evolution will continue to outstrip gains in PC hardware performance gains both now and in the future.

Such is the natural evolution of PC software. As applications become larger and more feature-laden, the platform performance required to make them run effectively increases. In fact, application and operating system features and improvements have become so significant that today's state-of-the-art software solutions have outgrown PC hardware configurations that were cutting edge just 2-3 years ago.

In today's connected, managed PC environments, raw application performance has taken a back seat to less tangible, yet equally important, characteristics like the ability to maintain consistent foreground response time while concurrently juggling significant background processing loads. It is from this premise that we approached the development of this Special Report on PC Performance Levels

What We Found

After testing various Windows NT Workstation 4.0-based systems that were configured to simulate Windows 2000, one clear message emerged: Advances in operating system design are indeed taking a substantial toll on foreground application throughput.

The magnitude of this phenomenon is most easily understood within the context of currently available PC configuration. Based on our projections a 450MHz Pentium II system, while speedy by today's standards, will be reduced to the performance of an unloaded 300MHz system if and when a more advanced OS and application suite (like Windows 2000 Professional) is deployed. Likewise, a 300MHz system that is considered adequate today will become only marginally usable within 12-18 months (the current projected timeframe for Windows 2000's release to manufacture).

This, in turn, translates into a less responsive user experience as applications compete with the OS for CPU time. The best solution is to continue to "buy high" on the processor performance scale in an effort to compensate for the demands placed on PCs by these next generation OS architectures. That means choosing performance systems whenever possible and resisting the lure of bargain basement models that incorporate last year's technology.

While it is true that low cost platforms meet many of today's immediate performance needs, the rapid pace of OS evolution will ultimately overtake these systems long before they can be fully depreciated. In the end, they fail to deliver the kind of long-term investment protection that today's enterprise customers demand – an equation that IT organizations can no longer afford to follow.

Conclusions

The performance of today's low-to-mid range PCs will be substantially reduced by the demands of a next generation Windows operating environment. This puts the IT planner in the unenviable position of having to choose between saving dollars today by purchasing mid-range hardware or buying high in the expectation that the price delta will translate into a longer life span.

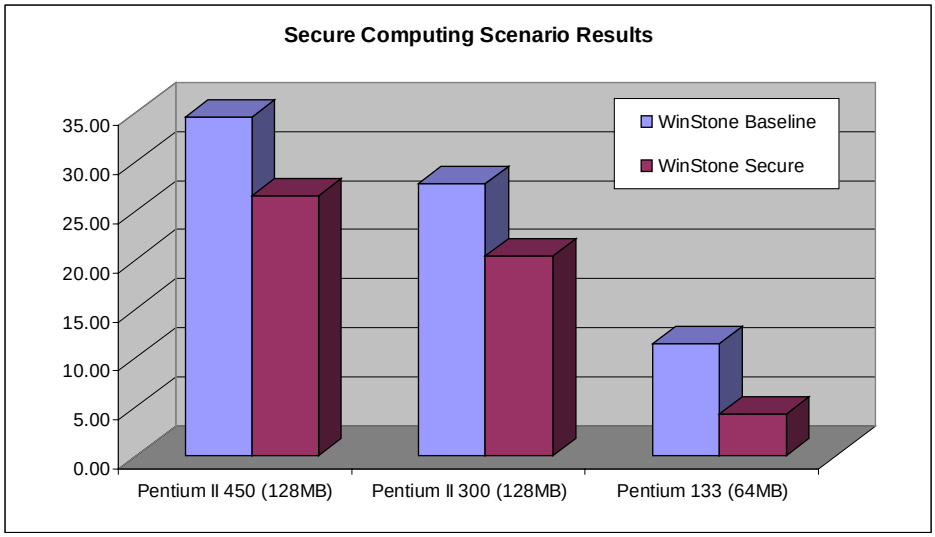

Figure 1.1 – Baseline vs. Loaded Performance (Scenario 1)

In many ways it is the classic PC performance sales argument, only instead of investing in speed for speed's sake, customers are being forced to seek out higher powered systems in order to realize their goal of creating a more intelligent, more manageable, more productive PC environment. Complexity breeds overhead, so customers that wish to get the most out of tomorrow's operating system advances need to continue to invest in the fastest, most capable PCs their budgets will allow.

