

## Effects of Multi-Threading on Response Time in Microsoft Office Communicator 2005 Scenarios

Analyzing the Responsiveness Benefits of the Intel® Pentium® D Processor (with Dual-Core Processing) and the Intel® Pentium® 4 Processor Supporting Hyper-Threading Technology

### For Intel Corporation

### Executive summary

Intel Corporation commissioned Principled Technologies to compare the performance of collaborative multitasking scenarios using Microsoft® Office Communicator 2005 on desktop platforms with either the Intel® Pentium® D processor (with dual-core processing) or the Intel Pentium 4 Processor with HT Technology (Hyper-Threading Technology†) against a roughly three-year-old Pentium 4 processor-based desktop platform. We tested system performance using common enterprise scenarios involving real-time communication and collaboration with Microsoft Office Communicator 2005 and other common office applications on three different Intel processor/platform combinations:

- New Intel 2005 High Performance Platform: Intel Pentium D Processor 840 (3.2-GHz dual-core processor) on the Intel D955XBK desktop board (with the Intel 955X Express chipset)
- New Intel 2005 Professional Business Platform with HT Technology: Intel Pentium 4 Processor 640 (3.2 GHz with HT Technology) on the Intel D945GTP desktop board (with the Intel 945G Express chipset)
- A roughly three-year-old platform: Intel Pentium 4 Processor 2.0 GHz on the Intel D845GVFN desktop board (with the Intel 845G chipset)

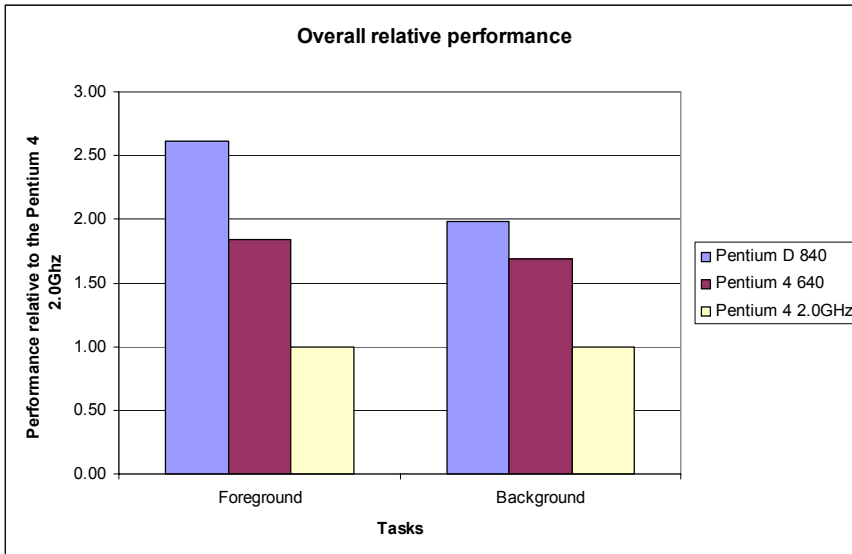
We selected three scenarios and created scripts that allowed us to automate performance testing. Each scenario involved a real-time communication function—such as making PC-to-PC calls using Voice over IP (VoIP), creating emails and sharing applications—that members of work teams perform frequently. Because team members typically perform multiple tasks during these exchanges, each scenario involved multiple tasks running simultaneously. We varied the type and computational intensity of the tasks in those scenarios to reflect a range of user experiences.

We used Microsoft Office Communicator 2005 (OC) for the real-time communications tasks in all of the scenarios. OC is a communications client that allows people to communicate in real time via instant messaging, voice, white-boarding, and application sharing. It is Microsoft's recommended client for Microsoft Office Live Communications Server 2005.

### Key findings

- ❖ Collaborative software, such as Microsoft Office Communicator 2005, frequently involves multitasking scenarios whose performance benefits greatly from current Intel platforms.
- ❖ Intel's desktop platforms with either the Intel Pentium D Processor (with dual-core processing) or the Intel Pentium 4 Processor with HT Technology delivered significant performance improvements over a roughly three-year-old Intel platform when running multiple applications.
- ❖ The newer Intel platforms consistently delivered much better performance when facing the sustained load of a VoIP call and multiple applications running simultaneously.
- ❖ The newer platforms consistently won on both responsiveness and throughput, significantly improving all foreground and background tasks.

As Figure 1 shows, we found that both of the representative newer business platforms can yield significant performance advantages for users running real-time communication and simultaneous collaborative or security tasks. The system with dual-core processing significantly outperformed the older system with the Intel Pentium 4 processor 2.0 GHz on all timed tasks, coming in from 50 percent faster to over 350 percent faster on different applications and tasks. The system with HT Technology outperformed the system with the



**Figure 1: Overall average performance, relative to the Intel Pentium 4 Processor 2.0 GHz-based system, on foreground and background tasks in all scenarios for all three systems.**

- Adobe Acrobat\* 7.0.3 Standard
- Microsoft Office Access 2003 (Service Pack 1)
- Microsoft Office Communicator 2005 (trial)
- Microsoft Office Excel 2003 (Service Pack 1)
- Microsoft Office Word 2003 (Service Pack 1)
- Microsoft Office Outlook 2003 (Service Pack 1)
- Network Associates' McAfee VirusScan\* Enterprise version 8.0i
- Webroot Spy Sweeper\* version 4.0.4 using Spyware Definitions 537 (14-day trial)

So that we could make the three test systems as similar as reasonably possible, while varying the processors and motherboards, we built the systems rather than purchasing them from vendors. Intel specified the general system types and supplied the 2005 processors and motherboards. We purchased the older motherboard and processor, as well as such common components as RAM, hard disks, and optical drives. Each test system had the following basic components (see Appendix B for in-depth configuration details):

- 512MB of the fastest RAM its motherboard supported
- 80GB hard disk with an 8MB buffer (SATA or EIDE depending on what the system would support)
- DVD-RW optical drive
- Windows XP Professional Service Pack 2

The application scenarios we tested on these systems include such common functions as:

- Starting a whiteboard session in OC
- Sharing files in OC
- Scanning for viruses
- Recalculating Excel spreadsheets
- Scanning for spyware
- Converting documents to .PDF format
- Conducting VoIP one-to-one OC calls

To make it easier to test our scenarios repeatedly and accurately, we automated the hand-timed application functions using scripts we wrote in IBM's Rational Visual Test\* 6.5. In our analyses we used the times from our tests of those scripts.

Pentium 4 processor 2.0 GHz by 10 percent to over 150 percent, depending on the application and task. Many of these performance improvements translated into multi-second time savings that would be obvious to users. For example, a task that completed in 9.3 seconds on the dual-core processing system and 12.2 seconds on the system with HT Technology took over 32 seconds on the system with the Pentium 4 processor 2.0 GHz.

We used the following common enterprise business applications in our testing (in alphabetical order):

In the following sections we look more closely at our test application scenarios (Application scenarios), examine the results of our tests (Test results and analysis), and give detailed information about how we actually performed the tests (Test methodology). In the appendices, we present the configurations of the test systems, explain how to manually execute the application functions in our scenarios, and discuss some issues in the development of the test scripts.

## Application scenarios

To demonstrate the types of performance improvements that 2005 business platforms running with either dual-core processing or Hyper-Threading Technology can yield, we developed a set of common business application multitasking scenarios using typical applications and operations. Each scenario includes a real-time communication task using Microsoft Office Communicator 2005 and business functions that involve Microsoft Office 2003 System. We also include security tasks that use Network Associates' McAfee VirusScan and Webroot Spy Sweeper, because virus scanning and anti-spyware scans are typical functions that run on business platforms and can affect a system's responsiveness. We primarily examined processor-intensive operations that can force users to wait, because users are most likely to appreciate performance improvements on such operations.

In the first scenario, Anna, a marketing manager, is putting the final touches on a presentation to her team for a campaign she is developing. Before making that presentation, she needs to review her ideas with another member of her team, Bob. She plans to use the Office Communicator whiteboard during the call to sketch out her ideas, and she will need to consult a large Word document containing the product specification. When it's time for her to make the call using Office Communicator, an automatic virus scan scheduled by the IT department begins. While the scan is running, Anna opens the document in Word, starts a whiteboard sharing session in Office Communicator, and waits for Bob to respond.

