Performance and energy consumption of three notebook PCs with Intel processors

Executive summary

Intel Corporation (Intel) commissioned Principled Technologies (PT) to run a set of performance and energy consumption tests on the following notebook systems in their out-of-the-box (OOB) configurations:

- an HP 510 Intel Pentium M notebook processor 770-based system
- an HP Compaq nc6320 Intel Core Duo notebook processor T2500-based system
- an HP Compaq 6910p Intel Core 2 Duo notebook processor T7300-based system

The goal of the testing was to gauge the performance and energy consumption of each system. Intel specified the test systems and provided the test, test procedures, and test settings. PT purchased and set up the HP 510 Intel Pentium M notebook processor 770-based system and the HP Compaq nc6320 Intel Core Duo notebook processor T2500-based system. Intel provided the HP Compaq 6910p Intel Core 2 Duo notebook processor T7300-based system and PT set it up. PT executed the tests.

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KEY FINDINGS

- The HP Compaq 6910p Intel Core 2 Duo processor T7300-based notebook PC performed as much as 138 percent faster than the HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz notebook PC, which in turn performed as much as 117 percent faster than the HP 510 Intel Pentium M 770 processor-based notebook PC. (See Figure 1.)

- Running those tests, the HP Compaq 6910p Intel Core 2 Duo processor T7300-based notebook PC consumed as much as 119 percent less energy than the HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz notebook PC, which in turn consumed as much as 63 percent less energy than the HP 510 Intel Pentium M 770 processor-based notebook PC. (See Figure 2.)

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We measured system performance and energy consumption using the following five custom business application tests designed to simulate tasks that users commonly perform on notebook PCs:

- Two spreadsheet recalculation tests using Microsoft Office Excel 2007 to recalculate a spreadsheet
- Multitasking test using Microsoft Office Outlook 2007, Word 2007, and Internet Explorer 7 while running a McAfee virus scan
- Multitasking test using Microsoft Office Word 2007 to convert to PDF while running a Windows Defender scan
- Multitasking test using Microsoft Office Word 2007 to combine two documents while printing a PowerPoint XPS document

We used an Extech Power Analyzer to measure energy consumption while running the custom tests.

The Test results section shows these results in more detail, while the Test methodology section explains how we ran the test. Appendix A provides the price of the test systems and Appendix B details their configurations.

Test results

Figure 1 presents both raw performance results (the median of five runs for each test) and comparative results. Because performance scores represent the time, in seconds, that the system required to complete the workload, lower is better. Because comparative ratings indicate how much faster one system is than another, higher is better.

Test	Performance Results			Comparative Ratings		
	HP 510 Intel Pentium M 770 2.13 GHz	HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz	HP Compaq 6910p Intel Core 2 Duo T7300 2.00 GHz	HP 510 Intel Pentium M 770 2.13 GHz	HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz	HP Compaq 6910p Intel Core 2 Duo T7300 2.00 GHz
Custom business application tests	**Performance in seconds – lower is better**			**Comparative rating – higher is better**		
Microsoft Office Excel 2007 Monte Carlo Black-Scholes	167	94	61	1.00	1.78	2.74
Microsoft Office Excel 2007 Big Number Crunch	75	38	16	1.00	1.97	4.69
Open Microsoft Office Outlook 2007, Internet Explorer 7, and Word 2007 while running a McAfee virus scan	694	467	375	1.00	1.49	1.85
Microsoft Office Word 2007 creating a PDF while running a Windows Defender custom scan	13 (foreground task) 30 (Defender scan)	6 (foreground task) 23 (Defender scan)	7 (foreground task) 17 (Defender scan)	1.00 (foreground task) 1.00 (Defender scan)	2.17 (foreground task) 1.30 (Defender scan)	1.86 (foreground task) 1.76 (Defender scan)
Microsoft Office Word 2007 and PowerPoint 2007 Word combine + PowerPoint Print	159	105	91	1.00	1.51	1.75

Figure 1: Performance results and comparative performance ratings for the test systems. In the performance results, lower numbers are better. In the comparative ratings, higher numbers are better. We have rounded performance scores to the nearest second but comparative ratings reflect actual scores.

As Figure 1 shows, the HP Compaq 6910p Intel Core 2 Duo processor T7300-based notebook PC performed the custom business application tests faster than did the HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz notebook PC, which in turn performed faster than the HP 510 Intel Pentium M 770 processor-based notebook PC.

Figure 2 presents both raw energy consumption measurements (the median of five runs for each test) and comparative results. (In the event of a tie, we chose the run with the higher energy consumption. If the energy consumption score was also tied, we then chose the first run we executed with those scores.) Because energy consumption results represent the energy the system used when completing the workload, lower is better. Because comparative ratings indicate how much less energy one system used than another, higher is better.