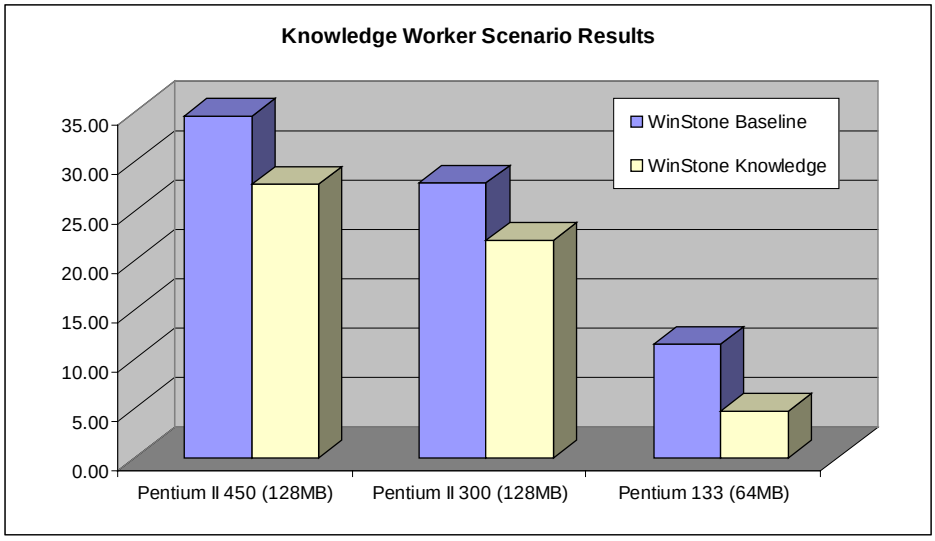

Figure 1.2 – Baseline vs. Loaded Performance (Scenario 2)

The preceding chart shows the significant performance impact that just a few background services have on a set of typical mainstream PCs running Windows NT 4.0. Advanced features, like encrypted I/O, background file replication and sophisticated directory integration all take their respective bites out of the CPU apple. With the advent of Windows 2000 and its significantly expanded feature set, it is our belief that the trend identified in this report will continue into the foreseeable future.

Key takeaways:

- The current installed base of Pentium class platforms will suffer significant performance loss under a next generation OS environment.

- Today's mid-range performance PCs will suffer noticeable performance degradation when upgraded to a next generation OS such as Windows 2000.

- A top of the line performance PC will provide good performance now, and absorb the upgrade to future OS environments over the next few years.

Once again, the bottom line message is this: Customers who are planning for a Windows 2000 future should continue to "buy high" on the PC processor performance scale. Following such a purchasing strategy is the best way to hedge against the coming waves of "OS inflation."

Methodology – How We Tested

Our primary goal in preparing this report was to effectively quantify the impact of increased operating system-level complexity on foreground application performance. To achieve this goal, the CSA Labs test team conducted comprehensive benchmark testing across a series of Windows NT 4.0-based desktop systems of various processor levels (Pentium II/450MHz, Pentium II/300MHz and Pentium Classic/133MHz). The tests were run against both baseline and simulated production environments and involved the use of industry standard test scripts (WinStone 98) driving real-world Windows applications.

The obvious target of the underlying testing methodology was to simulate Windows 2000 Professional (previously Windows NT 5.0), the current heir apparent to Windows 9x and Windows NT 4.0 on desktops and laptops. Unfortunately, Windows 2000 was still only in its second beta phase when the tests were conducted. Rather than execute against a prerelease (and hence, not yet optimized) beta version, the team instead chose to employ a series of Windows NT Workstation 4.0 systems configured to simulate a typical Windows 2000 desktop.

Constructing such a simulation was a complex process that involved installing various Internet Explorer and Option Pack components and then configuring certain Windows NT Services tasks (for example, background file replication) to execute at specific intervals during the testing process. Wherever possible, the benchmark design team employed Windows NT 4.0 technologies that are available today and that are representative of the processes and components that will make up a typical post-Windows NT 4.0 environment.

The result is a first of its kind analysis of foreground application performance on a real world Windows NT configuration. Using results returned by WinStone 98 as it was run against various NT 4.0 usage scenarios, the benchmark team was able to accurately quantify the impact of increased OS-level complexity and CPU overhead on a suite of popular business productivity applications.

Baseline Definition

The first step in defining the overall testing methodology was to identify the target platforms and components. The team began with Windows NT Workstation 4.0, adding vendor-optimized device drivers for video, audio and disk I/O, and updating the core OS files with Service Pack 3. This served as the “Baseline” configuration against which benchmark results from other configurations would be measured.