In the second scenario, Hannah, a business manager, is preparing the monthly sales reports using Excel and Access. She and her team will share the reports and work on them with Office Communicator. Like everyone else in her organization, she has VirusScan installed on her system, where it scans files as she opens them. As this scenario starts, Hannah has already exported sales data from Access into an XML report. She wants a colleague, Lily, to post the XML report on the company intranet, so she's going to send Lily the file. She also needs to create a report from an Excel file that is set for manual recalculation, and she needs a title for that report from Otto, a marketing manager. During the scenario, Hannah uses Office Communicator to initiate the transfer of the XML file to Lily. Office Communicator sends a message to Lily asking if she will accept the file. Office Communicator will start the file transfer as soon as Lily responds to that message. Meanwhile, Hannah starts the manual recalculation of the large Excel spreadsheet that she'll be using to create the report for Otto. Once the recalculation is underway, she uses Office Communicator to create a new email message to Otto. As Hannah does that, Lily accepts the file transfer, and the transfer starts.

In the third scenario, Nan, a developer, is on an Office Communicator one-to-one VoIP call with a team member, Emme. During the call, a Spy Sweeper scan, which the IT department has scheduled, starts. As the scan runs, Nan mentions a spreadsheet that she has created and Emme requests a PDF copy of it. While the scan progresses, Nan starts the PDF conversion and opens an XML file in Word that she will use as she and Emme move to their next topic.

For more details on how we executed and measured these scenarios, our specific test functions, and the files the scenarios use, see Appendix B.

## Test results and analysis

In this section we examine the results of the tests with the application scripts we created. Each of the times we present in this section and in the corresponding graph for each scenario is the median, in seconds, over five test runs. The following table shows the median times, in seconds, on each scenario for each of the test systems.

System	Intel® Pentium® D Processor 840 (3.2-GHz dual-core) on Intel® D955XBK	Intel® Pentium® 4 Processor 640 (3.2 GHz) on Intel® D945GTP	Intel® Pentium® 4 processor (2.0 GHz) on Intel® D845GVFN
<b>Scenario 1</b>			
OC start sharing (FG)	6.328	7.734	11.875
McAfee VirusScan (BG)	31.391	37.547	52.062
Word open (BG)	19.156	21.078	45.375
<b>Scenario 2</b>			
OC send email (FG)	6.343	10.734	28.891
OC send file (FG)	10.187	13.859	15.281
Excel recalc (BG)	14.61	16.437	27.312
<b>Scenario 3 (female voice)</b>			
Word open XML (FG)	9.281	12.203	32.812
Webroot Spy Sweeper (BG)	112.344	133.906	178.313
Excel convert to PDF (BG)	14.406	17.531	38.375
<b>Scenario 3 (male voice)</b>			
Word open XML (FG)	8.719	13.61	32.672
Webroot Spy Sweeper (BG)	112.875	133.954	174.469
Excel convert to PDF (BG)	13.938	18.797	38.078

Figure 2: Median results for all three test systems on all three scenarios. The medians are over five test runs. Times are in seconds. FG indicates a foreground task. BG indicates a background task.

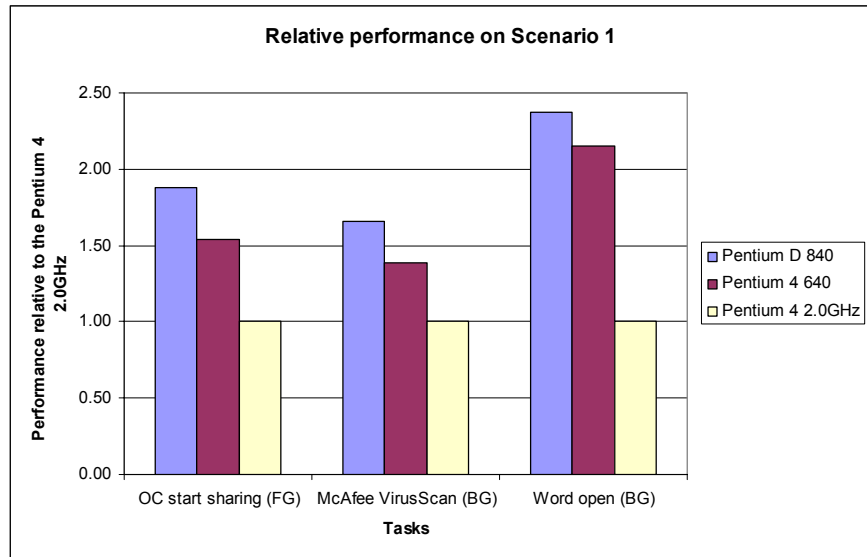
In the following sub-sections we explore these results in more detail. To make comparisons easier, we always show normalized results in which we divided each system's time by the time it took the system with the Intel Pentium 4 processor 2.0 GHz to perform the same task. The result for the 2.0 GHz system is thus always 1.00, because it's the comparison basis. Results higher than 1.00 indicate how much faster a system is than that 2.0 GHz system. Because of the normalization, higher result numbers are better. For example, a result of 1.80 would mean the system in question was 80 percent faster than the system with the Intel Pentium 4 processor 2.0 GHz.

As part of our discussion of each scenario, we show processor utilization curves that we captured with Windows XP's Perfmon utility. Our goal for each of these curves is to illustrate how demanding each task would be if run alone on a current system. In multitasking scenarios, the system faces each of these same demands, but all at the same time, because the tasks run simultaneously. When each of the simultaneous tasks has minimal processor requirements, keeping them all executing smoothly in parallel may not be difficult. When one or more of the tasks has significant processor demands, meeting those demands at the same time can be extremely difficult for a processor without the added execution ability of dual-core processing or HT Technology. We captured each task's processor-demand curve on the Intel Pentium 4 Processor 640 system with HT Technology turned off. We chose the Intel Pentium 4 Processor 640 system because it is a current platform with a single core; had we captured the processor utilization on the oldest system tested in this report, we might have given the impression of overstating the processor demands of individual tasks. We chose to turn off HT Technology to make it easy to see the processor demands; had we captured the processor utilization with HT Technology enabled, Perfmon would have capped each logical core at 50 percent utilization. In all the processor utilization charts, we use a blue line for foreground tasks and a red line for background tasks.

*Application scenario 1*

This scenario initiates a Microsoft Office Communicator 2005 whiteboard sharing session (the foreground task) while Network Associates' McAfee VirusScan performs a scan on a medium-large (164MB) directory (the first background task) and Microsoft Word opens an 8.2MB document with uncompressed graphics (the second background task). One of the two background tasks in this scenario is very demanding and wants most, if not all, of the processor; the other is moderately demanding. The foreground task's processor demand is fairly light.

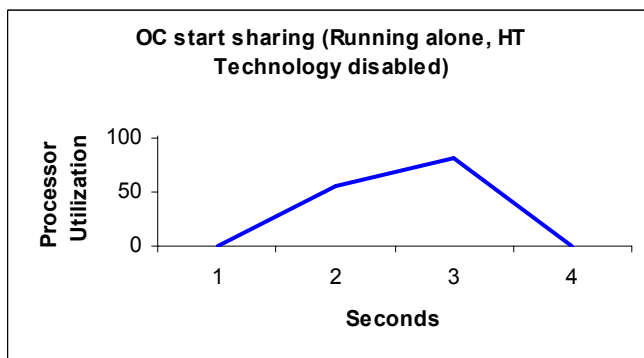
Figure 3 shows the improvement in performance of both the foreground and background tasks over the system with the Pentium 4 processor 2.0 GHz. These results show that the dual-core processing system delivered performance improvements of 88 percent and 66 percent on the background tasks, as well as 137 percent on the foreground task. These large percentages represent significant improvements in the time it took to perform each task—decreasing the elapsed time from 11.9 to 6.3 seconds on the foreground task, from 52.1 to 31.4 seconds on the first background task, and from 45.4 to 19.2 seconds on the second background task.