We used the Extech Instruments 380803 Power Analyzer to gauge energy consumption. The Extech Power Analyzer is an external unit that connects to a host computer through a RS-232 communications cable. The device also has a DC power cable that powers the system under test. We used the Extech Power Analyzer to

monitor the average DC energy consumption of each system while running the five custom business application tests. We then multiplied Extech's average DC power score by the time the workload took to complete to calculate the Workload Energy Consumption (WEC) in watt-seconds. We divided the WEC watt-seconds score by 3,600 (the number of seconds in an hour) to calculate the WEC Watt-hours we report below.

Test	Energy Consumption Results			Comparative Ratings		
	HP 510 Intel Pentium M 770 2.13 GHz	HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz	HP Compaq 6910p Intel Core 2 Duo T7300 2.00 GHz	HP 510 Intel Pentium M 770 2.13 GHz	HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz	HP Compaq 6910p Intel Core 2 Duo T7300 2.00 GHz
Custom business application tests	Energy consumption in watt-hours – lower is better			Comparative rating – higher is better		
Microsoft Office Excel 2007 Monte Carlo Black-Scholes	1.96	1.29	0.82	1.00	1.52	2.39
Microsoft Office Excel 2007 Big Number Crunch	0.75	0.46	0.21	1.00	1.63	3.57
Microsoft Office Outlook 2007, Word 2007, and Internet Explorer 7 while running a McAfee virus scan	4.16	3.47	3.20	1.00	1.20	1.30
Microsoft Office Word 2007 creating a PDF while running a Windows Defender Custom Scan	0.29	0.25	0.18	1.00	1.16	1.61
Microsoft Office Word 2007 and PowerPoint 2007 Word combine + PowerPoint Print	1.71	1.34	1.11	1.00	1.28	1.54

Figure 2: Energy consumption results and comparative energy consumption ratings for the test systems. In the energy consumption results, lower numbers are better. In the comparative ratings, higher numbers are better.

As Figure 2 shows, the HP Compaq 6910p Intel Core 2 Duo processor T7300-based notebook PC consumed less energy during the custom business application tests than did the HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz notebook PC, which in turn consumed less energy than the HP 510 Intel Pentium M 770 processor-based notebook PC.

Test methodology

This section discusses some differences in the configurations of the test systems and details the methodologies we followed in testing them. We ran the tests five times and report the median of those runs.

Configuration differences

We purchased the built-to-order systems from the vendor's Web site. We could not avoid the following differences:

- The operating systems differ. The Intel Pentium M processor system came configured with Microsoft Windows XP Professional, while the Intel Core Duo and Intel Core 2 Duo systems came configured with Microsoft Windows Vista Business.
- The hard drive controllers in the systems differ. The Intel Pentium M processor 770-based system uses the Intel 82801FBM (ICH6-M) controller, while the Intel Core Duo processor T2500-based system uses the Intel 82801GHM (ICH7-M) controller and the Intel Core 2 Duo processor T7300-based system uses the Intel 82801HBM (ICH8-M) controller.
- The graphics controllers in the systems differ. The Intel Pentium M processor 770-based system uses the Intel GMA 900 controller, while the Intel Core Duo processor T2500-based system uses the Intel GMA 950 controller and the Intel Core 2 Duo processor T7300-based system uses the Intel GMA X3100 controller.
- The prices differ. At the time of purchase, the retail prices for the Intel Pentium M processor 770-based system and the Intel Core Duo processor T2500-based system were $699.99 and $1,665.00 respectively, not including sales tax or shipping. (For complete information on the prices PT paid, see Appendix A). Intel provided the Intel Core 2 Duo processor T7300-based system.

For detailed system configurations, see Appendix B.

Initial setup

When the systems arrived, we unpacked and set up each one. We went through the following process with the Windows XP Professional system the first time we booted it:

1. At the Welcome to Microsoft Windows screen, click Next.
2. At the User Information screen, select United States, English and U.S. keyboard, and click Next.
3. At the What time zone are you in screen, select Eastern Time, and click Next.
4. At the Microsoft and Manufacturer End User License Agreements, select Yes, I accept them, and click Next.
5. At the Do you want to turn on automatic updates screen, select Not right now to automatic updates (because our goal is to test each PC as it came directly out of the box), and click Next.
6. Name each computer with its model.
7. Leave the computer description blank, and click Next.
8. Leave the Administrator password blank, and click Next.
9. At the Register screen, click Skip.
10. At the Thank you screen, click Finish.
11. At the Recovery Media Creator screen, click Remind me later.
12. At the Software Update dialog screen, click Cancel.
13. At the Norton Internet Security 2006 screen, click Next.
14. At the License Agreement screen, select I accept the License Agreement, and click Next.
15. At the 60 day Subscription Status screen, click Next.
16. At the Next Steps screen, click Finish.
17. At the LiveUpdate screen, click Next.
18. Click Finish.
19. Close the Norton Internet Security Console.
20. At the Norton AntiVirus Definition Alert screen, select Notify me again in 14 days, and click OK.

