Principled Technologies

Media Center PC Performance: Built-To-Order Systems

For Intel Corporation

Executive summary

Intel Corporation (Intel) commissioned Principled Technologies (PT) to run a set of performance tests on two built-to-order Hewlett Packard (HP) Media Center PCs as the systems came out of the box. The goal of the testing was to assess how well each PC would serve as a media center in a home office or bedroom. Intel identified the test systems and defined the methodologies for all non-standard tests. PT purchased and set up the two PCs and executed all tests. We ran the following benchmarks and performance tests:

Overall benchmark
- PCMark04 1.20 – Overall score
- PCMark04 – CPU score
- WebMark 2004 – Overall Score

Digital Media
- iTunes 4.7.1 performance test
- Windows Movie Maker 2.1 performance test
- Adobe Photoshop Elements 3.0 and Adobe Premiere Elements 1.0 performance test
- Windows Media Center TV viewing, recording, and playback tests

Gaming
- Doom 3 version 1.1 timedemo
- Unreal Tournament 2004 custom timedemos (source: Intel)
- Half-Life 2 custom timedemo (source: Intel)

We also performed a variety of Windows Media Center functions, such as playing CDs, viewing DVDs, and integrating the systems with common audio/video (AV) components, to further assess how well each system functioned as a media center. Appendix B provides detailed configuration information for each system, and Appendix A provides cost information for the systems and other equipment we used, and Appendix C details the AV content and games we used in our tests.

To set up a typical office or bedroom home theater environment, we purchased consumer-class components, such as a Sony 5.1 surround-sound receiver and speaker set, a separate Sony STR-DE598 home theater receiver, Samsung 22" LCD HDTV, and a Samsung Hi-Definition (HD) DVD player.

Whenever possible, we tested each system as it came out of the box. To enable some tests to run, however, we had to make system changes. We note all such changes in the Performance and feature comparison section below and applied those changes only to the specific tests for which they were necessary. The Test methodology section explains how we ran each test.

Though the systems had very similar specifications for their peripherals (e.g., hard drive, class of graphics adapter), we found the Intel-based HP m1050y to have superior audio capabilities, some noticeable performance wins when playing DVDs, and better scores in the majority of our performance tests. We also found that in our gaming tests the Intel-based system was much better suited to the HDTV environment, because it could play all games at both the monitor's native (16:9 aspect ratio) resolution. We present details of these findings below in the Test observations and feature comparisons section.

Figure 1 below summarizes the scores of our tests. For each system we show the median result of three tests (with the exception of WebMark 2004, which calculates its score after three runs). In the rightmost

column we compare the results of both systems. We calculate this comparison by dividing the Intel-based system's score by the AMD-based system's score for tests in which a higher score is better, and by dividing the AMD-based system's score by the Intel-based system's score for tests in which a lower score is better. Consequently, comparative results above 1.00 indicate tests the Intel-based system won, and those below 1.0 indicate tests the AMD-based system won.

For a few tests on the AMD-based system we show a result of "N/A". Such a result indicates a test that we were unable to run due to a problem or limitation with the system. Unless we note otherwise, higher scores are better. "FPS" stands for "frames per second."

Tests	HP m1050y	HP m1050e	Comp. Result
Processor	Intel Pentium 4 540J	AMD Athlon64 3700+	
PCMark04 1.20 – Overall score	4811	N/A	N/A
PCMark04 1.20 - CPU score	4886	4273	1.14
WebMark 2004 + patch1 (offline) - Geomean (overall score)	132	133	0.99
3DMark'05 -- CPU Tests Overall	4468	3113	1.44
iTunes version 4.7.1 (in seconds - lower is better)	192	197	1.03
Windows Movie Maker 2.1 (in seconds - lower is better)	73	90	1.23
Adobe Photoshop Elements 3.0 with Adobe Premiere Elements 1.0 (in seconds - lower is better)	361	416	1.15
Windows Media Center TV viewing (FPS)	59.94	59.94	1.00
Windows Media Center TV viewing and recording (FPS)	59.94	59.94	1.00
Windows Media Center TV viewing of recording material (FPS)	59.94	59.96	1.00
Doom 3 v1.1 Timedemo1 - High Quality @ 800x600x32-bit (FPS)	31.2	27.4	1.14
Doom 3 v1.1 Timedemo1 - High Quality @ 1024x768x32-bit (FPS)	21.7	NA	NA
Unreal Tournament 2004 - bots.bat @ 800x6000x32-bit colors (FPS)	86.38	70.17	1.23
Unreal Tournament 2004 - flyby.bat @ 800x600x32-bit colors (FPS)	86.23	71.92	1.20
Unreal Tournament 2004 - bots.bat @ 1024x768x32-bit colors (FPS)	63.24	N/A	N/A
Unreal Tournament 2004 - flyby.bat @ 1024x768x32-bit colors (FPS)	82.65	N/A	N/A
Half-Life 2 timedemo @ 1024x768x32-bit colors (FPS)	50.21	N/A	N/A
Half-Life 2 timedemo @ 800x600x32-bit colors (FPS)	51.49	67.58	0.76

Figure 1: Overall results of performance tests on the two systems.

Test observations and feature comparisons

In the course of running the above performance test and exercising other media center capabilities of the two systems, we observed a number of differences between the systems and encountered a variety of issues. In this section we discuss selected test results, our observations, and the issues we found.

Video playback

Windows Media Center lets you play back video from a variety of sources. We examined how well each system displayed video from each of those sources. We assessed picture quality, including the frequency of such flaws as pixilation and video artifacts, and the smoothness of the playback.

As the TV viewing test results in Figure 1 show, the two systems performed almost identically on this test. Any limitations or loss of definition we detected were a result of the DVD itself and not the performance of the video reproduction. The same was true when we recorded the video and played back the material using the PVR function in Windows Media Player: playback was smooth and without interruption, and the units reproduced the source material well.

DVD playback was also generally good on both units, with their DVI interfaces helping the systems produce bright, rich pictures on the 22-inch Samsung LCD screen. The only exceptions were infrequent stutters and time skips on the AMD-based system. These stutters, though noticeable, did not in our opinion noticeably detract from the enjoyment of the overall movie-watching experience.

Audio

Both systems provide surround-sound capabilities, but they do so somewhat differently and vary in the number and type of audio hardware interfaces they offer.

As Figure 3 shows, the Intel-based system provides two 7.1 channel outputs. One is a digital PCM (Pulse Code Modulation) coaxial connection that lets you connect to any receiver with a coax audio input; it's on the left in Figure 3. The PCM signal identifies to the receiver the type of audio signal--such as Dolby Digital 2.0 or 5.1, DTS, Pro Logic surround, and so on—that the PC is sending. To use this port you need only a composite RCA cable.

Figure 2: Audio interfaces for the Intel-based HP m1050y.

The second interface (on the right in Figure 3) is a straight eight-channel, or 7.1 surround, analog connection; each speaker pair (left/right, center/subwoofer, surround left/surround right, side left/right) has a separate composite mini plug that you connect to the receiver. Lower-end receivers often don't support this type of connection, but it is readily available on slightly more expensive units that can connect to a DVD-Audio or Sony SACD (Super Audio CD) player. With this connection style the PC does not need to encode the type of audio signal, because each analog connection directly connects to the appropriate speakers.

If you want to connect a simple typical PC setup (two speakers plus sub-woofer), you use the front left/right jack (green in Figure 3).

By offering the two types of connections, the system makes it easy for users to have both surround-sound and standard PC speaker setups. Switching between the setups is easy, because the Realtek sound card includes a program for doing so in software.

The AMD-based system, as Figure 4 shows, provides only a single audio interface, which you can use for 5.1 surround sound.

Figure 3: Audio interface for AMD-based HP m1050e.

As the icons on the jacks indicate, they come configured out of the box for microphone, stereo 2.0 output, and stereo 2.0 line input. The software that comes with the sound adapter lets you easily convert these jacks to support the subwoofer/center, front left and right, and surround left and right speakers, respectively.

This setup does not support a digital audio connection. All 5.1 surround is available only via analog connections, which do support Dolby Digital 5.1. The ability to customize your sound at the receiver, a feature many entry to mid-level receivers support, does not work with this type of connection—though you can do some customization from the PC. (By contrast, with the digital PCM coaxial connection on the Intel-based system, you can take advantage, for example, of the LFE (Lower Frequency Effects) capabilities on most receivers. LFE diverts various signal ranges to the subwoofer to create a deeper and wider range in the overall sound.)

More importantly, we also found that the lack of a digital line connection meant we could not use the DTS track on DVDs or even play those DVD-Audio discs that did not come with a Dolby Digital 5.1 track.

Figure 5 summarizes the audio playback capabilities of the two systems.

System	HP Media Center PC m1050y	HP Media Center PC m1050e
Processor	Intel Pentium 4 540J	AMD Athlon64 3700+
CD	Yes	Yes
DVD (Dolby Digital 5.1)	Yes	Yes
DVD (DTS)	Yes	No
DVD-Audio (Dolby Digital 5.1)	Yes	Yes
DVD-Audio (DTS 96 kHs/24-bit)	Yes	No

Figure 4: Audio playback capabilities of the two systems.

Game Play

While both running the game timedemo tests and actually playing the games, we encountered a few significant limitations in the graphics capabilities of the AMD-based 1050e system. The Intel-based system did not have any of these limitations. To work around these limitations and get comparison results, we had test at a lower common resolution setting of 800x600. Figure 2 summarizes the game-play resolutions between the units.