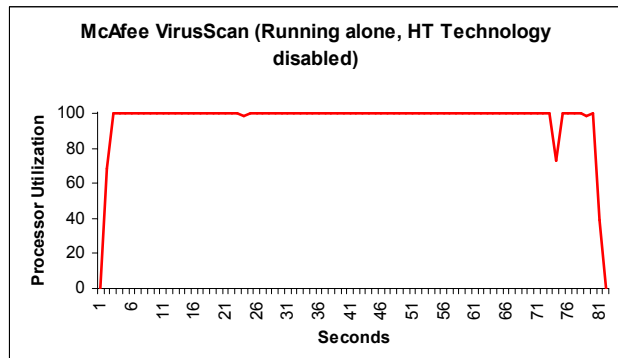
**Figure 3: Performance, relative to the Intel Pentium 4 Processor 2.0 GHz-based system, of each of the three systems on a set of concurrent tasks. Larger numbers represent better performance.**

The system with HT Technology also yielded large performance improvements of 54 percent and 39 percent on the background tasks, as well as 115 percent on the foreground task. The absolute time improvements were from 11.9 to 7.7 seconds on the foreground task, from 52.1 to 37.5 seconds on the first background task, and from 45.4 to 21.1 seconds on the second background task.

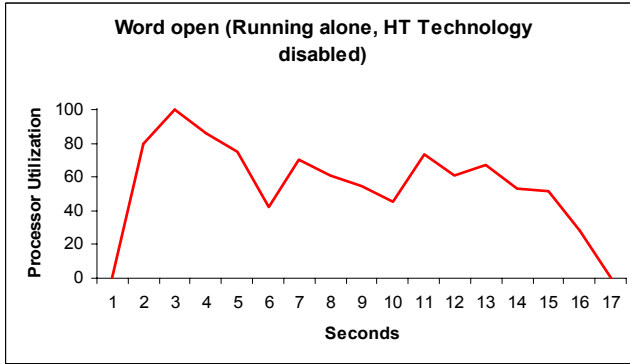
The processor utilization curves in Figures 4, 5, and 6 help illustrate the reason for these time savings. As Figure 5 shows, the McAfee VirusScan task demands practically the full processor. The Word open task (Figure 6) is fairly demanding as well and needs more than half of the processor. On top of that, even the light load of the OC whiteboard sharing task is enough to further load down the system. These tasks enable the second core in the Pentium D Processor 840-based system to provide a huge benefit. The processor with HT



**Figure 4: System processor utilization of the Scenario 1 foreground task (starting an Office Communicator whiteboard sharing session) running alone.**



**Figure 5: System processor utilization of the Scenario 1 background task (a virus scan using McAfee VirusScan) running alone.**



**Figure 6: System processor utilization of one of the Scenario 1 background tasks (opening a Word document) running alone.**

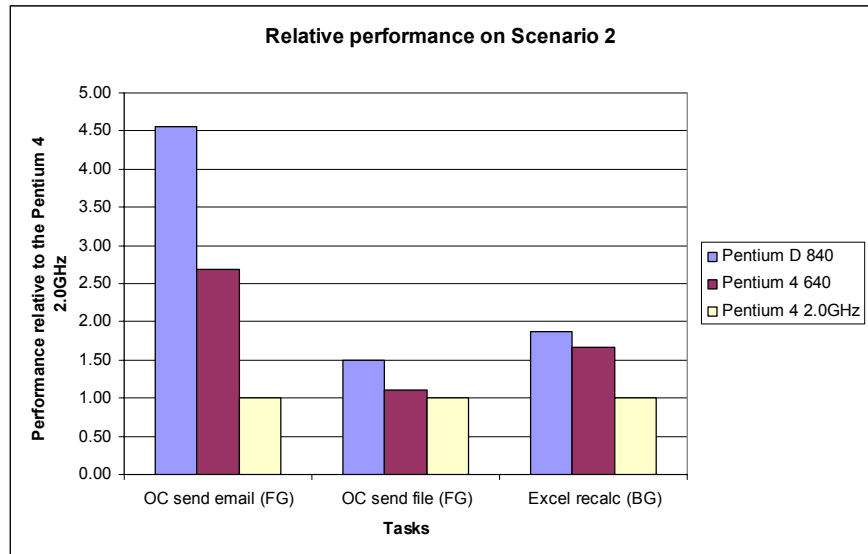
Technology also helped improve performance with this workload, as you can see from the significant wins it delivered versus the Intel Pentium 4 processor 2.0 GHz-based system without HT Technology.

*Application scenario 2*

This scenario sends a 56.8MB XML file over OC (the first foreground task) and then sends an email message via OC (the second foreground task), while recalculating a function-rich, 2.6MB Excel spreadsheet (the background task). None of the tasks in this scenario are quite as demanding as those in Scenario 1, but the two foreground tasks

together represent a significant load. On top of that, one foreground task demands as much of the processor as it can get, even if for a few seconds.

Figure 7 shows the performance improvement for the 2005 systems on both the foreground and background tasks over the older system with the Intel Pentium 4 processor 2.0 GHz. The first foreground improvement for the Intel Pentium D 840-based system is very large: the Intel Pentium D processor 840-based system completed the OC send email task in 6.3 seconds, while the system with the Pentium 4 processor 2.0 GHz took 28.9 seconds—more than four times as long. The second foreground task (OC send file) showed an improvement of 50 percent, while the background task (Excel recalculation) showed an 87 percent improvement.

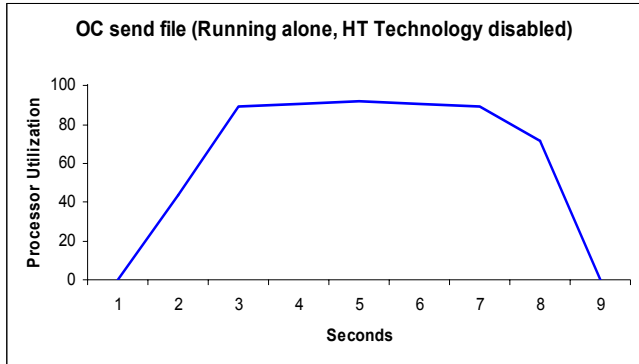


**Figure 7: Performance, relative to the Pentium 4 2.0GHz-based system, of each of the three systems on three concurrent tasks. Larger numbers represent better performance.**

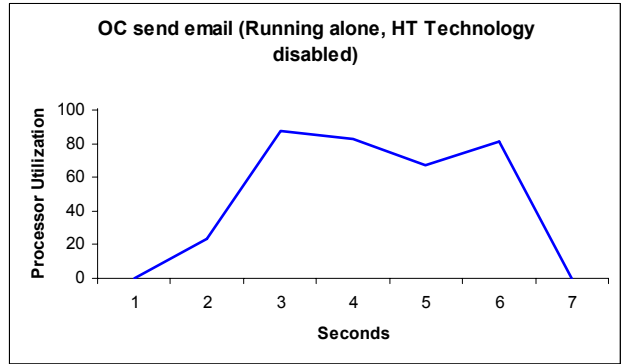
The Pentium 4 processor 640-based system delivered significant improvements as well, completing the send mail task in 10.7 seconds versus 28.9 seconds on the system

with the Pentium 4 processor 2.0 GHz. On the OC send file task, the Pentium 4 processor 640-based system completed the task about 10 percent faster (13.8 versus 15.3 seconds). The background task was much faster, taking 27.3 seconds on the system with the Pentium 4 processor 2.0 GHz but only 16.4 seconds on the Pentium 4 processor 640-based system.

The processor utilization curves in Figures 8, 9, and 10 help explain the performance results. The background task demands the full processor most, but not all, of the time. This usage level allows the processors with HT Technology to do a decent job of servicing both the background task and another task. The Pentium 4 processor 2.0 GHz-based system, without HT Technology, is basically unable to cope with the demanding foreground tasks on top of this level of background load, so it takes significantly longer to complete all the work.

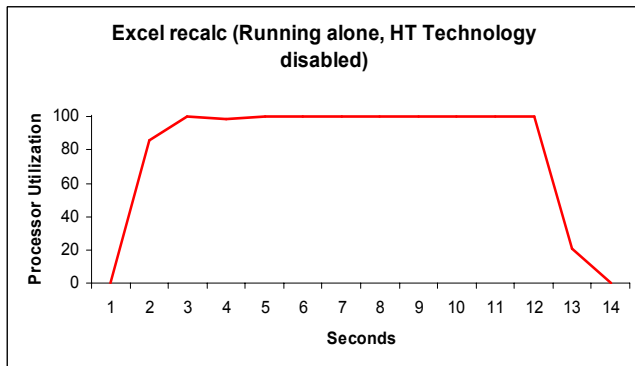


**Figure 8: System processor utilization of the Scenario 2 first foreground task (sending a file in OC) running alone.**



**Figure 9: System processor utilization of the second Scenario 2 foreground task (sending an email in OC) running alone.**

This type of scenario shows how HT Technology can be of benefit and yet also how, as the amount of work a system must perform simultaneously increases, a dual-core processing system can provide even greater benefit.