We went through the following process with the Windows Vista Business systems the first time we booted it:

1. At the Set up Windows screen, select United States, English and U.S. keyboard. Click Next.
2. At the Microsoft and Manufacturer End User License Agreements, select Yes, I accept them, and click Next.
3. Type a user name.
4. Leave the password blank, and click Next.
5. Name the computer with its model, and click Next.
6. At the Help protect Windows automatically screen, click Ask me later (because our goal is to test each PC as it came directly out of the box).
7. At the Review your time and date settings, select Eastern Time, and click Next.

8. At the Thank you screen, click Start.
9. At the manufacturers registration screen, fill in the required information and click Begin.
10. At the Congratulations screen, click Finish.
11. At the Norton Internet Security screen, click Next.
12. At the User Account Control dialog, click Continue.
13. At the License Agreement screen, select I agree, and click Next.
14. At the 60 day Subscription Status screen, click Next.
15. Click Finish.
16. At the LiveUpdate screen, click Next.
17. Click Finish.
18. Close the Norton Internet Security Console.
19. At the Norton AntiVirus Definition Alert screen, select Notify me again in 14 days, and click OK.
20. At the Registration screen, select Do not remind me anymore, and click Next.

Capturing an image of the hard drive

We used Symantec's Ghost product to capture an exact image of the hard disk to a DVD using the internal DVD-RW drive. Each time we ran a new benchmark or test on a machine, we used the Ghost image DVD to return that machine to the above configuration. After re-imaging, we installed the software necessary to run each test and rebooted. We followed this process to capture the image.

1. Restart the computer.
2. Insert a bootable network CD.
3. Press the Escape key, at the Current Configuration dialog screen, to accept the automatic network options.
4. At the DOS command prompt, use the net use command to map a network drive to the dedicated Ghost image server, i.e., type net use z: \\ghostserver\ghost and press Enter.
5. Type z: to change to the mapped drive.
6. Type ghost -ia, and press Enter.
7. At the Symantec Ghost screen, click OK.
8. Select Local→Disk→To Image.
9. Click OK.
10. Select the Primary disk, and click OK.
11. Click Save.
12. Select Fast at the Compress Image dialog.
13. Select Yes at the Proceed dialog.
14. When the ghost image is complete, click OK, and exit Ghost.
15. Reboot the computer.

Extech Power Analyzer setup and test procedure

We did the following to set up the Extech Power Analyzer and software:

1. Power off and remove the battery from the notebook PC under test.
2. Connect the power cord from the Kensington Universal 120W AC/DC to the Power Analyzer's DC output load power outlet.
3. Plug the power cord from the Power Analyzer's DC input voltage connection into a power outlet.
4. Connect a separate host computer to the Power Analyzer using an RS-232 cable. This computer will monitor and collect the power measurement data.
5. Turn on the Extech Power Analyzer, by pressing the green On/Off button.
6. Turn on the host computer.
7. Insert the Extech software installation CD into the host computer, and install the software as follows:
   a. Using Windows Explorer, browse to the Extech Power Analyzer installation CD and click on the Setup.exe.
   b. At the Welcome to the Power Analyzer screen, click OK.
   c. At the installation screen, leave the default installation directory, and click the icon button to begin installation.
   d. At the Setup has completed successfully screen, click OK.

8. Launch the Extech Power Analyzer software by clicking Start→All Programs→Power Analyzer.
9. At the Select COM port dialog, click OK.
10. From the top menu, select Option→COM. Select COM1.
11. Exit the Extech Power Analyzer software.

We did the following to measure energy consumption during a test:

1. Power on the notebook PC, and make sure we have prepped it to run a test.
2. On the host computer, launch the Extech Power Analyzer software by going to Start→All Programs→Power Analyzer.
3. From the top menu, click Option→Sample Rate. Type 1.0 and click OK.
4. From the top menu, click File→Name.
5. In the Name field, type a name that appropriately describes the platform and configuration, and click OK.
6. To begin recording power, click File→Start Recording→Now (Auto) at the same time we start a test.
7. To stop recording power, click File→End Recording at the same time we stop a test.