Complete details of the configuration and parameters used can be found in Appendix A of this document. However, suffice to say that the team made every effort to ensure a clean, fully optimized Windows NT Workstation 4.0 environment. Outside of the aforementioned vendor-optimized drivers, only one 3rd party application was introduced to the Baseline configuration: Executive Software’s Diskeeper 3.0.

Diskeeper was introduced to allow for file system de-fragmentation. Unlike Windows 95/98, Windows NT 4.0 does not ship with a de-fragmentation utility. Since a manually activated version of Diskeeper will be included as part of the Windows 2000 product (the “defrag” utility and MMC snap-in – Source: Executive Software press release), it seemed logical to use the current generation Diskeeper product to perform this critical function. Note that, though Diskeeper was used to de-fragment the NTFS volume prior to each benchmark pass, the corresponding Diskeeper Service was configured for manual activation under the Baseline configuration. This ensured that the service would not generate any file system overhead during testing.

Common Components

Considerable thought went into the selection of common components for the various real world configurations against which the team would be running the benchmarks. To help establish a set of baseline parameters, the team installed and evaluated a copy of Windows NT 5.0 Beta 2, dissecting the operating system's default configuration service-by-service.

Examining the list of running processes revealed that, in addition to the components normally associated with the Windows NT Internet Explorer 4.0/5.0 shell integration, Beta 2 also incorporated portions of the Windows NT 4.0 Option Pack – specifically, the Microsoft Index Server component. This led the team to choose a configuration that included both Internet Explorer 4.01 with Active Desktop and a full installation of the Option Pack.

Other common components included Office 97 (with Service Pack 1), Outlook 98 (connected to an Exchange 5.5 server) and Diskeeper 3.0 (see notes on Baseline Definition) – all typical applications for a general purpose Windows NT desktop configuration.

Secure Computing Scenario

The Secure Computing Scenario test suite consisted of a locked-down Windows NT 4.0 desktop environment performing timed client/server file replication and Internet access through a Virtual Private Network (VPN). The goal was to simulate the operating system-level overhead associated with two key Windows 2000 technologies – IntelliMirror and File/Network encryption – and then to measure the impact of this overhead on a foreground benchmark suite (WinStone 98).

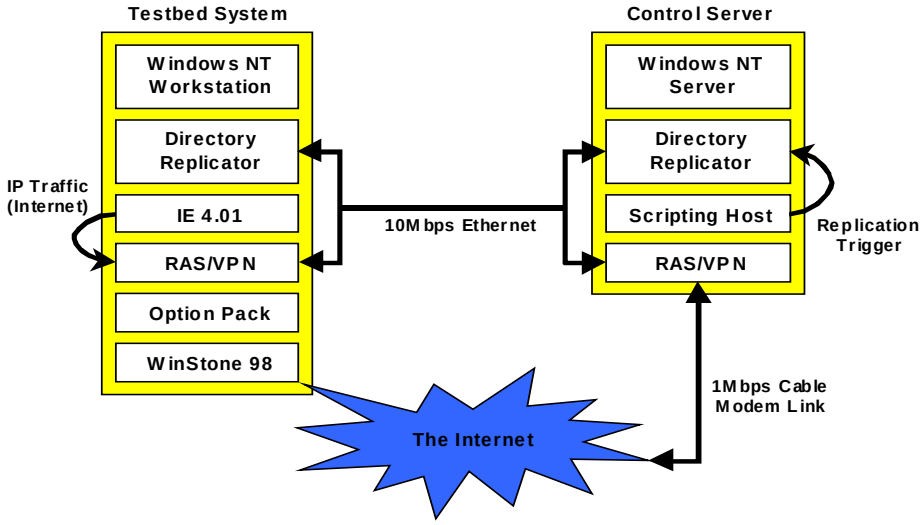

Figure 2.1 – Secure Computing Configuration Diagram

IntelliMirror proved to be particularly difficult to simulate given its unique architecture: Client-side persistent caching attached to a push/pull-through server connection with replication. The team's solution was to use the existing Windows NT 4.0 directory replication feature, employing a timed, server-side script to trigger server-to-client replication at regular intervals.