System	HP Media Center PC m1050y	HP Media Center PC m1050e
Processor	Intel Pentium 4 540J	AMD Athlon64 3700+
Doom 3	The game offered play resolutions of 1024x768 and higher, even with its Ultra High Video Quality setting.	The game would not let us set the resolution any higher than 800x600, even when we used its Low or Medium Video Quality setting.
Unreal Tournament 2004	The game's pull-down menu let us run at resolutions of 1024x768 and higher.	The highest resolution the game's pull-down menu offered was 800x600.
Half-Life 2	Using an aspect ratio of 4:3, the game offered play resolutions of 1024x768 and higher. At the display's natural aspect ratio of 16:9, the game offered play resolutions of 1280x720 and higher. Using a 16:10 aspect ratio, the game offered play resolutions of 1280x768 and higher.	Using an aspect ratio of 4:3, the game would not let us set the resolution higher than 800x600. At the display's natural aspect ratio of 16:9, the game offered no play resolution higher than 1280x720. The game did not offer a 16:10 aspect ratio option.

Figure 5: Game-play resolution differences between the two systems.

We attempted to remove these limitations from the AMD-based system by updating the nVidia driver to the latest version available. This update did not, however, change any of the limitations, so we ran the game tests with the out-of-the-box driver.

To accommodate these limitations of the AMD-based system, we had to test the games on both systems at the 800x600 settings. This resolution was not the natural one for the monitor and so yielded considerable graininess in the images, though game play was smooth. This resolution obviously reflects a 4:3 aspect ratio, so users would have to endure some stretching of the game's image. This stretching was particularly prominent when an object, such as a space ship or gun, was angled on the screen; the angle produced a stair- stepping effect.

By contrast, the Intel-based system let us test at higher resolutions and with the LCD monitor's natural aspect ratio. In those Doom 3 and Unreal Tournament 2004 tests, the screen image was consequently tighter, crisper, and not stretched. We also took advantage of these abilities to run the timedemo tests on this system at a higher resolution than was possible on the AMD-based unit.

To further explore these limitations, we connected the AMD-based system to a high-quality 17" CRT monitor. With this configuration, we were able to match the same resolutions as those available on the Intel-based system (though only at the 4:3 aspect ratio; the monitor did not support the other aspect ratios).

From these experiments we conclude that the AMD-based system did not support gaming as well in the wide-screen LCD environment as the Intel-based system.

On the Intel-based system, Half-Life 2 offered the ability to switch the aspect ratio from the 4:3 one common on computer monitors to the 16:9 one typical of wide-screen monitors and TVs, such as our test LCD monitor. Half-Life 2 did not offer this ability on the AMD-based system. The AMD-based system did, however, win the Half-Life 2 timedemo test at the 800x600 resolution.

Benchmark issues with the AMD-based HP m1050e
While we had no trouble completing all the standard benchmarks on the Intel-based system, we encountered multiple problems running two of those benchmarks on the AMD-based unit. This section details those problems.

The PCMark04 test produced many errors on the out-of-the-box AMD-based m1050e, because the tests that included graphics adapter testing repeatedly failed. This group included all the tests in the Graphics Suite and the Graphics Memory tests. Figure 6 summarizes the PCMark04 errors we encountered.

Test in PCMark 04	Error on the AMD-based m1050e
PCMark04 1.20 - System Test Suite - Graphics Memory - 64 Lines - Graphics Memory - 64 lines - fps	Init failed.
PCMark04 1.20 - Graphics Test Suite - Transparent Windows - windows/s	Init failed.
PCMark04 1.20 - Graphics Test Suite - Graphics Memory - 16 Lines - fps	Init failed.
PCMark04 1.20 - Graphics Test Suite - Graphics Memory - 32 Lines - fps	Init failed.
PCMark04 1.20 - Graphics Test Suite - 3D - Fill Rate Single Texturing - MTexels/s	Runtime Error! Program: C:\Program Files\Futuremark\PCMark04\PCMark04.exe This application has requested the Runtime to terminate it in an unusual way. Please contact the application's support team for more information.
PCMark04 1.20 - Graphics Test Suite - 3D - Fill Rate Multitexturing - MTexels/s	Runtime Error! Program: C:\Program Files\Futuremark\PCMark04\PCMark04.exe This application has requested the Runtime to terminate it in an unusual way. Please contact the application's support team for more information.
PCMark04 1.20 - Graphics Test Suite - 3D - Polygon Throughput Single Light - MTriangles/s	m1050e: Runtime Error! Program: C:\Program Files\Futuremark\PCMark04\PCMark04.exe This application has requested the Runtime to terminate it in an unusual way. Please contact the application's support team for more information.
PCMark04 1.20 - Graphics Test Suite - 3D - Polygon Throughput Multiple Lights - MTriangles/s	Runtime Error! Program: C:\Program Files\Futuremark\PCMark04\PCMark04.exe This application has requested the Runtime to terminate it in an unusual way. Please contact the application's support team for more information.

Figure 6: PCMark04 errors on the out-of-the-box AMD-based m1050e.

We attempted to work around these problems by downloading a driver update from nVidia's Web site (www.nvidia.com). Figure 7 details the driver versions.

Driver versions for the AMD-based m1050e	Date	Version
Out-of-box nVidia driver	09/20/2004	6.6.7.2
Updated nVidia driver	02/24/2005	7.1.8.4

Figure 7: nVidia drivers we used on the AMD-based m1050e for the PCMark04 tests.

The upgrade did not stop the errors. So, because our goal was to compare out-of-the-box systems when possible, we reverted to the out-of-box drivers. To complete the other PCMark04 tests, we had to unselect all graphics-related tests. PCMark04 thus could not complete those tests or produce an overall score. We indicated the inability to complete the overall score with an N/A in Figure 1.

We also had some difficulty installing and running the WebMark 2004 benchmark on the AMD-based system. This benchmark uses several well-known programs, including the Sun Java Runtime Environment (JRE), Macromedia's Flash and Shockwave, Adobe Acrobat Reader, and Microsoft Windows Media Player. For each of these programs, as part of the benchmark installation process WebMark 2004 installs the specific version it needs. If the system under test already contains conflicting versions of any of these programs, WebMark 2004 will produce an error message and may not run properly. Consequently, as the benchmark's vendor, BAPCO, recommends on its Web site (http://www.bapco.com/support/webmark2004/index.html), we uninstalled the existing version of each of these programs. In our experience and per the BAPCo instructions, doing so should have allowed WebMark 2004 to proceed.

It did not. When we tried to install WebMark 2004 on the AMD-based system, the system locked up during the Sun JRE portion of the process. We attempted the installation three times, and the system locked up each time at the same point. We reverted to a fresh Ghost image before each installation attempt to ensure that one failure did not cause another.

We then tried individually installing the Sun JRE application using the WebMark 2004 disk. This installation locked up during the JAR file creation process. We then eliminated all unnecessary services, including Norton AntiVirus, that were currently running, and tried the installation again. This time, the Sun JRE installation process completed successfully. We then uninstalled the Sun JRE, rebooted the system, and installed WebMark 2004. This installation completed successfully.

We then consistently encountered errors while running WebMark 2004 on his system. One error was a lock-up in which the system would simply stop running the test. (We verified this multiple times by allowing the system to sit at this point for an hour.) Each time this occurred, we rebooted the system, at which point the same iteration of WebMark 2004 would resume running. By repeating this process we were able to eventually get the system to finish the benchmark.

At that point, however, we consistently encountered an error that terminated the results-calculation process, and we could not get the results data we needed. Figure 8 shows the error message we received.
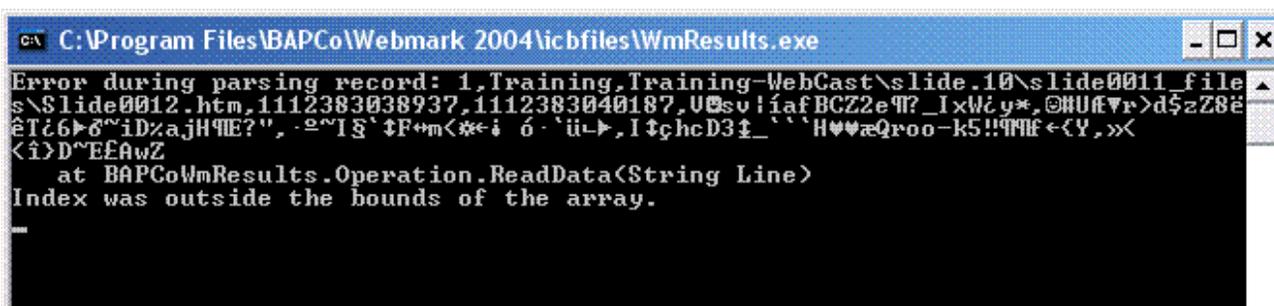
Figure 8: Error message from WebMark 2004 on the AMD-based m1050e.

We ultimately were able to work around this problem by uninstalling all of the Symantec security applications, such as Norton Anti-Virus and Norton Personal Firewall. Doing so let us complete the WebMark 2004 test without encountering any errors.

Because we had uninstalled all of the Symantec applications on the AMD-based system for this test, to provide fair comparisons we did the same on the Intel-based system—where doing so had not been necessary—and repeated the WebMark 2004 tests. We reported those retest results in Figure 1.

Test methodology

We unpacked and set up each system. We tested each system with the same LCD TV, home theater system, DVD player, camcorder, and digital camera. Figure 9 shows all the main test components:

- Left, right, center, and subwoofer speakers. (The rear left and right speakers were on the opposite wall and so are not in the picture.)
- Sony STR-DE598 Receiver (black). We had to add this receiver to the test bed to work with the AMD-based system's multi-channel audio outputs.
- Sony DreamSystem Home Theater Receiver (silver, below other receiver). Though we used the other receiver for all the home-theater tests, we needed this one to act as an amplifier for the subwoofer.
- Samsung 22" LCD High Definition TV.
- RF Modulator (on the DVD player). We used this component to convert the component video and audio connection from the DVD player to a coax connection for the TV tuner inputs on the two PCs.
- Samsung DVD player (silver, right).
- Remote controls.
- Mouse and keyboard. Both PCs came with the same mouse and keyboard models.
- AMD-based HP Media Center m1050e (left, below table).
- Intel-based HP Media Center m1050y (right, below table). In this picture it is the active system and so has the remote-control receiver on it.