To view the power measurement data, double-click on the My Computer desktop icon→select the C: drive→Program Files→Power Analyzer. When the program launches, select the test name selected earlier and double-click that file name. To open the file, select Excel as the program for viewing the data. This is the file we will use to calculate the average power usage. We calculate average power usage by doing the following:

1. Use Windows Explorer to locate the log file. By default, the log file is saved in C:\Program Files\Power Analyzer.
2. Open the log file with Microsoft Excel.
3. Insert a column by right clicking on column E and clicking Insert.
4. In cell E1, type =value(left(D1,7)), and press Enter.
5. Scroll down to the last row in column E and press Ctrl + Shift + Up. This should select the entire E column.
6. Press Ctrl + D to fill in column E.
7. Select cell A1 and press Ctrl + F.
8. In the Find What Field, type olw, and click Find Next. This will find any outliers that may have occurred during the test.
9. Delete any row that produced an outlier.
10. In an empty cell, type =average(e:e), and press Enter. This is the Average Power Draw in Watts.

Microsoft Office Excel 2007 Monte Carlo Black-Scholes
Intel provided the file this test uses: MonteCarloBlackScholesOptionPricing.xlsm. The file size is 70.1 MB (73,607,121 bytes).

We performed the following steps to set up and run this test:

Setting up the test
1. Reset the system to the base test image.
2. Copy the MonteCarloBlackScholesOptionPricing.xlsm test file to the My Documents directory.
3. Install Microsoft Office 2007 Ultimate Edition with default settings:
   a. At the Enter your Product Key screen, enter the product key and click Continue.
   b. At the License Agreement screen, select I accept the terms of this agreement, and click Continue.
   c. At the Microsoft Office Ultimate 2007 has been successfully installed screen, click Close.
4. Launch Microsoft Office Excel 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office Excel 2007.
5. Select I want to activate the software over the Internet, and click Next.
6. Click Finish.
7. Uncheck Search Microsoft Office Online for Help content when I'm connected to the Internet, and click Next.
8. Select I don't want to use Microsoft Update, and click Finish.

9. Click on the Microsoft Office button located in the top left.
10. Click Excel Options.
11. Click Trust Center located in the left column.
12. Click the Trust Center Settings button.
13. Click Macro Settings located in the left column, and select Enable all macros.
14. Click OK.
15. Close Excel.
16. On the host computer, launch the Extech Power Analyzer software by clicking Start→All Programs→Power Analyzer.
17. From the top menu, click Option→Sample Rate. Type 1.0 and click OK.
18. From the top menu, click File→Name.
19. In the Name field, type a name that appropriately describes the platform and configuration, and click OK.

Running the test
1. Launch Microsoft Office Excel 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office Excel 2007.
2. Press Ctrl + O.
3. Locate the MonteCarloBlackScholesOptionPricing.xlsm workload file and click Open.
4. Press Ctrl + R while at the same time starting the Extech Power Analyzer by clicking File→Start Recording→Now (Auto).
5. When the results dialog appears stop the Extech Power Analyzer by clicking File→End Recording.
6. Record the results and click OK to close Excel.
7. Repeat the steps four more times without rebooting between runs.

Microsoft Office Excel 2007 Big Number Crunch
Intel provided the file this test uses: BigNumberCrunch.xlsm. The file size is 6.24 MB (6,543,413 bytes).

We performed the following steps to set up and run this test:

Setting up the test
1. Reset the system to the base test image.
2. Copy the BigNumberCrunch.xlsm test file to the My Documents directory.
3. Install Microsoft Office 2007 Ultimate Edition with default settings:
    a. At the Enter your Product Key screen, enter the product key and click Continue.
    b. At the License Agreement screen, select I accept the terms of this agreement, and click Continue.
    c. At the Microsoft Office Ultimate 2007 has been successfully installed screen, click Close.
4. Launch Microsoft Office Excel 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office Excel 2007.
5. Select I want to activate the software over the Internet, and click Next.
6. Click Finish.
7. Uncheck Search Microsoft Office Online for Help content when I'm connected to the Internet, and click Next.
8. Select I don't want to use Microsoft Update, and click Finish.
9. Click on the Microsoft Office button located in the top left.
10. Click Excel Options.
11. Click Trust Center located in the left column.
12. Click the Trust Center Settings button.
13. Click Macro Settings located in the left column, and select Enable all macros.
14. Click OK.
15. Close Excel.
16. On the host computer, launch the Extech Power Analyzer software by clicking Start→All Programs→Power Analyzer.
17. From the top menu, click Option→Sample Rate. Type 1.0 and click OK.
18. From the top menu, click File→Name.
19. In the Name field, type a name that appropriately describes the platform and configuration, and click OK.

Running the test

1. Launch Microsoft Office Excel 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office Excel 2007.
2. Press Ctrl + O.
3. Locate the BigNumberCrunch.xlsm workload file and click Open.
4. Press Ctrl + R while at the same time starting the Extech Power Analyzer by clicking File→Start Recording→Now (Auto).
5. When the results dialog appears stop the Extech Power Analyzer by clicking File→End Recording.
6. Record the results and click OK.
7. Close Excel. Click No to saving results made to file.
8. Repeat the steps four more times without rebooting between runs.