To observe the effects of encryption on Windows NT performance, the team configured a secure NTFS volume using a 3rd party utility – Sentry 2020 version 2.04 from Soft Winter Corporation. The Windows NT Workstation Directory Replicator service was then reconfigured to deliver the roughly 22MB of Windows CAB files from the server to a directory within the encrypted volume (to simulate accessing a server-based installation of an IntelliMirror/Microsoft Installer-driven replication).

Such an arrangement seemed logical given Microsoft's own statements regarding IntelliMirror security. In response to questions about unauthorized users browsing the contents of the IntelliMirror cache to obtain sensitive information, Microsoft advised members of the team that the solution was to encrypt the cache's contents using the new file system-level encryption feature. Again, the team made every effort to assess the real world application of future NT technologies using currently available components. Their choice of the Directory Replicator service was in line with this philosophy.

Finally, to simulate the overhead of network-level encryption, the team constructed a small VPN using the Microsoft Point-to-Point Tunneling Protocol (PPTP). An instance of Internet Explorer 4.01 was then launched and instructed (through scripting) to cycle through a selection of 10 commercial Web sites. Note: Though the test system in question had unencrypted LAN access to the Internet, the ROUTE METRIC value of the Remote Access Server (RAS) PPTP connection forced the system to communicate exclusively through the encrypted VPN pipe.

A working configuration that combined the above mentioned components and services was eventually agreed upon and subsequently incorporated into the testing process as the team's "Secure Computing" configuration. The suite proved particularly challenging to execute given the complexity of the overall architecture and the precise timing that an effective WinStone 98 benchmark run required. In the end, the team managed to stabilize the configuration, and the resulting test scores proved quite revealing.

Knowledge Worker Scenario

The Knowledge Worker Scenario test suite involved simulating the impact of file system indexing on foreground application performance. This simulation was deemed particularly relevant given Windows 2000's built in Content Indexing feature. All Windows 2000 systems index file and directory entries by default. The CPU overhead associated with this feature can be observed quite readily on lower-end PC hardware platforms. It's not uncommon for a supposedly "idle" Windows 2000 system to consume as much as 40% of the CPU's available cycles when the various instances of the "cidaemon" service are crawling through the file system in the background.

The actual indexing subsystem in Windows 2000 is based on the Index Server 2.0 engine that ships with the Windows NT 4.0 Option Pack. Here the team ran into what turned out to be an insurmountable obstacle: As of the release of Option Pack 4.0, Index Server is no longer available for Windows NT Workstation 4.0. Unlike its predecessor, Index Server 1.1, which was readily available for both Workstation and Server as part of Service Pack 3, Index Server 2.0 is only available as part of the Windows NT Server version of the Option Pack.

The team was unable to obtain a copy of Index Server 2.0 from Microsoft for test purposes, so they elected to look for an alternative indexing engine in order to complete the simulation. Not wanting to stray too far from Microsoft technology, the team ultimately decided on the Find Fast utility that ships with Microsoft Office 97. Using the Find Fast Control Panel, the team configured the indexing engine to seek out all files on the test volume, and also to index the file contents for speedier full text searches.

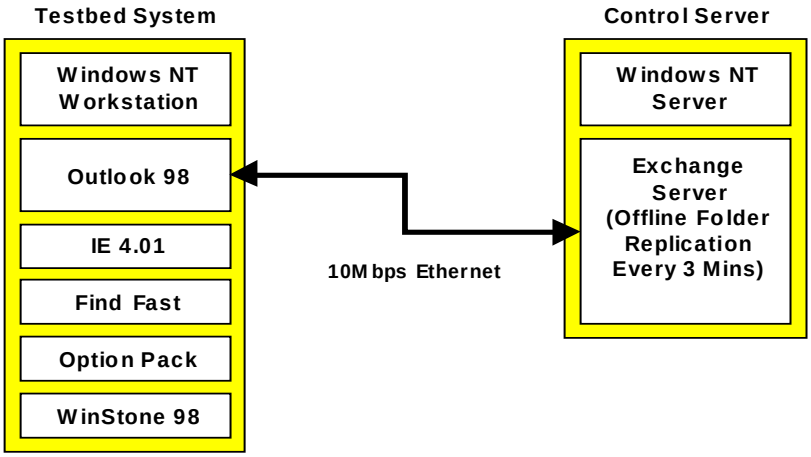

Figure 2.2 – Knowledge Worker Configuration Diagram

The other component of what was to eventually become the "Knowledge Worker" scenario involved simulating the impact of messaging application overhead. To that end, the team configured Microsoft Outlook 98 to work with a set of offline folders. They then programmed Outlook to re-synchronize the folder contents every 3 minutes, exercising the system's MAPI components in an effort to reproduce the kind of overhead that might be associated with a workflow application.