**Figure 10: System processor utilization of the Scenario 2 background task (recalculating an Excel spreadsheet) running alone.**

Application scenario 3

This scenario opens a 1.3MB XML file in Word (the foreground task) while Webroot Spy Sweeper scans for spyware (the first background task) and Excel converts a 2.6MB spreadsheet to a PDF file (the second background task). As these tasks are running, OC is running a VoIP call. (See Figure 17 for a diagram of the systems involved in this test.) To make sure that there was no appreciable difference between different voice types, we ran the test once with a female voice and once with a male voice. We used high-quality female ([www.voiceoverdirectory.com/female\\_voiceover\\_melanie\\_haynes.html](http://www.voiceoverdirectory.com/female_voiceover_melanie_haynes.html)) and male ([www.voiceoverdirectory.com/male\\_voiceover\\_Rick\\_Adamson.html](http://www.voiceoverdirectory.com/male_voiceover_Rick_Adamson.html)) voices during this scenario. The results here are the average of the results for each of the two voice types. (See Figure 2 for the full results for both female and male voices.)

While the Webroot Spy Sweeper spyware scan running in the background demands most of the processor, the other tasks are not particularly demanding. Thus, this scenario shows that multiple individual tasks with modest processing demands can add up to cause slow-downs on older processors.

Figure 11 shows the large performance improvement on both the foreground and background tasks over the system with the Pentium 4 processor 2.0 GHz. The dual-core processing system was more than 250 percent faster on the foreground task, and it was 57 percent and 170 percent faster on the two background tasks. These large percentage improvements represent absolute time improvements from 32.7 to 9.0 seconds on the foreground task, from 176.4 to 112.6 seconds on the first background task, and from 38.2 to 14.2 seconds on the second background task—time savings that users would be happy to realize.

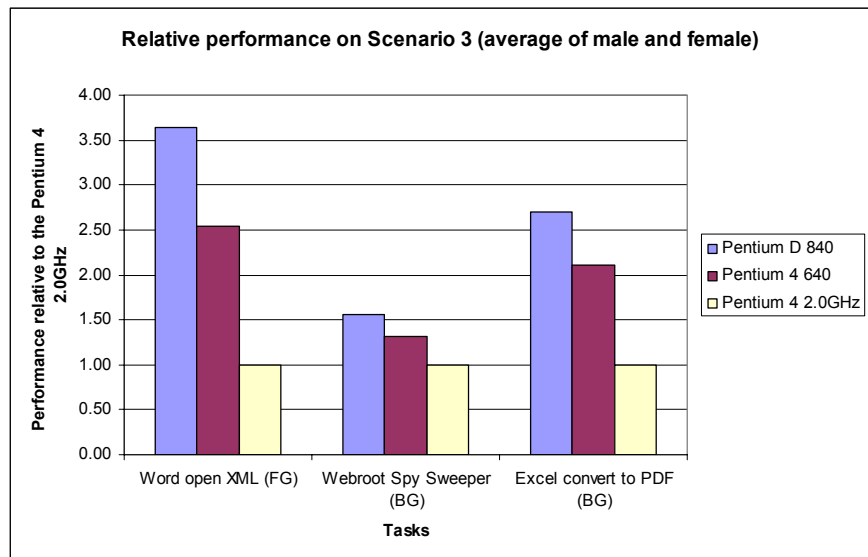


Figure 11: Performance, relative to the Intel Pentium 4 processor 2.0GHz-based system, of each of the three systems on a trio of concurrent tasks. Larger numbers represent better performance.

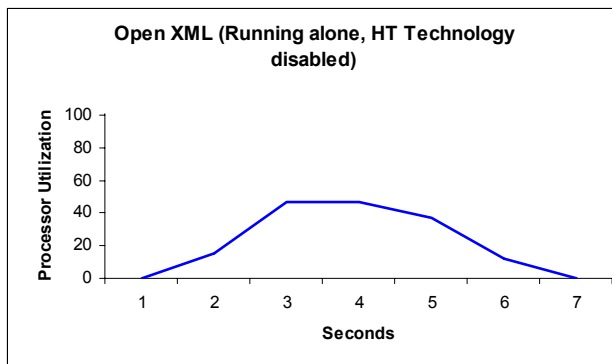


Figure 12: System processor utilization of the Scenario 3 foreground task (opening an XML file in Word) running alone.

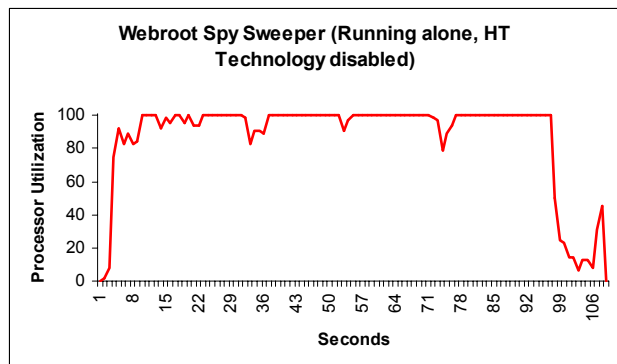


Figure 13: System processor utilization of one of the Scenario 3 background tasks (scanning for spyware with Webroot Spy Sweeper) running alone.



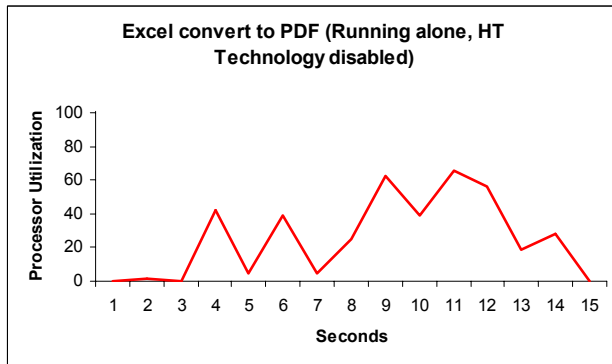


Figure 14: System processor utilization of one of the Scenario 3 background tasks (converting an Excel spreadsheet to PDF format) running alone.

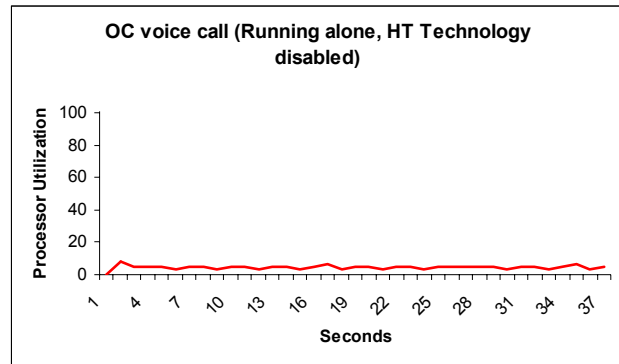


Figure 15: System processor utilization of the Scenario 3 VoIP one-to-one call in Office Communicator running alone.

The Pentium 4 processor 640-based system showed significant improvements as well, with a 154 percent improvement over the system with the Pentium 4 processor 2.0 GHz on the foreground task and improvements of 32 percent and 110 percent on the background tasks. These percentage improvements translated to absolute time improvements of 32.7 to 12.9 seconds on the foreground task, 176.4 to 133.9 seconds on the first background task, and 38.2 to 18.2 seconds on the second background task.

The processor utilization curves in Figures 12, 13, 14, and 15 give an overview of the demands the systems faced. In this scenario, the Office Communicator one-to-one VoIP call puts a modest but steady load on the processor. The background Webroot Spy Sweeper spyware scan requires almost all of the processor, while the Excel PDF conversion puts an appreciable additional load on the system. With these three demands, there is little capacity left on a system without dual-core processing or HT Technology for the relatively mild requirements of the Word XML open. The need to run all four tasks at the same time (even though only one of them has a very high processor requirement) clearly shows how the second core in the Pentium D processor 840-based system can improve performance over a system with a single-core processor.