Microsoft Office Outlook 2007, Word 2007, and Internet Explorer 7 while running a McAfee virus scan

PT provided the files this test uses. The file sizes are as follows:

- Outlook.pst – 265 KB (271,360 bytes)
- Web site directory - 447 KB (458,414 bytes)
- ExactTech report.docx – 810 KB (830,276 bytes)
- Virus Scan Workload – 2.26 GB (2,435,346,022 bytes)

A stopwatch is required for this test. We performed the following steps to set up and run this test:

Setting up the test

1. Reset the system to the base test image.
2. Uninstall Norton Internet Security 2006 by clicking Start→Control Panel→Uninstall a program.
3. Download and install McAfee VirusScan Plus Firewall & AntiSpyware 30-day trial from http://us.mcafee.com/root/downloads.asp?id=freeTrials.
   a. Double-click the 30 day McAfee setup executable.
   b. At the User Account Control dialog, click Continue.
   c. At the Welcome screen, click Next.
   d. At the License Agreement screen, click Accept.
   e. Select Complete Installation type and click Next.
   f. At the Safe Surfing Protection screen, accept the defaults and click Next.
   g. At the Select your options screen, accept the defaults and click Next.
   h. Click Finish.
4. Install Microsoft Office 2007 Ultimate Edition with default settings:
   a. At the Enter your Product Key screen, enter the product key and click Continue.
   b. At the License Agreement screen, select I accept the terms of this agreement, and click Continue.
   c. At the Microsoft Office Ultimate 2007 has been successfully installed screen, click Close.
5. Launch Microsoft Office Outlook 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office Outlook 2007.
6. Click Next at the Outlook 2007 Setup screen.
7. Select No and click Next at the E-mail Accounts screen.
8. Check the box next to Continue with no e-mail support and click Finish.
9. Select I want to activate the software over the Internet, and click Next.
10. Click Finish.
11. Uncheck Search Microsoft Office Online for Help content when I'm connected to the Internet, and click Next.
12. Select I don't want to use Microsoft Update, and click Finish.
13. Copy the Outlook.pst to C:\Users\User\Appdata\Local\Microsoft\Outlook.
14. Copy the Web site directory to Documents.
15. Copy the ExactTech report.docx to Documents.
16. Copy the Virus Scan workload directory to C:\VirusWL.
17. Open the Pool page.html file in the Web site directory.

18. Set the Internet Explorer homepage.
    a. Open the Pool page.html file in the Web site directory.
    b. Open the Home drop-down menu by typing Alt-M.
    c. Select Add or Change Home Page.
    d. Select Use this webpage as your only home page.
    e. Click the Yes button.
    f. Close Internet Explorer.
19. On the host computer, launch the Extech Power Analyzer software by clicking Start→All Programs→Power Analyzer.
20. From the top menu, click Option→Sample Rate. Type 1.0 and click OK.
21. From the top menu, click File→Name.
22. In the Name field, type a name that appropriately describes the platform and configuration, and click OK.

Running the test
1. Reboot the system under test.
2. Wait four minutes.
3. Right-click the VirusWL folder and click Scan while at the same time starting the Extech Power Analyzer by clicking File→Start Recording→Now (Auto).
4. Prepare the stopwatch.
5. Simultaneously launch Outlook 2007: Start→E-mail and start the stopwatch.
6. Stop the stopwatch when Outlook 2007 finishes opening as indicated by the word Done appearing in the Outlook 2007 status bar.
7. Record this time as the Outlook load task test result.
8. Prepare the stopwatch.
9. Simultaneously launch Internet Explorer 7: Start→Internet and start the stopwatch.
10. Stop the stopwatch when the home page has loaded completely.
11. Record this time as the Internet Explorer 7 load task test result.
12. Open the Documents folder: Start→Documents.
13. Click the ExactTech report once to highlight; then simultaneously press Enter to open the file and start the stopwatch.
14. Stop the stopwatch when the document displays.
15. Record this time as the Word 2007 load task test result.
16. Wait for the Scan completed alert to pop up in the lower right-hand corner of the desktop.
17. Click the McAfee desktop icon once to highlight and press Enter to open.
18. Click Scan in the left pane.
19. Click Finish under Scan Progress: Manual Scan.
20. Click View Recent Events in the left pane.
21. Click View Log.
22. Click Scan Information under Computer & Files.
23. Calculate the difference between the Manual scan start time and end time.
24. Record the calculated difference as the virus scan task test result.
25. Close each of the open applications, clicking No if asked if you want to save a file.
26. Repeat the steps four more times rebooting between runs.