Taken together, these two components – content indexing via Find Fast and regularly schedule MAPI activity through the Microsoft Outlook 98 client – served as the background Knowledge Worker load against which the foreground WinStone 98 benchmark was executed.

A Note on Hardware

As was stated at the beginning of this section, one of the goals for this project was to evaluate the results of any tests within the context of current generation PC hardware. It's no secret that PC technology evolves at a breakneck pace. System configurations that were adequate just a few short years ago are now barely able to keep up with the demands of the latest operating systems and applications.

To explore this issue, the benchmark team recreated both Baseline and Real World test environments across multiple hardware platforms. The goal was to present each test result within the context of several different PC configurations. The configurations themselves were chosen based on representative parameters associated with common vendor offerings. For example, Pentium II/450MHz system was tested with 128MB of RAM – the most likely configuration to be purchased with that particular CPU. Likewise, a Pentium II/300MHz system was tested with 64MB and while the Pentium 133MHz system was tested with 32MB of RAM.

Though it was important to test against representative configurations, the benchmark team recognized the fact that RAM can also significantly affect application performance. So to further qualify the results, the team re-ran each benchmark scenario against a common 64MB RAM configuration and also against a common 128MB configuration for the Pentium II systems. Details on the exact hardware configurations used, including vendor information and how performance-related parameters were tuned, can be found in Appendix A of this document. A quick note of thanks is in order to Compaq Computer Corporation for providing the DeskPro EN Pentium II systems. Without their assistance this project would not have been possible.

Test Results

The first thing that jumps out from the results is the relative consistency of loading across the various platforms. For example, the percentage delta between WinStone 98 scores for the Baseline and Secure Computing configurations was 23% and 32% for the 128MB and 64MB Compaq Pentium II/450MHz configurations. Likewise, the delta for the 128MB and 64MB Compaq Pentium II/300MHz configurations was 27% and 36%, respectively.

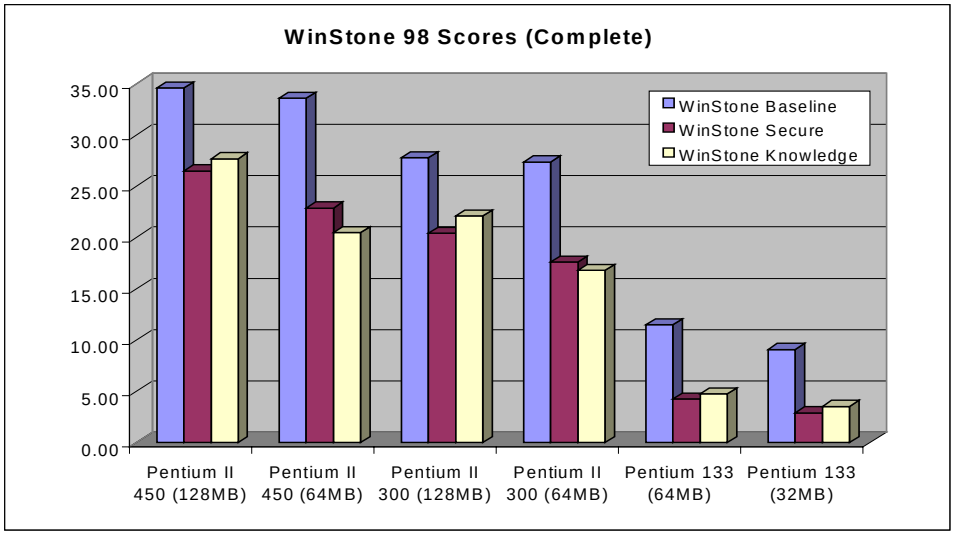

Figure 3.1 – Overall WinStone 98 Results

When factored against the original Baseline WinStone 98 scores, this means that a heavily loaded Pentium II/450MHz running the Secure Computing suite is about as fast as the Baseline Pentium II/300MHz system with no loading. Conversely, a Pentium II/300MHz system is reduced to the performance of a slower Pentium Pro/200MHz or even high-end Pentium Classic (based on comparative performance data provided with the WinStone 98 benchmark).