These application scenario results show that dual-core processing technology is likely to yield performance improvements to a wide range of business users—particularly those on typical three-year-old systems—when running Microsoft Office Communicator 2005 and performing multiple processor-intensive tasks at the same time.

## Test methodology

We evaluated the performance of each of the application scenarios (see “Application scenarios”) both by hand and with automated test scripts, which we developed with IBM’s Visual Test 6.5. Appendix C details the steps we followed when we hand-timed the scenarios. In this paper, we concentrate our discussions on the results of the automated scripts, because those results are generally more repeatable than hand timings.

We collected results for five runs of each script in each system configuration. We refer in this paper only to the median results of those runs on each system/processor configuration. The scripts produce times (in milliseconds), with lower times to complete a given function indicating better performance.

Appendix A provides detailed configuration information on the test systems. We set up each of those systems using the following process:

- Install Microsoft Windows XP Professional.
- Using the standard Microsoft Windows Update Web site, apply all current (as of September 19, 2005) Windows XP critical updates, including Windows XP SP2—but not including optional updates, such

as Windows Media Player 10 or Windows Media Connect, that were totally unrelated to the goal of this paper.

- Install Microsoft Office 2003.
- Using the standard Microsoft Office Update Web site, apply all current (as of September 19, 2005) Office 2003 updates.
- Turn off Windows Service Pack 2 Security Center Pop-up Alerts. Doing so prevents such alerts from occurring during testing and affecting results.
  - Open the system Control Panel.
  - Choose Security Center.
  - Click “Change the way Security Center Alerts me” on the left.
  - Uncheck Firewall, Automatic Updates, and Virus Protection.
- Turn off Windows Automatic Updates. Doing so prevents such updates from occurring during testing and affecting results.
  - Open the system Control Panel.
  - Choose Automatic Updates.
  - Select “Turn off Automatic Updates”.
- To ensure as consistent a starting point as possible for the performance measurements, defragment the hard disk of each system.
- Using Symantec’s Ghost utility, make an image of each system’s hard disk. (This image lets us return to a clean and consistent starting point whenever necessary.)
- Install the additional software (versions current as of September 19, 2005) that each scenario requires:
  - Scenario 1
    - Microsoft Office Communicator 2005 (trial)
    - Microsoft Office Word 2003 (Service Pack 1)
    - Network Associates’ McAfee VirusScan Enterprise version 8.0i
  - Scenario 2
    - Microsoft Office Communicator 2005 (trial)
    - Microsoft Office Excel 2003 (Service Pack 1)
    - Microsoft Office Outlook 2003 (Service Pack 1)
    - Network Associates’ McAfee VirusScan Enterprise version 8.0i
  - Scenario 3
    - Adobe Acrobat Standard 7.0.3
    - Microsoft Office Communicator 2005 (trial)
    - Microsoft Office Excel 2003 (Service Pack 1)
    - Microsoft Office Word 2003 (Service Pack 1)
    - Webroot Spy Sweeper version 4.0.4 using Spyware Definitions 537 (14-day trial)

To obtain the results for each application scenario, we followed the same basic process:

1. Reboot the system.
2. Wait 10 seconds after the Windows hourglass disappears and Windows XP has completed its startup sequence. This delay ensures the system is in a consistent starting state.
3. Run the test script or hand-timed application functions, as appropriate.
4. Record the results.
5. Repeat the above three-step process five times. If any test or script failed, we discarded that test’s results and ran the test again.
6. Take the median result of the five iterations of each test as the representative result of that test.

## Appendix A: Test system configuration information

In this appendix, we provide in-depth configuration information for the three test systems.

We installed the applications necessary to run the scenarios on each system using the same steps. Because IT organizations often employ standard configurations—and to make the systems as comparable as reasonably possible—we installed on each system only those applications we needed for our testing. We applied all Windows critical updates, including SP2, available as of September 19, 2005, except those optional updates unrelated to enterprise systems, such as Windows Media Player 10 or Windows Media Connect. We applied all the application updates, such as those for Microsoft Office 2003, that were available as of the same date. We then defragmented the hard disk of each system and saved the resulting disk image. We performed all tests on these “clean” disk images.

This table provides detailed configuration information about each of the three test systems.

System	Intel® Pentium® D Processor 840 (3.2 GHz Dual-Core) on Intel® D955XBK	Intel® Pentium® 4 Processor 640 (3.2 GHz) on Intel® D945GTP	Intel® Pentium® 4 Processor 2.0 GHz on Intel® D845GVFN
<b>General</b>			
Processor and OS kernel: (physical, core, logical) / (UP, MP)	1P2C2L / MP	1P1C2L / MP	1P1C1L / UP
Number of physical processors	1	1	1
Single or dual-core processor	Dual	Single	Single
Processor Hyper-Threading Technology Status	N/A	On	N/A
System power management policy (AC/AlwaysOn, AC/Adaptive, DC/AlwaysOn, DC/Adaptive, Other)	AC/AlwaysOn	AC/AlwaysOn	AC/AlwaysOn
<b>CPU</b>			
Segment (server, desktop, mobile)	Desktop	Desktop	Desktop
Vendor	Intel	Intel	Intel
Model number	Pentium D Processor 840	Pentium 4 Processor 640	Pentium 4 processor
Stepping	4	3	9
Socket type and number of pins	Socket T/ LGA775	Socket T/ LGA775	Socket 478/ mPGA-478
Core frequency	3200	3200	2000
Front-side bus frequency	800	800	400
L1 cache	16KB + 12KB <sup>(1)</sup>	16KB + 12KB	8KB + 12KB
L2 cache	1MB <sup>(1)</sup>	2MB	512KB
<b>Platform</b>			
Vendor and model number	Intel D955XBK	Intel D945GTP	Intel D845GVFN
Motherboard model number	D955XBK	D945GTP	D845GVFN
Motherboard chipset	i955XE	i945G	i845GV
Motherboard revision number	AAC96732-405	AAC97837-202	AAC77646-105
Motherboard serial number	ABBK52000110	BQTP51700366	FCFN44613282
BIOS name and version	Intel BK95510J.86A.1959.2005.0826.1723	Intel NT94510J.86A.2104.2005.0825.1650	Intel FN84510A.86A.0020.P06.0503092001
BIOS settings	Setup default	Setup default	Setup default
Chipset INF driver	7.0.0.1025	7.0.0.1025	4.04.1007

System	Intel® Pentium® D Processor 840 (3.2 GHz Dual-Core) on Intel® D955XBK	Intel® Pentium® 4 Processor 640 (3.2 GHz) on Intel® D945GTP	Intel® Pentium® 4 Processor 2.0 GHz on Intel® D845GVFN
<b>Memory module(s)</b>			
Vendor and model number	Micron Technology CM32M6408U26AD2F-3VC	Micron Technology CM32M6408U26AD2F-3VC	Spectek s80032vmctl
Type	PC5300 DDR2-SDRAM	PC5300 DDR2-SDRAM	PC2700 DDR-SDRAM
Speed (MHz)	667	667	333
Speed in the system currently running (MHz)	533	533	266
Timing/Latency (tCL-tRCD-tRP-tRASmin)	4-4-4-12	4-4-4-12	2-3-3-6
Size	512MB	512MB	512MB
Number of sticks	2 x 256MB	2 x 256MB	2 x 256MB
Chip organization (Single-sided, Double-sided)	Single-sided	Single-sided	Single-sided
Channel (single/dual)	Dual	Dual	Dual
<b>Hard disk</b>			
Vendor and model number	Western Digital WDC WD800JD-75JNA0	Western Digital WDC WD800JD-75JNA0	Western Digital WDC WD800JB-00JAA0
Size	80GB	80GB	80GB
Buffer size	8MB	8MB	8MB
RPM	7200	7200	7200
Type	Serial ATA 1.5	Serial ATA 1.5	ATA-100
Controller	Intel 82801GB (ICH7)	Intel 82801GB (ICH7)	Intel 82801DB (ICH4)
Windows XP Microsoft hard disk driver version number	5.1.2535.0	5.1.2535.0	5.1.2535.0
<b>Operating system</b>			
Name	Microsoft Windows XP Professional	Microsoft Windows XP Professional	Microsoft Windows XP Professional
Build number	2600	2600	2600
Service pack	SP2	SP2	SP2
File system	NTFS	NTFS	NTFS
Kernel	ACPI Multiprocessor PC	ACPI Multiprocessor PC	ACPI Uniprocessor PC
Language	English	English	English
Microsoft DirectX version	9.0c	9.0c	9.0c
<b>Graphics</b>			
Vendor and model number	nVidia GeForce 6600	Intel 82945G	Intel 82845GV
Chipset	GeForce 6600	Intel 82945G Express	Intel 82915GV Express
BIOS version	5.43.02.16.00	Intel Video BIOS 1235	Intel Video BIOS 3364
Type (PCI Express, AGP 8X, integrated)	PCI Express	Integrated	Integrated
Memory size	256MB	128MB shared	64MB shared
Resolution	1024 x 768 x 32-bit color	1024 x 768 x 32-bit color	1024 x 768 x 32-bit color