Microsoft Office Word 2007 creating a PDF while running a Windows Defender Custom Scan
PT provided the files this test uses: Office11 Install Guide.doc and Windows Defender Workload. The file sizes are as follows:

- Office11 Install Guide.doc - 3.64 MB (3,819,008 bytes)
- Windows Defender Workload - 26.4 MB (27,767,601 bytes)

A stopwatch is required for this test. We performed the following steps to set up and run this test:

Setting up the test

1. Reset the system to the base test image.
2. Install Adobe Acrobat Reader 8.0 with default settings:
   a. Double-click the Adobe Acrobat Reader executable.
   b. Click Run at the Security Warning screen.
   c. Click Continue.
   d. Click Next at the Setup screen.
   e. Click Next at the Welcome screen.
   f. Accept the default installation path, and click Next.
   g. Click Install.
   h. Click Finish.
3. Copy the Windows Defender workload to C:\DefenderWorkload1.
4. Make four more copies of this workload, renaming them to DefenderWorkload2 to DefenderWorkload5.
5. Copy the Office11 Install Guide.doc test document to the desktop.
6. Install Microsoft Office 2007 Ultimate Edition with default settings:
   a. At the Enter your Product Key screen, enter the product key and click Continue.
   b. At the License Agreement screen, select I accept the terms of this agreement, and click Continue.
   c. At the Microsoft Office Ultimate 2007 has been successfully installed screen, click Close.
7. Launch Microsoft Office Word 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office Word 2007.
8. Select I want to activate the software over the Internet, and click Next.
9. Click Finish.
10. Uncheck Search Microsoft Office Online for Help content when I'm connected to the Internet, and click Next.
11. Select I don't want to use Microsoft Update, and click Finish.
12. Close Word.
13. On the host computer, launch the Extech Power Analyzer software by clicking Start→All Programs→Power Analyzer.
14. From the top menu, click Option→Sample Rate. Type 1.0 and click OK.
15. From the top menu, click File→Name.
16. In the Name field, type a name that appropriately describes the platform and configuration, and click OK.

Running the test

1. Reboot the system under test.
2. Wait 2.5 minutes to be sure the system has completed booting and is in a consistent starting state.
3. Open the Office11 Install Guide.doc.
4. Launch Windows Defender by clicking Start→All Programs→Windows Defender.
5. Click the drop-down menu next to Scan in the Windows Defender menu.
6. Choose Custom Scan from the drop-down menu.
7. Click the radio button next to Scan selected drives and folders.
8. Click Select.
9. Browse to the Windows Defender workload directory by expanding C:\ and checking the box next to DefenderWorkload*n*, where n is equal to the current test run.
10. Click OK.
11. Click the Office Button in Word 2007.
12. Left-click the arrow to the right of Save As. A dialog box titled Save a copy of the document will open.
13. Select PDF to XPS.
14. Prepare the stopwatch.
15. Bring Windows Defender to the foreground.
16. Click Scan Now while at the same time starting the Extech Power Analyzer by clicking File→Start Recording→Now (Auto). (Windows Defender reports the time elapsed under Scan Statistics.)
17. When the scan has run for 10 seconds, switch to Word 2007 (alt-Tab), and simultaneously click the Publish button in the Publish as PDF or XPS dialog box and start the stopwatch.
18. Stop the stopwatch when Adobe Reader 7.08 completes loading the newly created PDF file.
19. Record this time as the PDF creation test's result.
20. Bring Windows Defender to the foreground.

21. When the Windows Defender scan finishes stop the Extech Power Analyzer by clicking File→End Recording.
22. Record the scan time Windows Defender reports as the scan time's test result.
23. Delete the Office11 Install Guide.pdf file.
24. Repeat the steps four more times, rebooting between runs.

Microsoft Office Word 2007 and PowerPoint 2007 Word combine + PowerPoint Print

Intel provided the files this test uses: BusinessPowerPoint.pptx, MonteChristoRev1.docx, and MonteChristoRev2.docx. The file sizes are as follows:

- BusinessPowerPoint.pptx - 6.20 MB (6,512,387 bytes)
- MonteChristoRev1.docx - 1.40 MB (1,468,551 bytes)
- MonteChristoRev2.docx - 2.03 MB (2,133,436 bytes)

We performed the following steps to set up and run this test:

Setting up the test
1. Reset the system to the base test image.
2. Copy the three test files to the My Documents directory.
3. Install Microsoft Office 2007 Ultimate Edition with default settings:
    a. At the Enter your Product Key screen, enter the product key and click Continue.
    b. At the License Agreement screen, select I accept the terms of this agreement, and click Continue.
    c. At the Microsoft Office Ultimate 2007 has been successfully installed screen, click Close.
4. Launch Microsoft Office Word 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office Word 2007.
5. Select I want to activate the software over the Internet, and click Next.
6. Click Finish.
7. Uncheck Search Microsoft Office Online for Help content when I'm connected to the Internet, and click Next.
8. Select I don't want to use Microsoft Update, and click Finish.
9. Close Word.
10. On the host computer, launch the Extech Power Analyzer software by clicking Start→All Programs→Power Analyzer.
11. From the top menu, click Option→Sample Rate. Type 1.0 and click OK.
12. From the top menu, click File→Name.
13. In the Name field, type a name that appropriately describes the platform and configuration, and click OK.