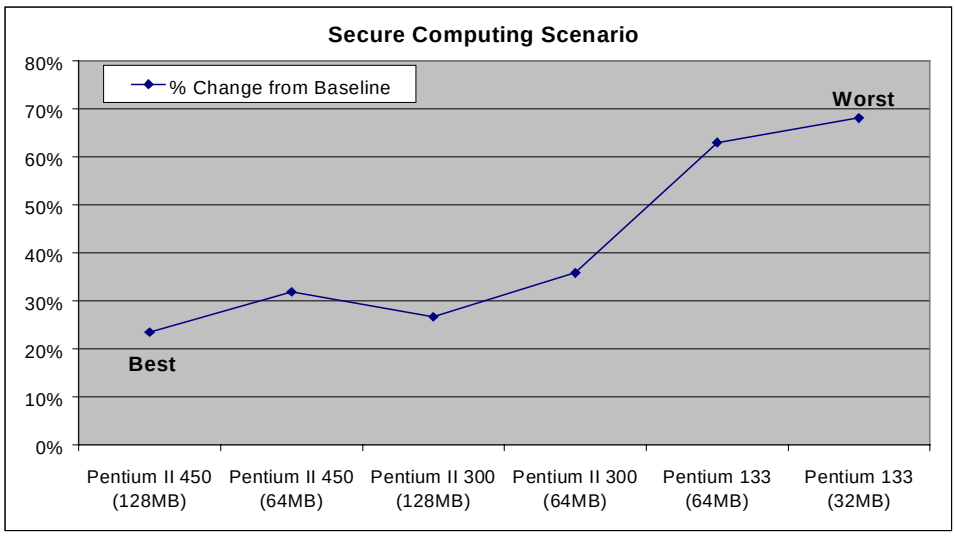

Figure 3.2 – Secure Computing Suite Results

One conclusion that was reached very early in testing was that the Pentium/133MHz configuration – a common desktop platform just 2-3 years ago –was completely overmatched by the usage scenarios being thrown at it. Getting the system to complete the benchmark tests at all was a struggle, especially in the 32MB representative configuration, and once they were running, the results were staggering: 60-70% performance losses across the board. Even allowing for a substantial margin of error, it seems clear that customers will need to invest in Pentium II-based systems in order to effectively support the rollout of any future Windows desktop environment.

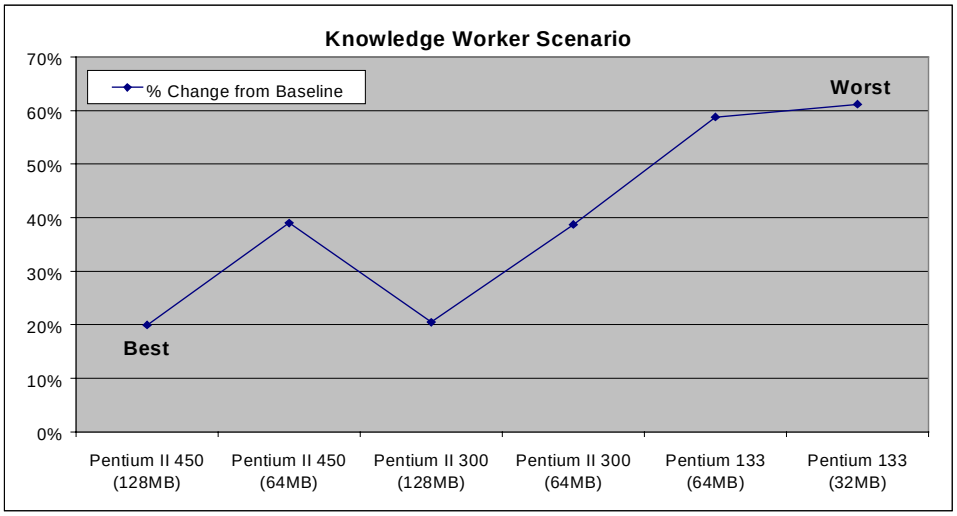

Figure 3.3 – Knowledge Worker Suite Results

The Knowledge Worker scenario seemed to confirm the trend identified in the Secure Computing scenario. Once again, the Pentium II/450MHz system took performance "hits" of 20% and 39% respectively for the 128MB and 64MB configurations. And again, the Pentium II/300MHz system followed suit with 21% and 39% losses.
Compared against their respective Baseline configurations, the Pentium II/450MHz with 128MB was once again on par with an unloaded Pentium II/300MHz, while the "representative" Pentium II/300MHz configuration with 64MB was reduced the performance of a mid to high-end Pentium Classic.