Figure 9: Picture of test equipment and computer setup.

After physically setting up the systems, we went through the following process with each PC the first time we booted it:

1. Pressed Next to set up Windows XP.
2. Answered "Yes" to "Do you hear music playing out of the speakers?"
3. Selected United States, English and U.S. keyboard.
4. Selected Eastern Time.
5. Selected "Yes" to both the manufacturer (if present) and Microsoft End User License Agreements.
6. Selected "No" to automatic updates, because our goal was to test each PC as it came out of the box.
7. We named each computer with its model and processor vendor (m1050e_AMD and m1050y_intel).
8. We left each machine description blank.
9. Selected "Skip" during the "How will this computer connect to the Internet?" part of the setup process.
10. Selected "No" to registering with Microsoft.
11. Selected "Finish".

We then used Symantec's Ghost product to capture an image of the system's disk over our local network to a server. (To avoid perturbing any system's disk, we did not make a local Ghost image.) We then burned each Ghost image to a DVD.

Each time we were to run a new benchmark or test on a machine, we used the Ghost image DVD to return that machine to the above image. We then installed the software necessary to run the benchmark or test, made any system changes necessary to let the benchmark or test run, and rebooted.

After we completed each run of a benchmark or test, we would reboot before running the next iteration of that benchmark or test.

The following subsections summarize the steps we followed to obtain each of the benchmark/test results in this report. We made changes to the out-of-the-box configurations only when necessary to run a test. For standard tests, such as the benchmarks and the built-in game tests, we followed the standard methodologies for those tests. Intel supplied the methodologies for the other tests.

3DMark05 Business Edition

We performed the following steps on each PC to install the benchmark:

1. Click Next at the Install Shield Wizard dialog box.
2. Click the "I accept the terms of the license agreement" check box at the License Agreement dialog box.
3. Click Next at the Choose Destination Location dialog box.
4. Click Install at the Ready to Install the Program dialog box.
5. Enter Registration Code and click Next to unlock Business Edition.
6. Uncheck "View Readme" check box, and click Finish at the Installation Complete dialog box.

We rebooted before each run and then followed the processes below to run the tests.

Steps to run the benchmark's Software test:

1. Start 3DMark05.
2. Under Tip of the Day, check Do not show this dialog again, and click Close.
3. Under the Tests section, click Select.
4. Click Select All so that all tests will run, and click OK.
5. Under the Settings section, click Change.
6. Change the resolution to match the current settings in Windows (typically 1280 x 720).
7. Check Force software vertex shaders, and click OK.
8. Click the Run 3DMark button to run the tests.

Steps to run the benchmark's Hardware test:

1. Start 3DMark05.

2. Under Tip of the Day, check Do not show this dialog again, and click Close.
3. Under the Tests section, click Select.
4. Click Select All so that all tests will run, and click OK.
5. Under the Settings section, click Change.
6. Change the resolution to match the current settings in Windows (typically 1280 x 720).
7. Click the Run 3DMark button to run the tests.

The benchmark produces, among other results, an overall score; higher scores are better.

PCMark04 Business Edition

We performed the following steps on each PC to make it ready to run this benchmark:

1. Install Windows Media Encoder 9, as it is a requirement for PCMark04 to run.
2. Place PCMark04 Business Edition CD in the CD-ROM drive.
3. Click Next at the Install Shield Wizard dialog box.
4. Click the "I accept the terms of the license agreement" check box at the License Agreement dialog box.
5. Click Next at the Choose Destination Location dialog box.
6. Click Install at the Installation dialog box.
7. Enter the registration code, and click Next.
8. Click OK at the Congratulations dialog box.
9. Click Finish at the Installation Complete dialog box.

We rebooted before each run and then followed this process to run the test:

1. Start PCMark04.
2. Under Tests, click Select.
3. Click Select All to check all tests available.
4. Click Run PCMark button to run the tests.

The benchmark produces, among other results, an overall score; higher scores are better.

WebMark 2004

We performed the following steps on each PC to make it ready to run this benchmark. First, we uninstalled the following programs, per BAPCo's recommendations for testing with WebMark 2004:

- Adobe Acrobat Reader 6.0
- Macromedia Flash & Shockwave players
- Microsoft .NET framework v1.1
- SUN Java Runtime Environment v1.4.1
- Windows Media Player 10

We then installed WebMark 2004:

1. Click Next at the Install Shield Wizard dialog box.
2. Click the Client install button, and click Yes at the Question dialog box.
3. Accept the license agreement by clicking Yes.
4. Enter "Default" for Company Name, and click Next at the Customer Information dialog box.
5. Click Next at the Destination Directory dialog box.
6. Enter the registration code, and click Next.
7. Click OK at the Congratulations dialog box.
8. Click Finish at the Installation Complete dialog box.

We rebooted before each run and then followed this process to run the test:

1. Double click on the WebMark 2004 desktop icon.
2. In the Web-based interface, click on Run Benchmark.
3. Under Project name, enter the name of the system (e.g., HP_m1090y (no spaces)).
4. Select Offline mode.
5. Select Official Run.
6. Click Run Project, and the benchmark will begin.
7. Once it completes, the WebMark Web interface reappears with the results.
8. Click Generate FDR.
9. Once the FDR is complete, click Export FDR and save the WMR file.

The benchmark produces, among other results, an overall score; higher scores are better. WebMark does not produce one score per run; instead, it computes its own geometric mean of the three runs. We report that result in Figure 1.

iTunes 4.7.1

The methodology for this test required a large .wav file. We used the Magix MP3 Maker Deluxe 2005 and Super Sound Joiner applications to create a single .wav file from all the songs on disc one of Pearl Jam greatest hits compilation, *Rearviewmirror*. We followed these steps to create the wav file:

1. Insert CD 1 of the PearlJam "Rearviewmirror" into the CD-ROM drive
2. Click Start, then start the Magix MP3 Maker Deluxe 2005 program.
3. In the Explorer Tab, browse to the music CD-ROM.
4. Highlight all the songs listed, and click the selection button under "Add to Playlist".
5. Highlight all the songs now listed in the playlist.
6. From the top menu bar select convert, and then convert playlist.
7. In the Format field under the encoder section select Wavefile (*.WAV).
8. Click Start.
9. After Magix MP3 Maker has encoded the songs, save the .wav files and close the application.
10. Click Start, then start the Super Sound Joiner program.
11. Click Add, then browse to where you saved the .wav files (default is the My Music directory).
12. Select all the songs, then click open.
13. From the top menu, click Join.
14. When the process completes, browse to where you want to store the joined .wav files (the default is c:\Documents and Settings). We named the joined file mixTest.wav.
15. Close the application.
16. Place the mixTest.wav file in the My Music folder under the My Documents folder.

We performed the following steps on each PC to make it ready to run this test:

1. Download iTunes 4.7.1 from http://www.apple.com/itunes/download/.
2. Launch the iTunes installer. The dialog below will appear. Click Next after it does.

3. Click Next at the Setup Type dialog box below.
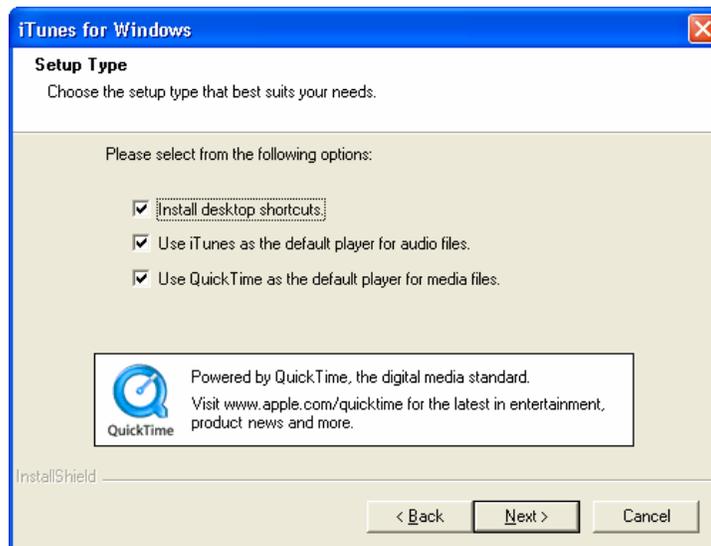
4. Click Next at the Choose Destination Location dialog box below.

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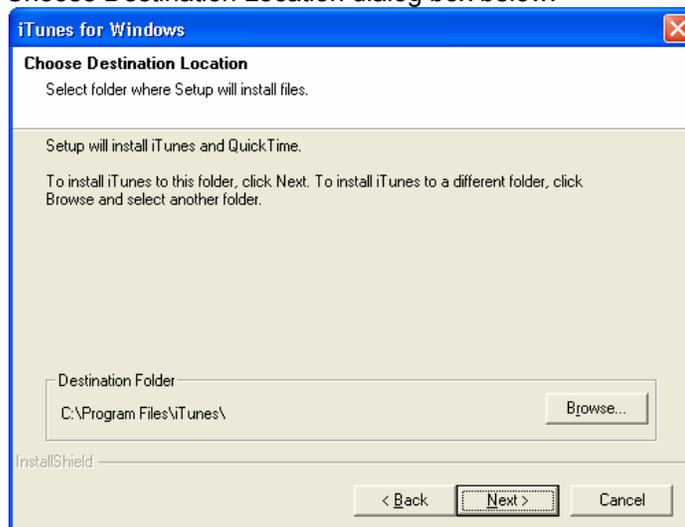
5. The next dialog box provides a progress bar indicating the installation status.
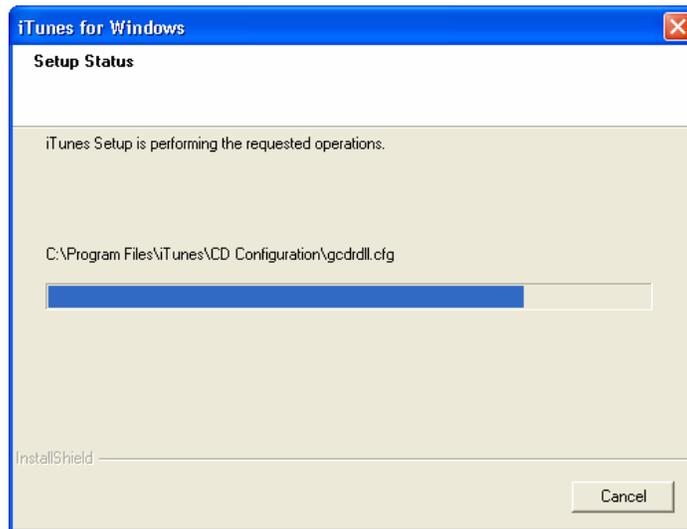
6. When the Installation Successful dialog box (below) appears, click Next.