System	Intel® Pentium® D Processor 840 (3.2 GHz Dual-Core) on Intel® D955XBK	Intel® Pentium® 4 Processor 640 (3.2 GHz) on Intel® D945GTP	Intel® Pentium® 4 Processor 2.0 GHz on Intel® D845GVFN
Driver	nVidia 7.8.0.1 8/2/2005	Windows XP driver: Intel 6.14.10.4363	Windows XP driver: Intel 6.14.10.3762
<b>Sound card/subsystem</b>			
Vendor and model number	SigmaTel High Definition Audio CODEC	SigmaTel High Definition Audio CODEC	Realtek AC'97 Audio
Type (PCI, Integrated)	Integrated	Integrated	Integrated
Driver	SigmaTel 5.10.4647.0	SigmaTel 5.10.4647.0	Realtek 5.10.0.5870
<b>Network card/subsystem</b>			
Vendor and model number	Intel PRO/1000 PM Network Adapter	Intel PRO/1000 PM Network Adapter	Intel Pro/100 VE Network Adapter
Type (PCI, integrated)	Integrated	Integrated	Integrated
Driver	Intel 9.1.30.0	Intel 9.1.30.0	Intel 6.4.14.0
<b>Optical drive</b>			
Vendor and model number	Lite-On DVDRW SHOW-1673S (CD 48X Rd, 48X Wr) (DVD 6X Rd, 6X Wr)	Lite-On DVDRW SHOW-16735 (CD 48X Rd, 48X Wr) (DVD 6X Rd, 6X Wr)	Lite-On DVDRW SHOW-16735 (CD 48X Rd, 48X Wr) (DVD 6X Rd, 6X Wr)
Type (CDROM, CDRW, DVD-ROM, DVD-W)	DVD-W	DVD-W	DVD-W
Interface (internal, external)	Internal	Internal	Internal
<b>USB ports</b>			
# of ports	5	5	4
Type of ports (USB1.1, USB2)	4 - 1.10 and 1 - 2.00	4 - 1.10 and 1 - 2.00	3 - 1.10 and 1 - 2.00
<b>Monitor</b>			
CRT/LCD type (plug & play, TFT, reflective)	Plug & play	Plug & play	Plug & play
CRT/LCD refresh rate	75Hz	75Hz	75Hz

Figure 16: System configuration information for all three test systems.

Notes:

<sup>(1)</sup> These cache sizes are per core for each of the two cores.

## Appendix B: Instructions for running the application scenarios

This appendix explains how we manually tested and timed each of the application scenarios. Though the vast majority of our discussions in this white paper focus on the results of the automated tests, we verified that manually performing the same functions yielded similar results similar to those of the automated scripts.

As the instructions below reflect, to get the most consistent possible timings and to make our hand-timed actions more like the ones the automated scripts perform, we sometimes chose to follow procedures for launching applications that were different from those typical users would follow. (See Appendix C for additional information on scripting issues.) When we made such choices, we also independently verified that the typical user procedures would still show similar results.

Consequently, we are confident that the benefits dual-core processor technology delivered in these scenarios are benefits that users can expect to realize in real work situations and are not artifacts of the measurement or scripting technology.

We ran all application scenarios five times on each of the three systems under test, and we reported the median of those runs. We did two sets of runs of the third scenario, one set with a male voice and one with a female voice.

In addition to the test systems, these scenarios require an additional system acting as a Live Communications server. The server running the Live Communications Server software must be part of a domain with Active Directory running. (Make sure that during the installation of Active Directory you perform the Prep Schema, Prep Forest, and Prep Domain functions.) For some of the email functions to work properly, the scenarios also require an Exchange Server. To simplify setup, a single server can act as a Domain Controller with Active Directory, Application Server (IIS), DNS, and Exchange Server all running. After you properly set up these applications or services, the final step is to set up Live Communications Server. The following steps, which assume those other server applications are already running, provide an overview of the process of installing and configuring Live Communications Server. For more details, consult the appropriate Microsoft documentation.

1. Install Live Communications Server with the default installation options.
2. Activate Live Communication Server.
3. Use TCP as the connection protocol.
4. The scenarios require one user for each system under test. Add those users first within Active Directory.
5. After you create the users in Active Directory, right click on each user name and select Properties.
6. In the Properties window select the Live Communications tab. Place a check in the Enable Live Communications for this user check box.
7. In the SIP URL, enter the user name. Select this server pool (in a clean test setup, there should be only one) from the drop-down menu, and click Apply.
8. Repeat the above steps for each test user.
9. Close the Active Directory window.
10. Once you have enabled the users for Live Communication, you should be able to see them in the Live Communications Server window in the Users folder.
11. Each of the systems should be able to log into the server with its appropriate user account.

Each of the test systems must be running Microsoft Office Communicator 2005. The following steps, which assume you've already set up the server, provide an overview of the process of installing and configuring Microsoft Office Communicator 2005. For more details, consult the appropriate Microsoft documentation.

1. Before installing the software, edit the Hosts file in C:\Windows\system32\drivers\etc\ so that the file includes the server's name and IP address.
2. Install Office Communicator 2005 using all the default options.

3. After the installation is complete, open Office Communicator, and choose Options from the Actions drop-down menu.
4. In the Accounts tab, enter the user name for this system.
5. Click the Advanced Options button.
6. In the Advanced Connection Settings window, choose Configure Settings, and enter the server name in the appropriate line.
7. Use TCP as the connection setting.
8. Close both the Advanced and Option windows.

To sign-in to the Office Communicator server before testing, do the following:

1. Select Sign In from the Connect drop-down menu.
2. When the Sign-In Name window appears, enter the user name, and click OK.
3. In the next window, enter the password, and select Save Password.

The following subsections, which assume all of the above setup work, describe how to run each of the individual scenarios.

### Scenario 1

This scenario uses two files or directories:

- C:\Program Files\Adobe\Acrobat 7\Setup Files\AcroStan\ENU. To make the VirusScan task a manageable length and to ensure that it always scanned the same files, we had it scan this one 164MB folder. The folder contains a large cab file and an installer file.
- Digital Home\_SC1.doc, an 8.2MB Word document with uncompressed pictures.

The scenario requires three applications:

- Microsoft Office Communicator 2005 (Trial)
- Microsoft Office Word 2003 (Service Pack 1)
- Network Associates' McAfee VirusScan Enterprise version 8.0i

We used the following process in our manual tests of this scenario.

First, we set up the system to run the scenario by doing the following steps, which are necessary only once:

1. Start Microsoft Office Word 2003.
2. Put Word into windowed mode, if necessary, by clicking the Restore Down button in the upper right.
3. Position the Word window so it takes up roughly the right half of the screen horizontally and the middle two-thirds vertically.
4. Exit Word.
5. Start McAfee VirusScan Console from the Start menu.
6. Position the Console on the upper right side of screen. Leave room above it for a row of icons.
7. Select Task > New On-Demand Scan Task.
8. Name the task Acrobat.
9. The VirusScan On-Demand Scan Properties – Acrobat dialog appears. If it does not, right-click on the Acrobat task name.
10. Click Remove twice to remove the two item names in the list box on that dialog. Click Yes on the confirm dialog that appears after each deletion.
11. Click Add, and scroll down to Drive or Folder.
12. Click Browse, and browse to C:\Program Files\Adobe\Acrobat 7\Setup Files\AcroStan\ENU.
13. Click OK to close the Browse for Folder dialog, and again to close the Add Scan Item dialog.
14. Click the Detection tab, and check the two checkboxes under Compressed Files.
15. Click OK.
16. Exit VirusScan Console.