Interpretation

With Secure Computing and Knowledge Worker scores on par with a baseline Pentium II/300MHz system, the Pentium II/450MHz system is clearly the best choice for maintaining acceptable levels of foreground performance under load. This would also seem to confirm our original premise going into this report: That organizations will need to buy towards the top of the PC processor food chain in order to ensure continued viability under future operating system environments.

The Pentium II/300MHz system, in contrast, was reduced to a performance level comparable to a high-end Pentium Classic – adequate for mundane tasks but far from reassuring in light of growing end user application complexity. As for the Pentium Classic/133MHz, the preceding benchmark results should serve to shatter any remaining illusions about the ongoing viability of this processor platform. Bottom Line: While an organization may be able to squeak by with a low-end (300MHz) Pentium II under a more advanced OS (e.g. Windows 2000), they will most certainly need to replace their remaining Pentium Classic systems in lieu of an eventual operating system upgrade.

About CSA

Formed in March of 1995, Competitive Systems Analysis, Inc., is an Information Technology advisory, consulting and decision support organization focusing on the vendor community. Our list of current and past clients includes such notable IT leaders as IBM Corporation, Microsoft Corporation, Compaq Computer Corporation, Citrix Systems, Inc., Microcom Corporation, New Moon Software, Inc. and Executive Software, Inc.

If you have any questions about this document, the testing methodologies employed or CSA in general, please don't hesitate to drop us a line. We can be reached on the World Wide Web at the following URL: http://www.xpnet.com. There you will find additional contact options as well as an in-depth overview of our company, its mission and unique strengths.

Appendix A – Methodology in Depth

Baseline Scenario

Configuration Details:

1. Original Windows NT 4.0 Desktop
2. Service Pack 3 and all optimized drivers installed
3. Disk de-fragmented prior to testing

Step by Step:

a. WinStone 98 is loaded and Business WinStone suite runs uninterrupted to measure optimal system performance against a baseline software configuration

Secure Computing Scenario

Configuration Details:

1. Windows NT 4.0 Active Desktop (IE 4.01)
2. Service Pack 3 and all optimized drivers installed
3. Disk de-fragmented prior to testing

Step by Step:

a. Sentry 2020 is loaded and a 100MB encrypted volume is mounted and shared (for access via a PDC script)
b. A PPTP link is established to the PDC – Windows NT RAS revises the ROUTE METRIC value so that all Internet-bound traffic flows through the PPTP link
c. Internet Explorer scripted browsing commences – META HTTP "Refresh" tags cause Internet Explorer to cycle to one of ten different web page every 10 seconds
d. Windows NT Directory Replicator service is started with the encrypted volume defined as the target for incoming files (approx. 22MB)
e. Replication trigger script is started at PDC using the Windows NT 4.0 Task Scheduler service – script cycles every 3 minutes, deleting files in server's Directory Replicator export directory and the Testbed PC's import directory, then re-copying files to server export directory which, in turn, causes replication to resume
f. System Settle time – Testbed PC is left alone for 3-5 minutes to allow all background processes to engage and stabilize
g. WinStone 98 is loaded and Business WinStone suite runs uninterrupted to measure optimal system performance against a secure computing software configuration

Knowledge Worker Scenario

Configuration Details:

1. Windows NT 4.0 Active Desktop (IE 4.01)
2. Service Pack 3 and all optimized drivers installed
3. Disk de-fragmented prior to testing

Step by Step:

a. Outlook 98 loaded and configured to replicate contents of 100MB mailbox to offline folders – process cycles every 3 minutes – Outlook 98 minimized to reduce application's working set footprint
b. Office 97 FindFast utility initialized and instructed to create new indices for all files, all volumes – all indexing options enabled, including file contents
c. System Settle time – Testbed PC is left alone for 3-5 minutes to allow all background processes to engage and stabilize
d. WinStone 98 is loaded and Business WinStone suite runs uninterrupted to measure optimal system performance against a knowledge worker software configuration

Appendix B – Configuration in Depth

Baseline Software Configuration

Operating System: Windows NT Workstation 4.0 (Service Pack 3)

Device Drivers:
Esstech Audio Drivers v2.00.82
ATI Rage Pro Turbo Drivers v5.1.118
Compaq Bus Mastering ATAPI Drivers v.2.21.1

Other MS Software Installed: None

3rd Party Software Installed:
Executive Software Diskeeper 3.0
Ziff-Davis Benchmark Operations WinStone 98