7. Reboot the computer.

We followed these steps to run the iTunes test:

1. Launch iTunes via its desktop icon. The following main screen will appear.

2. Under the Edit menu, select Preferences. Click on the Importing tab. In the drop-down menu next to Import Using, choose MP3 Encoder. The dialog box will now look like the one below. Click OK.
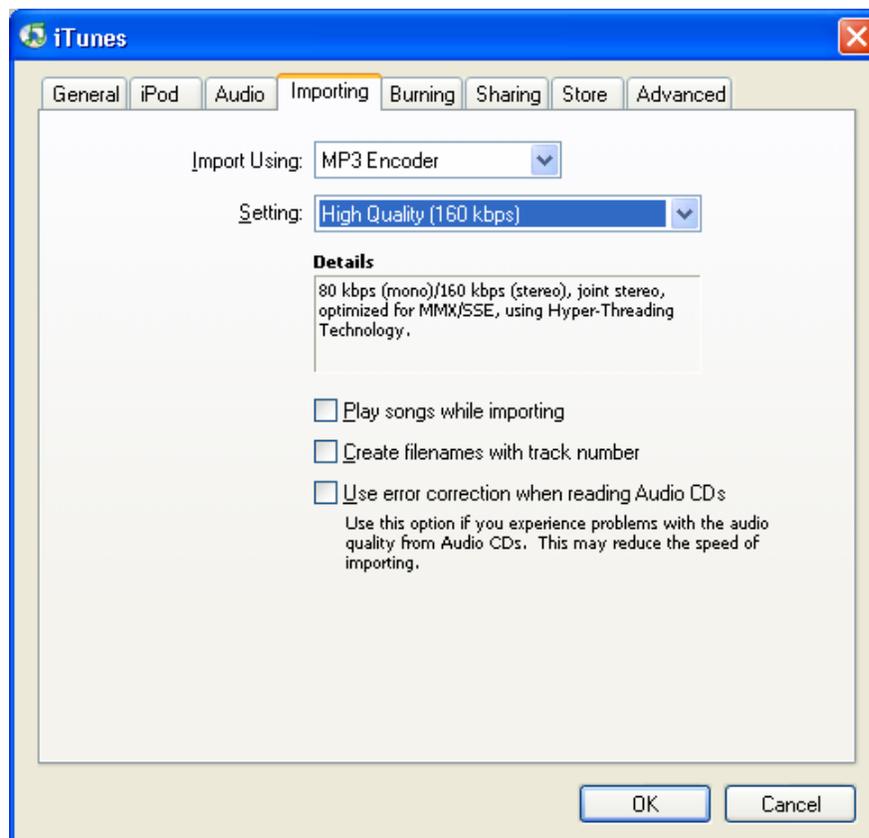
3. From the file menu, select Add File to Library. Browse to the My Music folder under the My Documents folder and choose the test file (mixTest) to add to the library. Click Open after you select the file. The dialog box should now look like the one below.
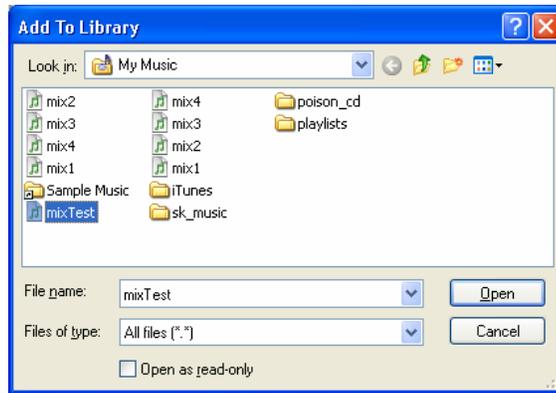
4. iTunes will now show this file in its song-list pane, as in the image below. Right-click on the file, and select the option Convert Selection to MP3.
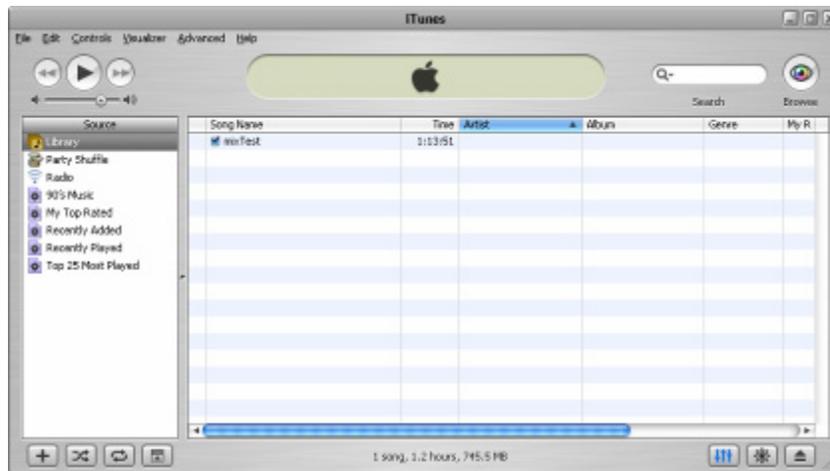
5. During the encoding process, the user interface shows the progress as in the image below.
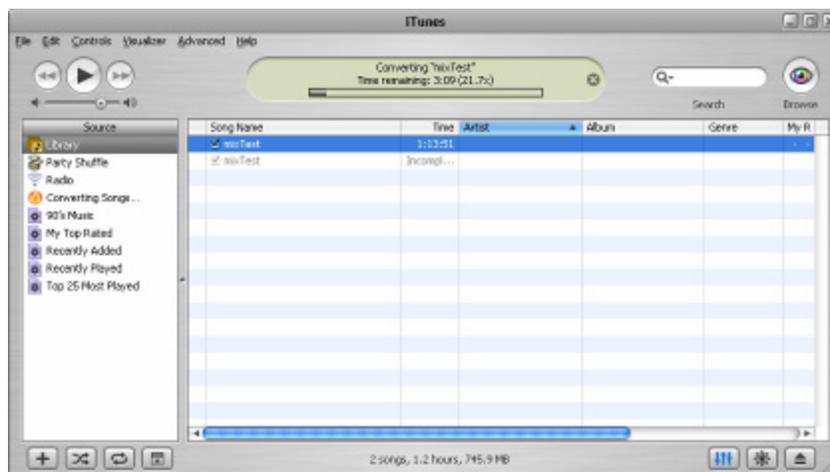
6. Once iTunes has finished the encoding, use Windows Explorer to locate the output .mp3 file in the iTunes directory within the My Music folder, as in the image below.
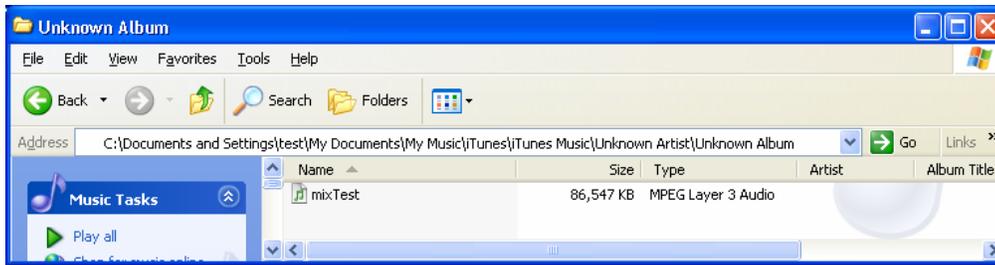
7. Right-click on the file, and choose Properties. A dialog box like the one below should appear.
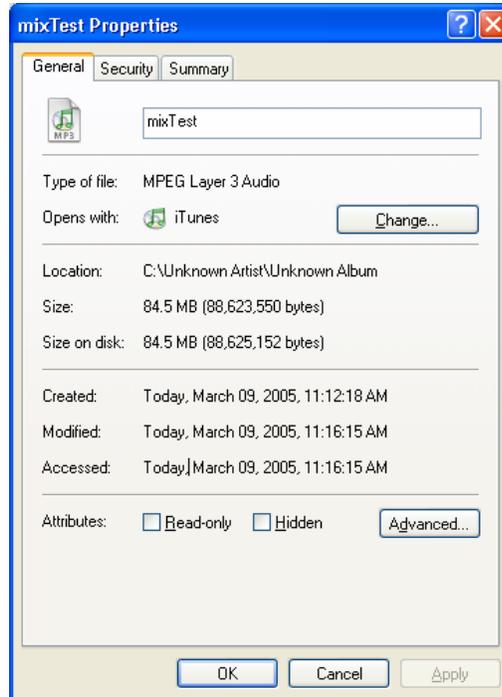
8. Calculate the difference between the file "Created" and "Modified" times. This time is how long iTunes took to encode the file to MP3 format.

Before each iteration of this test, we deleted the .mp3 file and rebooted the system.

Windows Movie Maker 2.1

This application is part of Windows XP Service Pack 2, so we did not need to install it.