17. Microsoft Office Communicator 2005 should load on system startup. Position its window on the left side of the screen.
18. In the upper right corner of the screen, create a desktop shortcut to the Digital Home\_SC1.doc file.
19. In the upper right corner of the screen, create a desktop shortcut to the VirusScan Console.

You will need to time two different tasks, so you'll either need to do two sets of runs to get the two sets of times or use two stopwatches; the latter approach is preferable. To run each timed test, we did the following:

1. Reboot the system.
2. Wait 10 seconds after the Office Communicator 2005 window displays so the system is in a consistent state.
3. Select Actions > More > Start Sharing... in that window.
4. Highlight the first contact on the Start Sharing dialog that displays.
5. Open the VirusScan console using its shortcut.
6. Select the Acrobat scan task.
7. Click Start. You do not need a stopwatch for this task.
8. Move the Scan Progress window to the lower right corner of screen and wait until the scan time is at five seconds (the time displays in the status bar at bottom of the Scan Progress window). This delay mimics the time a typical user might wait after confirming one task has started before moving to another.
9. Launch the Word document from its shortcut.
10. Start the stopwatch for the Word task when you start the launch.
11. Wait until Word displays the document title in its Window, and then immediately click on the OK button on the Start Sharing window. Start the stopwatch for the Office Communicator task when you click that button.
12. Stop the Office Communicator task stopwatch when Office Communicator opens a Conversation window that shows an instant message saying your contact is being invited to the data sharing session. The window usually pops up without this message and then after a short delay redraws with Instant Message and Sharing Controls. Record this time as the foreground time.
13. If the Word document does not have focus, click on it.
14. Stop the stopwatch for the Word task when the Word document status bar shows a page count of 1/42. Record this time as the Word background time.
15. The status bar in VirusScan gives you the elapsed time for the background task. Record this time as the VirusScan background time.
16. Exit Word.
17. Exit the Office Communicator Conversation window.
18. Exit VirusScan Console.

## Scenario 2

This scenario uses two files:

- Excel2MinMacro.xls, a formula-rich 2.56MB Excel file.
- Sales2002a.XML, a 56.8MB XML report we created from an Access database.

The scenario requires four applications:

- Microsoft Office Communicator 2005 (Trial)
- Microsoft Office Excel 2003 (Service Pack 1)
- Microsoft Office Outlook 2003 (Service Pack 1)
- Network Associates' McAfee VirusScan Enterprise version 8.0i

We used the following process in our manual tests of this scenario.



This scenario requires two systems. In addition to the system under test, this scenario requires a second system installed with Office Communicator 2005. In this scenario, the second system will receive the file that the test system sends. The process for setting up that system is the same as for setting up the test systems.

First, we set up the system to run the scenario by doing the following steps, which are necessary only once:

1. Open Office Communicator, and set up the contact list so that the system that will receive the files appears first. Include an offline system as the second contact.
2. Copy the Sales2002a.XML file to the desktop.
3. Create a shortcut to the Excel file on the desktop.
4. Make sure Outlook is set up with the same user name as the one you're using for Office Communicator.
5. Make sure Outlook has HTML and Word as formats for email messages.
6. Add the system you want to send the file to as a contact in the OC contact list.
7. Add an offline system as the second contact in that list.
8. Put Excel into windowed mode, if necessary, by clicking the Restore Down button in the upper right.
9. Position the Excel window so it does not overlap the Office Communicator window.
10. Close Excel.

You will need to time two different tasks, so you'll either need to do two sets of runs to get the two sets of times or use two stopwatches; the latter approach is preferable. To run each timed test, we did the following:

1. Reboot both systems between runs.
2. On the system that is going to receive the file, set the Office Communicator status to Online.
3. On the system under test,
  - a. Open the Excel spreadsheet.
  - b. In Office Communicator, select Actions > More > Send a File.
  - c. Highlight the contact you want to send the file to.
  - d. Press OK.
  - e. In the "Send a File" dialog, click Desktop, and select the Excel2minmacro.XLS file you copied to the desktop.
  - f. Click the Open button.
  - g. On the Microsoft Office Communicator window, select Actions > Send E-Mail.
  - h. Highlight the offline contact.
4. Go to the system that is going to receive the file, and accept the file. A confirmation window will appear. Leave that window in place.
5. Go back to the system under test.
6. To make it easier to get times, we included in the Excel file a macro that runs the manual calculation and shows the elapsed time on the Excel status bar. Start the macro by pressing Alt-a. If you prefer to stopwatch the task, instead of Alt-a press F9 to start the manual calculation, and start the stopwatch.
7. Wait 5 seconds. This delay mimics the time a typical user might wait after confirming one task has started before moving to another.
8. Press OK on the Send email dialog. Start the stopwatch for the send email task.
9. Wait 3 seconds. This delay mimics the time a typical user might wait after confirming one task has started before moving to another.
10. Go to the system receiving the file you're sending. Click OK on the confirmation window, and start the stopwatch for the send file task. A green progress bar displays.
11. The send file task is done when the green progress bar goes away. Stop the timer for the send file task then.
12. On the system under test, stop the timer for the send email task when the system displays the Untitled Message addressed to the contact you selected for this message.
13. If you pressed F9 to start the Excel manual calculation, the task is done when the spreadsheet status bar says Ready, so stop the stopwatch then. If you used the macro, it displays the elapsed time for the calculation.
14. Close Excel without saving the file.
15. Close all but the main Office Communicator window.

### Scenario 3

This scenario uses two files:

- Excel2MinMacro.xls, a formula-rich 2.56MB Excel file.
- Digital Home\_SC1.XML, a 1.27MB XML document with pictures and graphics.

The scenario requires three applications:

- Adobe Acrobat Standard 7.0.3
- Microsoft Office Communicator 2005 (trial)
- Microsoft Office Excel 2003 (Service Pack 1)
- Microsoft Office Word 2003 (Service Pack 1)
- Webroot Spy Sweeper version 4.0.4 using Spyware Definitions 537 (14-day trial)

We used the following process in our manual tests of this scenario.

First, we set up the system to run the scenario by doing the following steps, which are necessary only once:

1. Open Webroot Spy Sweeper.
2. Select the Options button.
3. On the Program Options tab, uncheck all checkboxes except Load at Windows Startup.
4. On the Sweep Options tab, leave all checkboxes checked, and select the radio button for Only Sweep Folders Where Threats Are Known to Reside.
5. Start Microsoft Office Word 2003.
6. Put Word into windowed mode, if necessary, by clicking the Restore Down button in the upper right.
7. Position the Word window so it fills up the upper-right quarter of the screen.
8. Start Microsoft Office Excel 2003.
9. Put Excel into windowed mode, if necessary, by clicking the Restore Down button in the upper right.
10. Position the Excel window over the Word window.
11. Open Adobe Acrobat.
12. Put Acrobat into windowed mode, if necessary, by clicking the Restore Down button in the upper right.
13. Position the Acrobat Window in the upper-left quarter of the screen.
14. Create one desktop shortcut for each of the two test data files.
15. Close Word, Excel, and Acrobat.
16. Open Microsoft Office Communicator 2005, and add a client to your contacts. To do this, select Contacts > Add Contact. This opens the Contacts Setup wizard.
17. In the wizard, enter the user name of the system you will be calling during testing.
18. Select Next through the remaining wizard options, thus keeping the defaults for each one.
19. After you've finished adding the contact, close Office Communicator.
20. To send the voice through the VoIP 1:1 call during the testing, you will need an additional system that is not otherwise part of this test.
  - a. This system will need to contain the male and female test voice files, because it will play those files.
  - b. Connect this system to the system under test with an audio cable. The audio cable should run from the speaker out port of this system to the microphone input on the system under test. This enables the additional system to mimic someone speaking into a microphone during the Office Communicator voice call.
  - c. The additional system will also capture and monitor the audio that the other call participant receives. To enable it to do that, connect a stereo cable from the speaker out port of the system receiving the call to the line in port of this system.
21. Figure 17 shows the systems and connections this scenario requires.