Running the test
1. Launch Microsoft Office Word 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office Word 2007.
2. Click Review located on the top menu.
3. Click the Compare button and then click Combine.
4. In the Original document field, browse to the MonteChristoRev1.docx file and click Open.
5. In the Revised document field, browse to the MonteChristoRev2.docx file and click Open.
6. Launch Microsoft Office PowerPoint 2007 by clicking Start→All Programs→Microsoft Office→Microsoft Office PowerPoint 2007.
7. Press Ctrl + O.
8. Locate the BusinessPowerPoint.pptx workload file and click Open.
9. Press Ctrl + P. Make sure the Print dialog defaults to the Microsoft XPS Document Writer.
10. Click OK.
11. In the Save As dialog select the location and name the file.
12. Click Save while at the same time starting the Extech Power Analyzer by clicking File→Start Recording→Now (Auto).
13. Immediately Alt + Tab to the Word dialog and click OK.
14. When the Word Combine finishes a new window will appear with the combined document. Minimize Word in order to view the PowerPoint progress bar.

15. When the PowerPoint progress bar completes stop the Extech Power Analyzer by clicking File→End Recording.
16. Locate the PowerPoint file and subtract the creation time from the modified time.
17. Record this result as the overall multitasking time.
18. Close Word and PowerPoint. Click No to saving results made to file.
19. Delete the PowerPoint file.
20. Repeat the steps four more times without rebooting between runs.

Appendix A – Pricing information

Figure 3 presents the price information for the test systems at the time of purchase (March 30, 2007). Intel provided the Intel Core 2 Duo T7300-based system.

System	HP 510 Intel Pentium M 770 2.13 GHz	HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz	HP Compaq 6910p Core 2 Duo T7300 2.00GHz
Price at time of purchase (March 30, 2007)			
Unit price	$699.99	$1,665.00	NA
Instant rebate	NA	NA	NA
North Carolina sales tax (7 percent)	47.57	117.73	NA
Shipping	4.81	16.15	NA
Total we paid	$752.37	$1,798.88	NA

Figure 3: Prices PT paid for the test systems.

Appendix B – Test system configuration information

This appendix provides detailed configuration information about each of the test notebooks, which we list in alphabetical order.

System	HP 510 Intel Pentium M 770 2.13 GHz	HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz	HP Compaq 6910p Core 2 Duo T7300 2.00GHz
General			
Processor and OS kernel: (physical, core, logical) / (UP, MP)	1P1C1L / UP	1P2C2L / MP	1P2C2L / MP
Number of physical processors	1	1	1
Single/Dual Core processors	Single	Dual	Dual
Processor HT Status	NA	NA	NA
System power management policy	Portable/Laptop	HP Optimized	HP Optimized
Processor power-saving option	Enhanced Intel SpeedStep Technology	Enhanced Intel SpeedStep Technology	Enhanced Intel SpeedStep Technology
System dimensions (length x width x height)	14 x 10½ x 1½	13 x 10½ x 1½	13 x 9½ x 1½
System weight	5 lbs. 10 oz.	6 lbs. 0 oz.	5 lbs. 5 oz.
CPU			
Vendor	Intel	Intel	Intel
Name	Pentium M	Core Duo	Core 2 Duo
Model number	770	T2500	T7300
Stepping	8	8	A
Socket type and number of pins	Socket 479 mPGA	Socket 479 mPGA	Socket 479 mPGA
Core frequency (GHz)	2.13	2.00	2.00
Front-side bus frequency (MHz)	533	667	800
L1 Cache	32 KB + 32 KB	32 KB + 32 KB per core	32 KB + 32 KB per core
L2 Cache	2 MB	2 MB shared	4 MB shared
Platform			
Motherboard model number	30C4	30AA	30BE
Motherboard chipset	Intel i915GMS	Intel i945GM	Intel GM965
Motherboard revision number	03	03	0C
System/motherboard serial number	CND70223PY	MXL7140194	CND71909BV
Bios name and version	68DTV Ver. F.05	68YDU Ver. F.0B	68MCU Ver. F.04
BIOS settings	Default	Default	Default
Memory module(s)			
Vendor and model number	Corsair VS1GSDS667D2	Samsung M470T6554EZ3-CE6	Nanya Technology NT1GT64U8HB0BN-3C
Type	PC2-5300	PC2-5300	PC2-5300
Speed (MHz)	667	667	667
Speed running in the system (MHz)	266	333	333