To create the test video file, we used our Sony Handycam to shoot approximately seventeen minutes of outdoor footage on a JVC digital tape cassette. Using the software and cables that came with the camera, we streamed approximately four minutes of the video through a USB connection to the PC. This process produced a file, which we named outdoors.avi, with the following specifications:

- Length (minutes:seconds): 4:01
- Size: 1.58 GB (1,698,713,600 bytes)
- Video: 320x240 at 24-bit color, uncompressed (30 fps)
- Audio: PCM at 1411kbps (bit rate)

We then followed these steps to run the Windows Movie Maker test:

1. Launch Windows Movie Maker.
2. In the Movie Maker window, click on the File menu item, and select Import.
3. Navigate to the video test file. Select it, and click the OPEN button. A dialog box like the one below should appear.

4. After you open the file, select the digital video scenes and drag them to the video time line. Windows Movie Maker should now resemble in the image below.
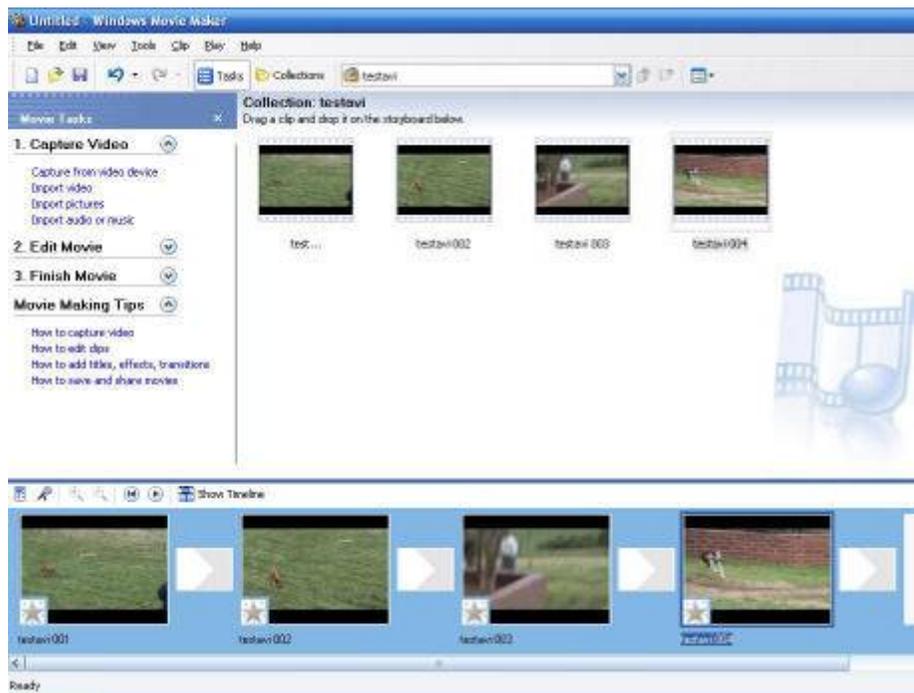
5. Click on the File menu item. and select Save Movie File.

6. In the Save Movie Wizard, select My computer. A dialog box like the one below should appear. Click Next.
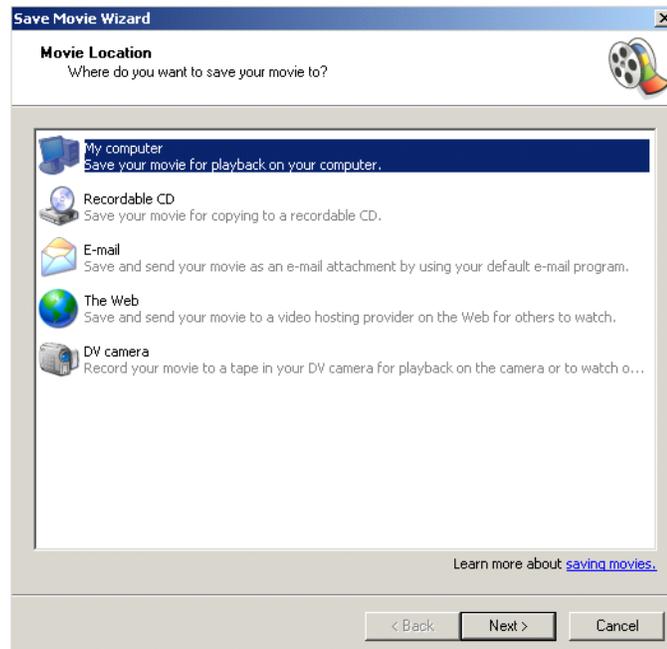
7. The Saved Movie File dialog below will appear. Click Next to save the file in the default location (My Videos).
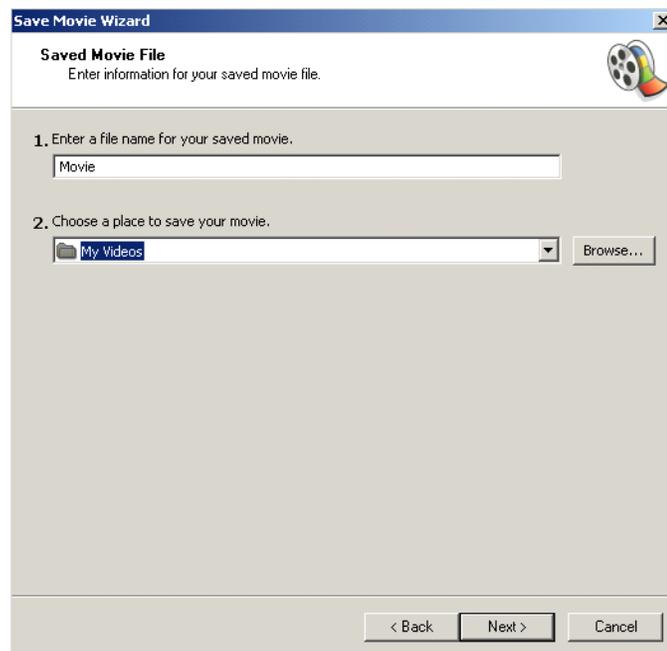
8. The Movie Setting dialog box below will appear. Click Next.

9.   Windows Movie Maker will start encoding the digital video movie, and a progress bar will appear in a Saving Movie dialog box like the one below.

10. When Windows Movie Maker finishes this process, use Windows Explorer to find your Movie.wmv output file.
11. Right click on the file, and select properties.
12. You should be able to see the Created and Modified times as in this example:

13. Calculate the difference between the file "Created" and "Modified" times. This time is how long Windows Movie Maker took to encode the digital video as a Windows Media video file.

Before each iteration of this test, we deleted the .wmv file and rebooted the system.

Adobe* Photoshop* Elements 3.0 with Premiere Elements 1.0

We used these applications to test the speed at which the PCs could convert a slide show to a movie that could go on a DVD.

To create the set of photos we needed for this test, we used our Canon PowerShot A95 digital camera to take thirty pictures of outdoor and indoor scenery. To transfer the photos to the computer, we removed the Compact Flash memory card from the digital camera and inserted it into the Compact Flash slot on each of the two HP Media Center systems. We used the Large/Fine setting on the camera, which produced pictures with the following specifications:

- Resolution: 2592W x 1944H (180 dpi horizontal x 180 dpi vertical)
- Size: Range from 974KB (996,860 bytes) to 3,933KB (4,026,764 bytes)
- Bit depth: 24-bit color

We performed the following steps on each PC to make it ready to run this test:

1. Install Adobe Photoshop Elements 3.0 with Premiere Elements 1.0. Accept the defaults in both installations.
2. Create a .mp3 file by ripping a song from a CD. In our test, we ripped the song "State of Love and Trust" from the Pearl Jam greatest hits compilation CD, *Rearviewmirror*. (The song is track 5 and runs 3:43). Rip the song at a sampling rate of 128KB. We named this test file "slideshow.mp3" and stored it in the My Music directory.

We then followed these steps to run the test:

1. Launch Photoshop Elements. The following startup screen appears.

2. Select and click the fifth icon from the left, Make Photo Creation. The following dialog box will appear.
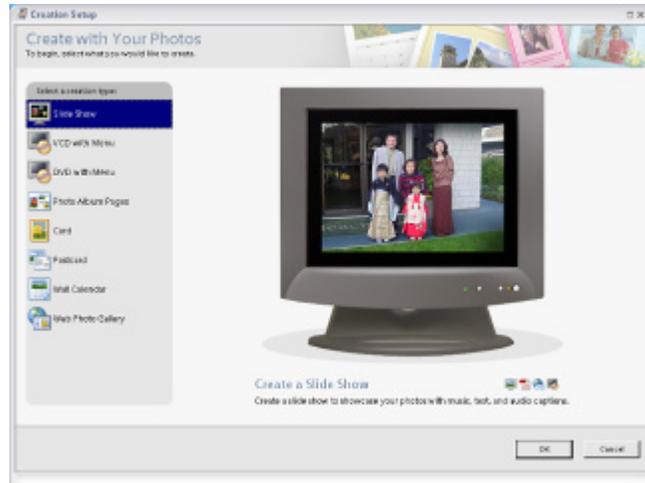
3. Click on creation type Slide Show to create a slide show. The following dialog will appear.
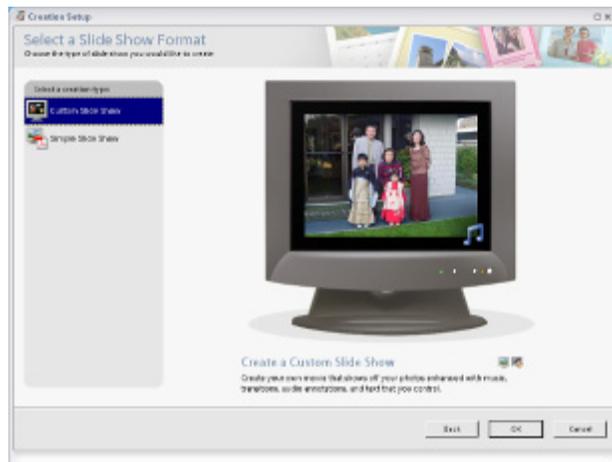
4. Choose the Custom Slide Show creation type.
5. The following dialog will appear and ask if you want to import the photos for the slideshow. Click Yes.