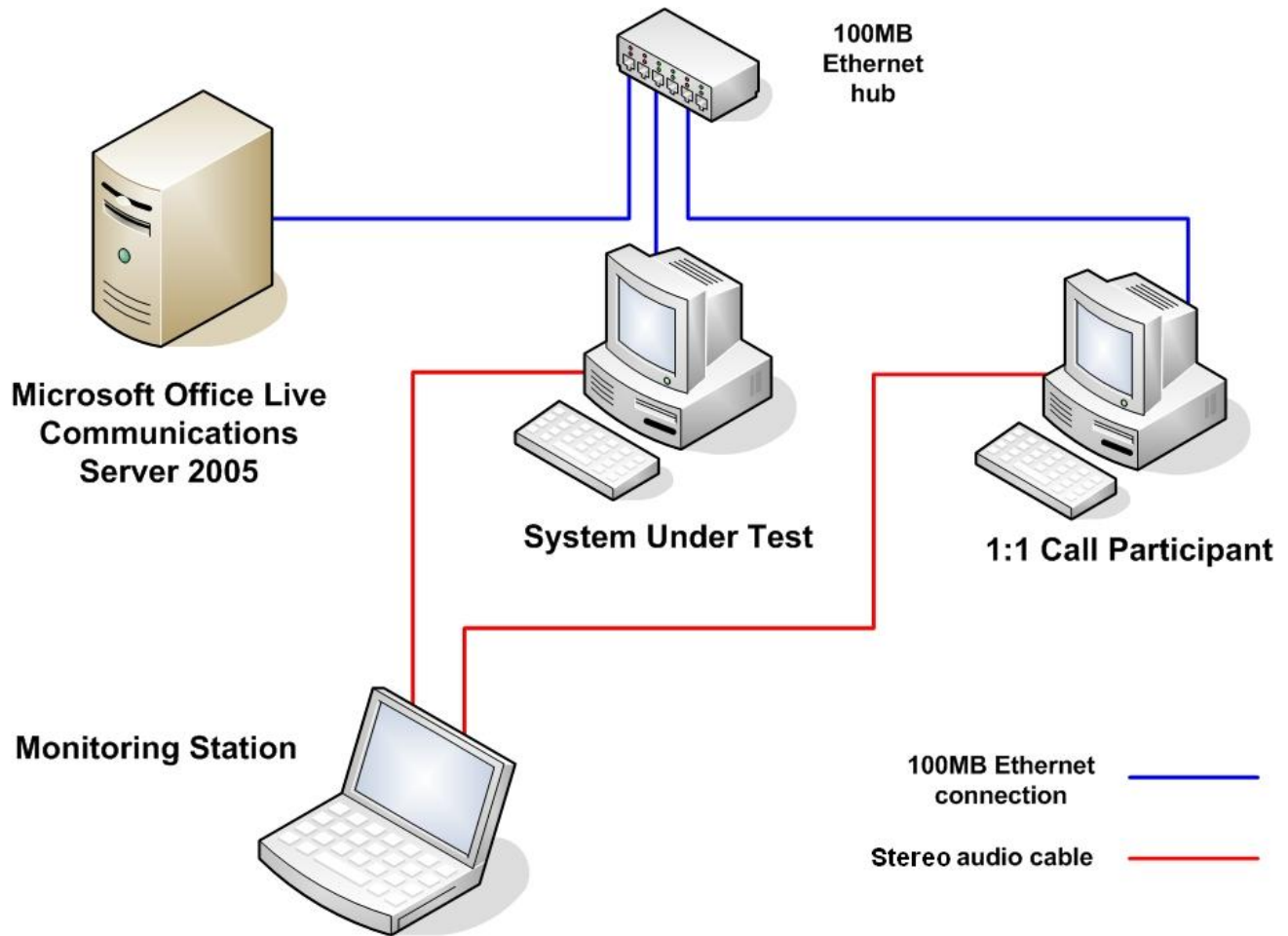


Figure 17: System configuration for the Microsoft Office Communicator 2005 voice call that Scenario 3 uses.

You will need to time multiple different tasks, so you'll either need to do multiple sets of runs to get the sets of times or use multiple stopwatches; the latter approach is preferable. To run each timed test, we did the following:

1. Reboot the system under test.
2. Wait 10 seconds after the Office Communicator 2005 window displays so the system is in a consistent state.
3. Start the VoIP 1:1 call between the systems by opening Office Communicator on the system under test.
4. In the Office Communicator window, right click the contact you want to call. This opens a Selection menu. Choose Call.
5. On the system receiving the call, click Accept to begin the call between the two computers.
6. After Office Communicator has established the call, begin playing the voice samples on the monitoring station system so the voice sample plays through the call.
7. Open the Excel from the shortcut you created.
8. Select Adobe PDF > Convert to Adobe PDF from the menu. The Save Adobe PDF File As dialog displays.
9. Open Spy Sweeper, and select the Sweep Now button.
10. Select the Start button to start the Spy Sweeper background task. Spy Sweeper will report elapsed time for the scan, so you do not need to stopwatch this task.

11. Wait 5 seconds. This delay mimics the time a typical user might wait after confirming one task has started before moving to another
12. Select Save on the Save Adobe PDF File As dialog, and start a stopwatch for this task.
13. Wait 5 seconds. This delay mimics the time a typical user might wait after confirming one task has started before moving to another
14. Double click the shortcut for the XML document, and start a stopwatch for this task.
15. Stop the stopwatch for the XML open task when the file displays in Word and the page counter in the Word status bar shows 1/10.
16. Stop the stopwatch for the Acrobat conversion task when Adobe Acrobat opens and displays the PDF file.
17. Get the time for the Spy Sweeper task from the status box at the bottom of its window.
18. Exit Acrobat, Excel, and Word.
19. Stop the Office Communicator 1:1 call by clicking on the red square in the Call window.
20. Delete the PDF file you created.

## Appendix C: Issues in script development

To the best of our knowledge, despite its age IBM's Visual Test 6.5 remains the tool most widely used today for constructing application-based benchmarks and performance tests for PCs running various versions of Microsoft Windows. We have used this product (and previous versions of it) for many years to build performance tests. The tool does, however, have some stated limitations that unavoidably affect the way one develops performance tests with it.

First, the product's own documentation notes that its primary goal is to be a tool for automating application testing, not a benchmark development system. Consequently, the granularity of some of its functions and the way some of its functions behave are not ideal for benchmark development.

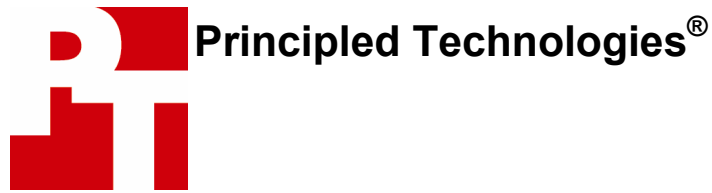
IBM also does not officially support Visual Test 6.5 for the Windows XP operating system. Because Windows XP is the leading and most current desktop version of Windows today, we nonetheless felt it was essential to use that operating system in our tests.

The presence of any scripting tool has the potential to affect the performance of a system. The tool unavoidably must, for example, occupy some memory and consume some processing power. Consequently, developing a performance-measurement script with such a tool involves maintaining a delicate balance between using the tool to automate typical real user behavior and minimizing the effects of the tool on system performance. To make sure the results of our scripts were accurate, we also hand-timed each of the functions we scripted.

To minimize these limitations and problems, we sometimes had to use scripting techniques that would achieve the same results as typical user behavior but not exactly mirror that behavior. Such techniques include inserting delays to mimic user think time and launching applications with a click on the OK button of a pre-filled Run command line. The hand timing instructions we provide in Appendix B reflect those techniques, so following those instructions will yield results similar to those the scripts produce. Whenever we had to use one of these alternative techniques, we manually verified that doing so did not materially alter the way the system behaved and that real users performing the same actions in more typical ways would see the type of dual-core processor technology benefits that we describe.

The timings the scripts produce also inevitably contain some variability. This variability is a result of the combination of the tool's limitations and the generally asynchronous nature of the many processes Windows XP and other modern operating systems have running at any given time.

Finally, though one of the goals of this effort was to produce reliable scripts, we were not trying to build bulletproof benchmarks for wide distribution and use. We developed the scripts to mimic user behavior on our specific test systems; on different systems the scripts might show different levels of benefit from a dual-core processor or even fail to work. So, although the scripts are as reliable, self-contained, and free of system dependencies as we could reasonably achieve within the project's timeframe, they do sometimes fail or encounter problems. Should a problem occur, rebooting the system and running the script again will generally yield a good result.



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