System	HP 510 Intel Pentium M 770 2.13 GHz	HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz	HP Compaq 6910p Core 2 Duo T7300 2.00GHz
Timing/Latency (tCL-tRCD-tRP-tRASmin)	4-4-4-12	5-5-5-15	5-5-5-15
Size	1,024 MB	1,024 MB	1,024 MB
Number of memory module(s)	1 x 1024 MB	2 x 512 MB	1 x 1024 MB
Chip organization (Single-sided, Double-sided)	Double-sided	Double-sided	Double-sided
Channel (Single/Dual)	Single	Dual	Single
Hard disk			
Vendor and model number	Western Digital WD600UE-22KVT0	Seagate ST98823AS	Seagate ST980811AS
Size	60 GB	80 GB	80 GB
Buffer Size	2 MB	8 MB	8 MB
RPM	5,400	5,400	5,400
Type	EIDE	SATA 150 MB/sec	SATA 150 MB/sec
Controller	Intel 82801FBM (ICH6-M)	Intel 82801GHM (ICH7-M)	Intel 82801HBM (ICH8-M)
Driver	Intel 6.1.0.1004	Microsoft 6.0.6000.16386	Intel 6.8.0.3002
Operating system			
Name	Microsoft Windows XP Professional	Microsoft Windows Vista Business	Microsoft Windows Vista Business
Build number	2600	6000	6000
Service pack	2	NA	NA
File system	NTFS	NTFS	NTFS
Kernel	ACPI Uniprocessor PC	ACPI x86-based PC	ACPI x86-based PC
Language	English	English	English
Microsoft DirectX version	9.0c	10.0	10.0
Graphics			
Vendor and model number	Intel 915GM Express Chipset	Intel Mobile 945GM Express Chipset	Intel Mobile 965 Express Chipset
Type	Integrated	Integrated	Integrated
Chipset	Intel GMA 900	Intel GMA 950	Intel GMA X3100
BIOS version	1284	1305	1436
Memory size	128 MB	256 MB	243 MB
Resolution	1280 x 800 x 32 bit	1024 x 768 x 32 bit	1280 x 800 x 32 bit
Driver	Intel 6.14.10.4410	Intel 7.14.10.1151	Intel 7.14.10.1244
Sound card/subsystem			
Vendor and model number	Conexant AC-Link Audio	SoundMAX Integrated Digital HD Audio	SoundMAX Integrated Digital HD Audio
Driver	Conexant 6.14.10.675	Analog Devices 6.10.1.5110	Analog Devices 6.10.1.5180
Ethernet			
Vendor and model number	Intel PRO/100 VE	Broadcom NetLink Gigabit Ethernet	Intel 82566MM Gigabit
Driver	Intel 8.0.27.0	Microsoft 9.20.0.3	Intel 9.7.32.0
Wireless			
Vendor and model number	Intel PRO/Wireless 2200BG	Intel PRO/Wireless 3945ABG	Intel Wireless WiFi Link 4965AG
Driver	Intel 9.0.4.17	Intel 10.6.0.29	Intel 11.1.0.86

System	HP 510 Intel Pentium M 770 2.13 GHz	HP Compaq nc6320 Intel Core Duo T2500 2.00 GHz	HP Compaq 6910p Core 2 Duo T7300 2.00GHz
Modem			
Vendor and model number	AC97 Soft Data Fax Modem with SmartCP	Agere Systems HDA Modem	Soft Data Fax Modem with SmartCP
Driver	CXT 7.50.0.53	Agere 2.1.74.0	CXT 7.57.0.0
Optical drive(s)			
Vendor and model number	TSSTcorp TS-L632D	TSSTcorp TS-L462D	MATSHITA UJDA775
Type	DVD-RW	DVD-RW	DVD-RW
USB ports			
Number	2	4	3
Type	USB 2.0	USB 2.0	USB 2.0
Other	NA	SD MS/Pro MMC SM XD card reader	SD MS/Pro MMC SM XD card reader
IEEE 1394 ports			
Number	0	1	1
Monitor			
LCD type	WXGA	XGA	WXGA
Screen size	15.4	15.0	14.1
Refresh rate	60 Hz	60 Hz	60 Hz
Battery			
Type	HSTNN-IB44 Lithium Ion	HSTNN-IB05 Lithium Ion	HSTNN-UB28 Lithium Ion
Size (length x width x height)	10½ x 2½ x 7/8	8 x 2 x 7/8	8 x 2 x 7/8
Rated capacity	2200 mAh / 14.4V (32Whr)	4800 mAh / 10.8V (52Whr)	5100 mAh / 10.8V (55Whr)
Weight	9 oz.	11 oz.	11 oz.

Figure 4: Detailed system configuration information for the test systems.