Configuration Details:
1. All Disk Volumes NTFS
2. Diskeeper 3.0 Service configured to Manual startup
3. WinStone 98 configured to run from hard disk

Simulation Software Configuration

Operating System: Windows NT Workstation 4.0 (Service Pack 3)

Device Drivers:
Esstech Audio Drivers v2.00.82
ATI Rage Pro Turbo Drivers v5.1.118
Compaq Bus Mastering ATAPI Drivers v.2.21.1

Other MS Software Installed:
Microsoft Office 97 (Service Release 1)
Microsoft Outlook 98
Microsoft Internet Explorer 4.01 (Service Pack 1)
Microsoft Windows NT Option Pack 4.0

3rd Party Software Installed:
Executive Software Diskeeper 3.0
Ziff-Davis Benchmark Operations WinStone 98
Soft Winter Corp. Sentry 2020 v2.04

Configuration Details:
1. All Disk Volumes NTFS
2. Diskeeper 3.0 Service configured to Automatic startup
3. WinStone 98 configured to run from hard disk
4. IE 4.01 shell integration and Active Desktop enabled
5. Sentry 2020 Configured with 100MB encrypted volume
6. Option Pack 4.0 PWS, FTP and IIS Admin services loaded

Hardware Configuration #1

System/CPU:	Compaq DeskPro EN Pentium II running at 450MHz (100MHz FSB)
RAM:	128MB PC100 RAM – two 64MB modules (64MB, single module configuration also tested)
Disk:	IBM DTTA-351010 10GB UltraDMA/33 EIDE Hard Disk
Video:	ATI Rage Pro Turbo-based AGP display adapter (8MB)
Network:	Compaq Fast Ethernet NIC NC3121 10baseT Adapter
Configuration Details:	1. Three Configured Disk Volumes – Baseline, Simulation and dedicated VMM (for Windows NT paging file) 2. Video resolution set to 1024x768 at 65K colors 3. DMA Bus Mastering Enabled for UltraDMA/33 disk

Hardware Configuration #2

System/CPU:	Compaq DeskPro EN Pentium II running at 300MHz (66MHz FSB)
RAM:	64MB SDRAM – one 64MB module
Disk:	WD Caviar AC36400 6GB UltraDMA/33 EIDE Hard Disk
Video:	ATI Rage Pro Turbo-based AGP display adapter (8MB)
Network:	Compaq Fast Ethernet NIC NC3121 10baseT Adapter
Configuration Details:	1. Three Configured Disk Volumes – Baseline, Simulation and dedicated VMM (for Windows NT paging file) 2. Video resolution set to 1024x768 at 65K colors 3. DMA Bus Mastering Enabled for UltraDMA/33 disk

Hardware Configuration #3

System/CPU:	Micron Millennia Pentium running at 133MHz w/512KB L2 Cache
RAM:	32MB Page Mode RAM – two 16MB SIMMs (64MB, two module EDO configuration also tested)
Disk:	Quantum Fireball 1080 1GB EIDE Hard Disk
Video:	Diamond Stealth 3D 2000 display adapter (2MB)
Network:	3Com EtherLink III ISA 10-baseT Ethernet Adapter
Configuration Details:	1. One configured disk volume 2. Video resolution set to 1024x768 at 65K colors 3. SP3 ATAPI DMA mode enabled via DMACHECK utility

CSA Labs Primary Domain Controller

System/CPU:	Micron Millennia Pro Pentium Pro at 200MHz (256KB L2 Cache)
RAM:	128MB EDO RAM – four 32MB SIMMs
Disk:	Western Digital Caviar 2100 2.1GB EIDE Hard Disk
Video:	Diamond Stealth 3D 2000 display adapter (2MB)
Network:	SMC Elite PCI 10BaseT Ethernet Adapter
Configuration Details:	1. Microsoft Windows NT Server 4.0 (Service Pack 3) 2. Microsoft Exchange Server 5.5 (Service Pack 1) 3. Microsoft Option Pack 4.0

CSA Labs Network Infrastructure

LAN Topology:	10Base-T (10Mbps)
Hubs/Routers:	3Com Office Connect 8 Port Hub
WAN Gateway:	1Mbps link to Internet via COM21 cable modem
Configuration Details:	1. WINS/DHCP handled by PDC 2. DNS serviced by ISP 3. No firewall or proxy server

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