6. Browse to the location of the test photos and select all of them. Click the Get Photos button. A main window like the one below will appear and show all the photos you selected.
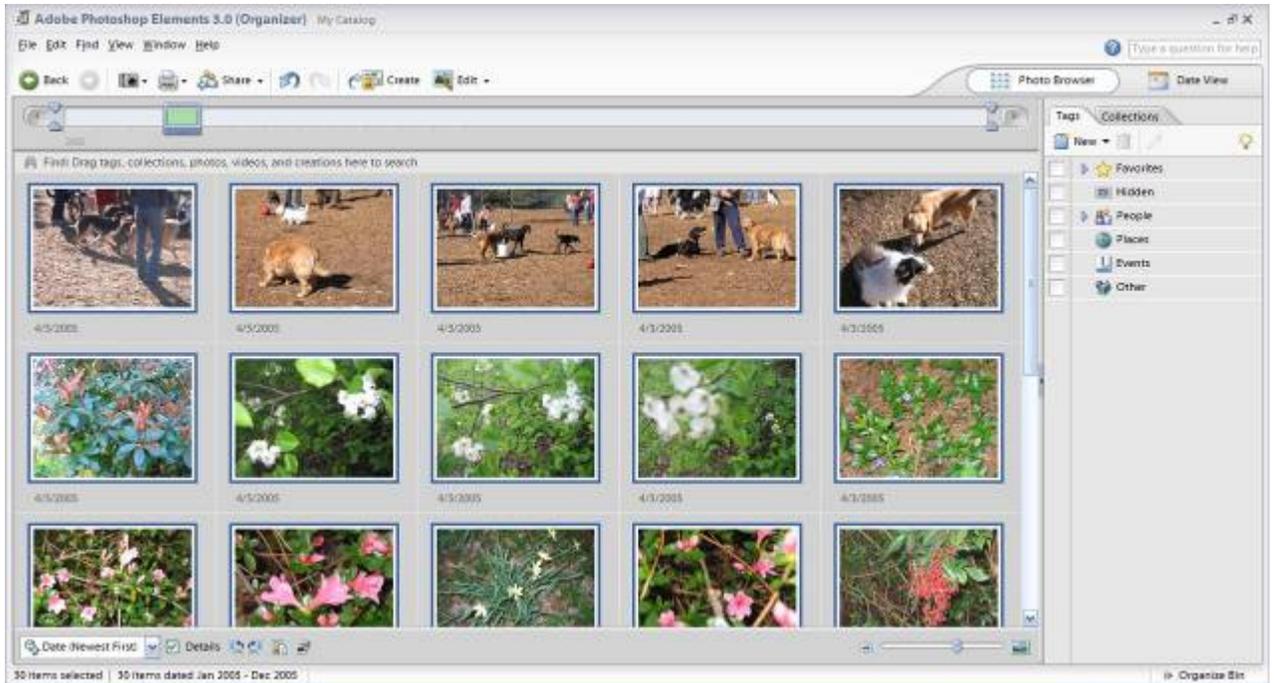
7. Select all of the photos, and click Create. A Slide Show editor display like the one below will appear.

8. Click on the first slide, and change the time delay to two seconds. Click on the same slide again, and apply the two-second delay to all slides.
9. Click on the first slide transition special effect icon that separates the first two slides. Choose the "fade" effect. Click on the "fade"' icon, and apply the same effect to all slide transitions.
10. At the bottom, click on the button Click Here to Add Audio to your Slideshow.

11. Add the .mp3 test file we created earlier (slideshow.mp3) from the My Music directory to the slideshow.
12. From the File pull-down menu at the top, select Save to save the slideshow. A dialog like the one below will appear. Name the slideshow "outdoors".
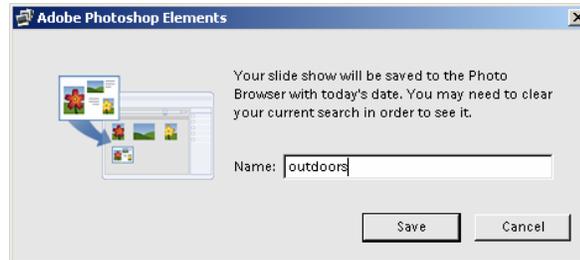
13. The Catalog screen will reappear with the newly created slideshow in the top left corner. Highlight this item, and click the Create button. The following dialog box will appear.
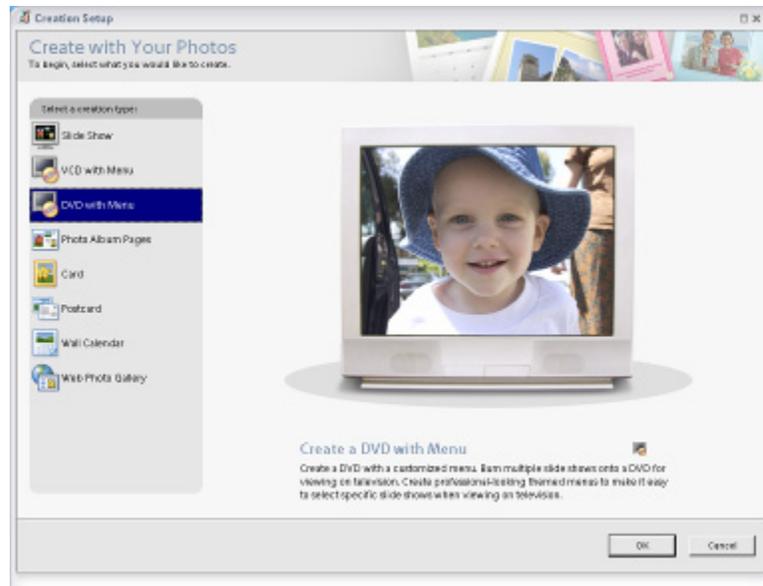
14. Choose DVD with Menu. At the following screen, choose Next.
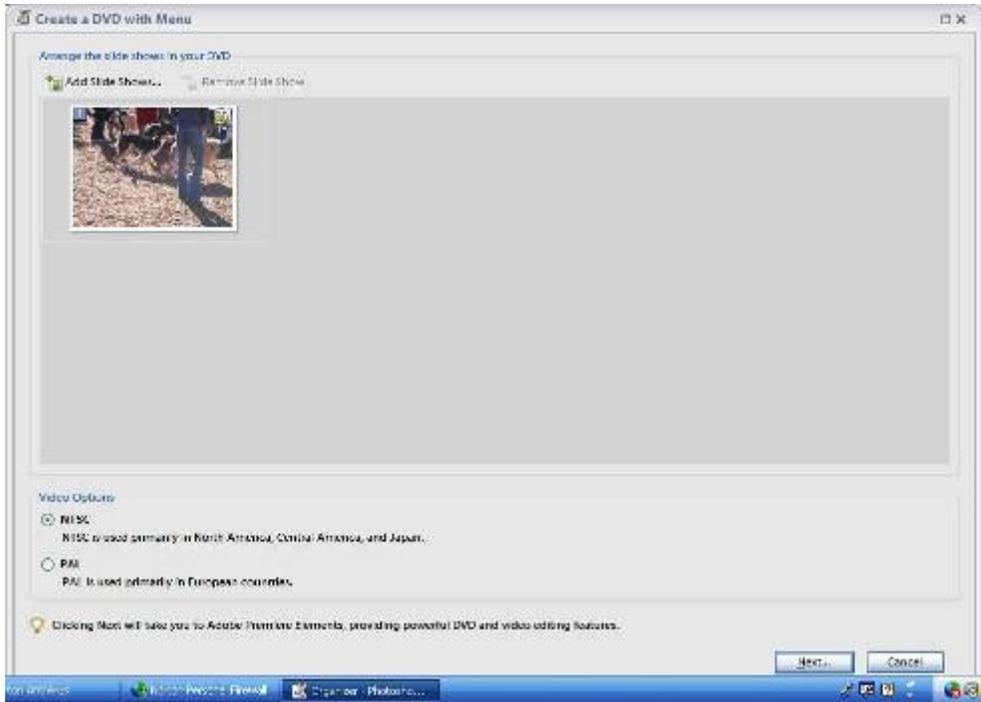
15. The application will now create the Windows Media Video file that holds the DVD creation. A dialog box like the one below will appear and allow you to choose the location of the output file.
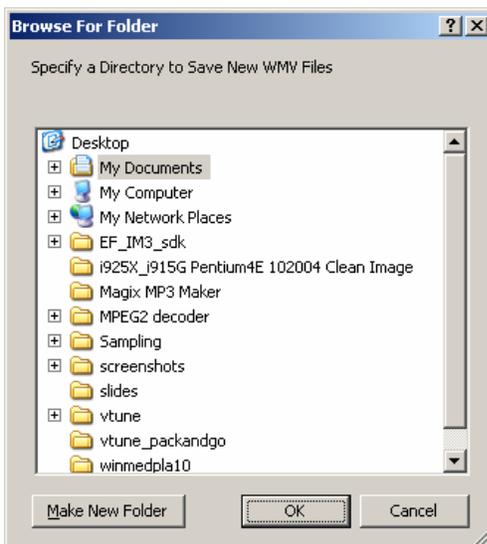
16. While the application is creating the file, a progress dialog like the one below will appear.
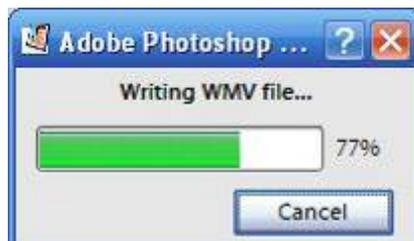
17. When the application has created the file, use Windows Explorer to find the file. Right-click on the file, and select Properties. Calculate the difference between the file "Created" and "Modified" times. This time is how long the application took to encode the slide show as a movie.
18. When Photoshop finishes creating the .wmv file, Premiere Elements automatically launches and displays a dialog prompt to create a new project. Click OK to create the default project. When a dialog like the following image appears, click Apply a Template for a DVD with Menus, and select the top template. Click OK.
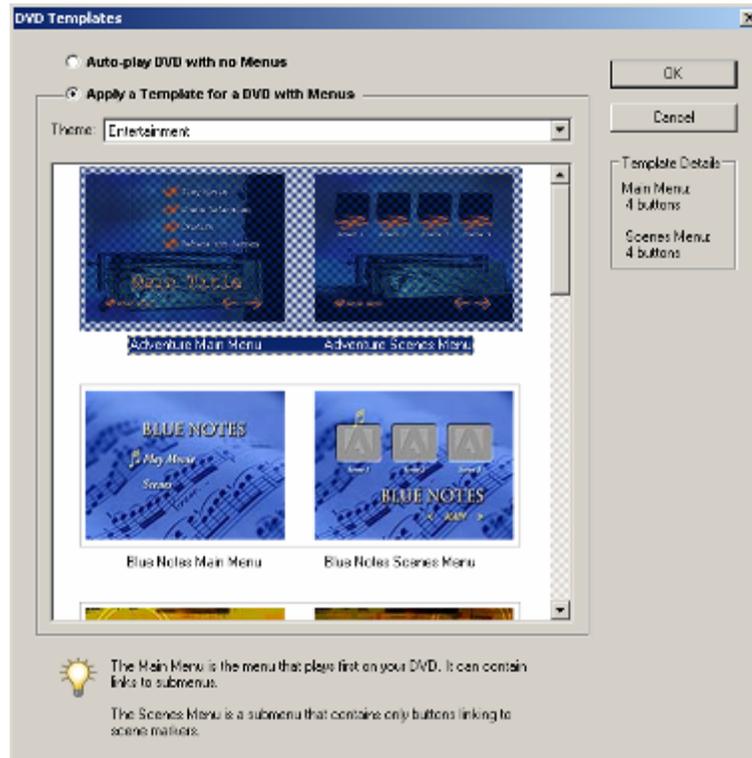
19. Premiere will then ask if you want to create scene markers. Click No. A dialog like the one below will appear.
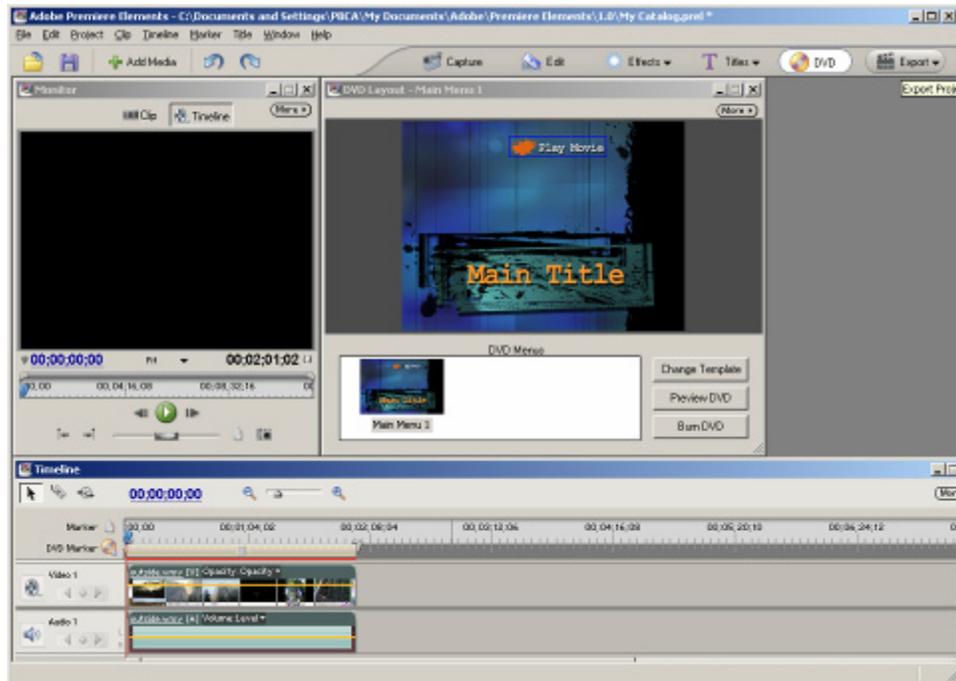
20. Click the Export button to export the file to a DVD. A dialog like the one below will appear. Select the radio button to burn files to a folder.
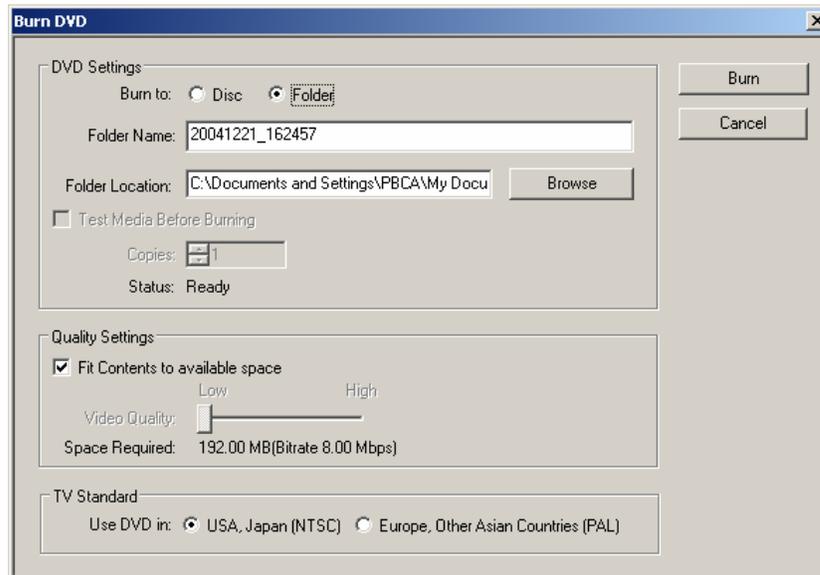
21. Click burn, and start a stopwatch to begin timing. A progress indication like the following one will appear.

Burn DVD Progress

Encoding Media
Burning in progress

Current Task Progress
Encoding...2 Minutes, 50 Seconds Remaining

Overall Progress

Cancel
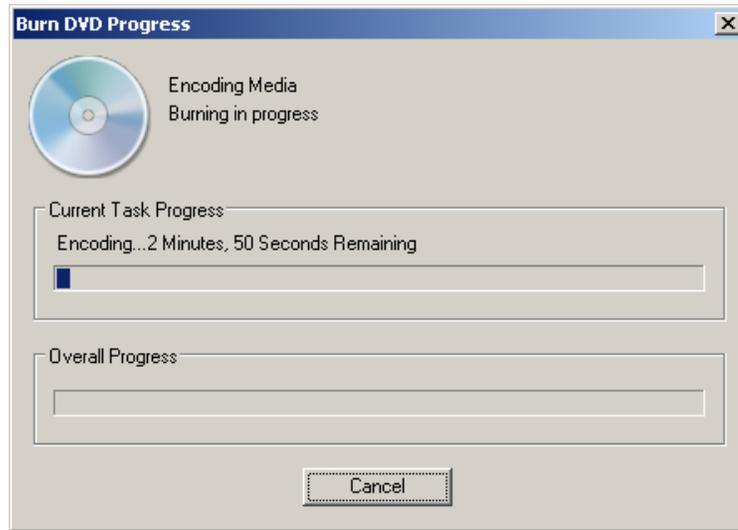
22. When the application has finished burning the folder, click the stopwatch and record the time the application took to create the DVD file.
23. The result for this test is the sum of the time the application took to create the .wmv file and the time for the DVD folder creation. Lower times are better.

TV viewing and PVR playback and recording performance and experience

We performed to connect each system to the surround-sound system for these tests:

1. Connect the video/audio component cable (which came with the DVD player) from the component output of the DVD player to the component input of the RF Modulator.
2. The RF Modulator converts component video and audio input, as well as S-Video inputs, to coax output. Connect the RF Modulator's coax output to the TV tuner coax input on the PC.

We then used the wizard in Windows Media Center to configure each PC's video reception in the following way:

1. Launch Windows Media Center.
2. At the Welcome screen, click Next.
3. At the Media Center Setup screen, click Next.
4. At the Media Center Privacy Policy, click Next.
5. At the Enhanced Playback screen, click No to not automatically connect to the Internet, then click Next.
6. At the Internet Connection screen, click No at the "always on" Internet Connection question, then click Next.
7. At the "No Internet Access" confirmation screen, click Next.
8. At the Required components confirmation screen, click Next.
9. At the Optional Setup screen, click the checkbox at "Configure tuners, TV signal, and Guide" line item, then click Next.
10. The next screen confirms the Region code (which in our case was the United States). Click the box next to "Yes, use this region to configure TV services", then click Next.
11. At the Automatic TV Signal Setup screen, click the box next to "I will manually configure my TV signal", then click Next.
12. At the Select Your TV Signal screen, click the box next to "Cable or digital cable" and then Next.
13. At the "Do You Have a Set-top Box?", click No and then Next.
14. At the number of tuners screen, click the box next to "One", then click Next.

15. At the "Verify Your TV Signal" screen, Windows Media Center presents a small TV screen showing channel 2. Change the channel to 3 and the feed from the DVD player should appear. Click the box next to "Yes" and then Next.
16. At the "Guide Privacy" screen, click the box next to "No" and then Next.
17. Windows Media Center will then return to the Optional Setup screen. Click the box next to "Set up your speakers" and then Next.
18. Click Next at the Welcome to Speaker Setup screen.
19. Click the box next to "5.1 surround speakers" and then Next.
20. Click Test to test the speaker configuration.
21. You should be able to hear sound from all the speakers. Assuming so, click the box next to "I heard sound from all of my speakers", then click Next.
22. Click Finish at the You Are Done! screen.
23. Windows Media Center will return to the Optional Setup screen. Click the box next to "I am finished", then click Next.
24. Click Finish at the You Are Done! screen.
25. Windows Media Center will return to its main screen.
26. Exit the application, then reboot the system.

We performed the following steps on each PC to make it ready for the test.

First, we installed the FRAPS application using the following process. (FRAPS is a tool for measuring display frame rates.)

1. Download the FRAPS frame rate measurement tool from http://www.fraps.com/download.htm.
3. Install the application with default settings.
4. Launch the FRAPS application.
5. Click on the FPS tab.
6. Click the Disabled radio button to disable Overlay Corner. The FRAPS screen should then look like the image below, in which we've circled the radio button in red.
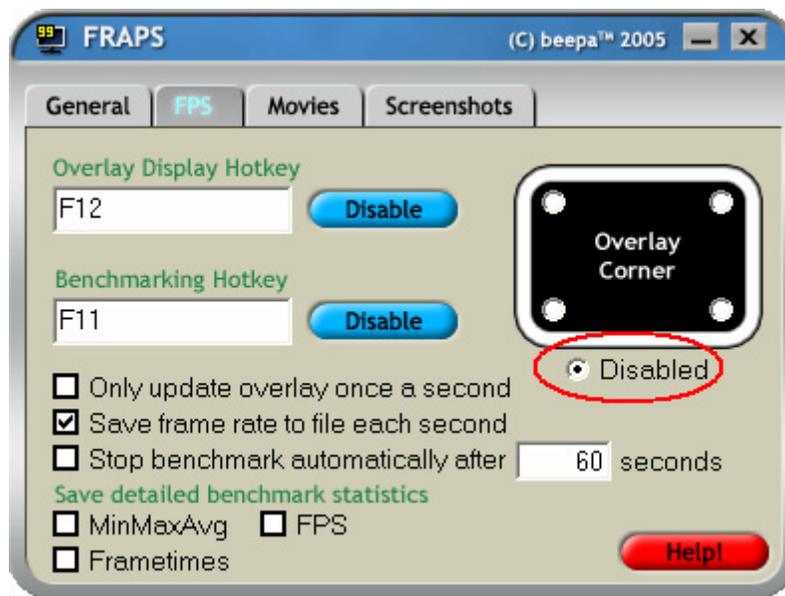
7. Check the box next to "Stop benchmark automatically after 60 seconds", and change the time to 300 seconds (five minutes).
8. Close the application, and click OK at the "Exit Fraps?" dialog box.
9. Reboot the system.

FRAPS generates a couple of results files when you run it. The image below shows an example results file that is the FPS rate for each second of a run of the tool.
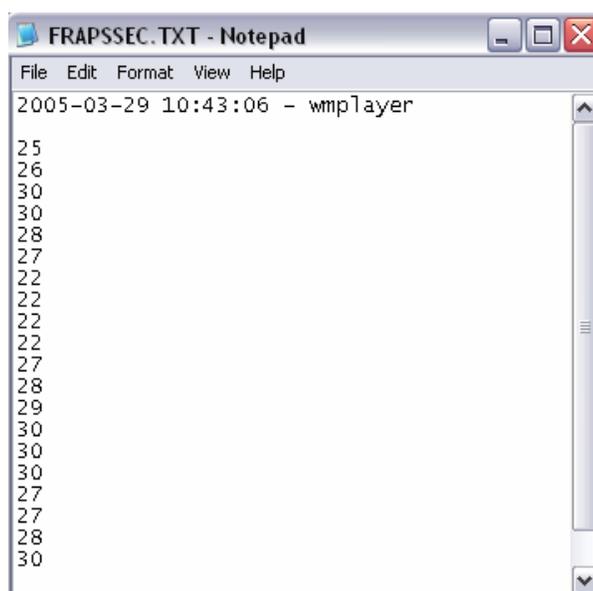
We used this results file to gauge video playback speed. We set 25 FPS as the minimal acceptable rate, because that rate yields reasonable quality video images (and is the frame rate for the PAL video standard in Europe and Asia).

To gauge the quality of a playback test, we calculated the percentage of seconds of playback with FPS rates of 25 or more. For example, in the three of our four tests that used five minutes (300 seconds) of video playback, we calculated the quality percentage by dividing the number of seconds with 25 or higher FPS by 300. Thus, if 270 of the seconds in a test were to have FPS rates of 25 or greater, the test would have 90% of its time at or above the minimum acceptable frame rate.

To try to relate this rate to user experience, we agreed with Intel that a video that played with 95% of its time at or above 25 FPS was an acceptable playback experience.

As with all other tests, we ran each of the video tests three times, rebooting before each test, and reported the median.

We performed the following steps to run the TV viewing performance test:

1. Launch FRAPS. The application will then be running and will wait for a keystroke to start capturing frame rates.
2. Launch Windows Media Center.
3. Select the menu option My TV, and click Live TV.
4. Get the test DVD to the 2:25:30 mark and pause it.
5. Press play again and, at the 2:25:40 mark, press F11 to start the FRAPS data collection.
6. Let the video run for at least five minutes, then stop playback.
7. Close all programs.
8. Use Windows Explorer to explore the benchmarks directory in the C:\Fraps folder. The results are in a text file named "ehshell <date> <time>.csv".
9. Open this file in Notepad, and record the results.
10. Reboot the system.

We performed the following steps to test TV viewing performance while recording with the PVR:

1. Launch FRAPS. The application will then be running and will wait for a keystroke to start capturing frame rates.
2. Launch Windows Media Center.
3. Select the Recorded TV from the My TV menu option.
4. Get the test DVD to the 2:25:30 mark.
5. Select Add Recording in Windows Media Center.
6. The default will be channel 3 and the current hour for the stop and start time. Click Record.
7. While Windows Media Center is recording the video feed, click play on the DVD player.
8. Click back to the Live TV to view the video feed.
9. At the 2:35:40 mark, press F11 to start the Fraps data collection.
10. Let the video run for at least five minutes, then stop playback.
11. Close all programs.
12. Use Windows Explorer to explore the benchmarks directory in the C:\Fraps folder. The results are in a text file named "ehshell <date> <time>.csv".
13. Open this file in Notepad, and record the results.
14. Reboot the system.

We performed the following steps to test the performance of viewing recorded material:

1. Launch FRAPS. The application will then be running and will wait for a keystroke to start capturing frame rates.
2. Launch Windows Media Center.
3. Select the menu option My TV, then click Recorded TV.
4. Play the first recording and wait for the moment that was the 2:25:40 mark on the DVD.
5. Press F11 to start the Fraps recording.
6. Let the video run for at least five minutes, then stop playback.
7. Close all programs.
8. Use Windows Explorer to explore the benchmarks directory in the C:\Fraps folder. The results are in a text file named "ehshell <date> <time>.csv".
9. Open this file in Notepad, and record the results.
10. Reboot the system.

We performed the following steps to test performance while viewing high-definition recorded material:

1. Open the FRAPS application.
2. Click the FPS tab in FRAPS, and change the number in the Stop benchmark automatically prompt to 120 seconds (two minutes).
3. Launch Windows Media Center.
4. Select the menu option My Videos, and click "Mysteries of the Nile (Hi-def)".
5. As soon as the recording starts, press F11 to start the FRAPS data collection.
6. Let the video run until it finishes.
7. Close all programs.
8. Use Windows Explorer to explore the benchmarks directory in the C:\Fraps folder. The results are in a text file named "ehshell <date> <time>.csv".
9. Open this file in Notepad, and record the results.
10. Reboot the system.

Gaming Tests

As with all other tests, we ran each game test three times and reported the median. We rebooted before each test.

Doom 3

We performed the following steps on each PC to make it ready to run this test:

1. Install Doom 3 with all the default settings except one: Do not install DirectX 9.0b. (XP SP2 comes with a newer version, 9.0c, that works with Doom 3.)
2. Launch Doom III.
3. Under Options, select System and make the following changes:
   - Make sure High Quality is selected; it should be the default.
   - Change the screen size option to 800x600.
   - For the Intel-based system, we also tested at 1024x768, a common setting for systems with similar hardware capabilities. We could not, however, test at the same resolution on the AMD-based system as Doom 3 would not allow us to set the resolution that high. (We would enter 1024x768, exit, and restart the game to let the changes take effect, but Doom 3 would automatically switch the resolution back to 800x600.)
4. Click Apply Changes, then click OK at the Apply Video Changes dialog box.
5. Exit Doom III, and click Yes to the Are you sure you want to exit dialog box.

We followed this process to run the test:

1. Launch Doom III.
2. At the main Doom III menu, press the Ctrl, Alt, and ~ keys to enter the game console.
3. In the console, type "timedemo demo 1", and press the Enter key.
4. When the demo concludes, record the FPS score, then click OK.

The timedemo produces results in frames per second; higher scores are better.

Unreal Tournament 2004

We performed the following steps on each PC to make it ready to run this test:

1. Install Unreal Tournament with all the default settings except the following:
   - Do not install DirectX 9.0b. (XP SP2 comes with a newer version, 9.0c, that works with Unreal Tournament 2004.)
   - Do not install the extra mods.
2. Install Patch 3355 with default settings.
3. Copy the demos Intel supplied (assault.demo4, bots.demo4, and flyby.demo4) into the C:\UT2004\Demo directory.
4. Copy the two text files Intel supplied (demo_bots.txt and demo_flyby.txt) into the C:\UT2004\System directory.
5. Copy the two batch files Intel supplied (bots.bat and flyby.bat) into the C:\UT2004 directory.
6. Edit the two batch files with Notepad to change the resolution from 1024x768 to 800x600. (For the Intel-based system, we also ran the tests with the 1024x768 resolution and changed this file appropriately.)
7. Create a desktop shortcut to each of the two edited batch files.
8. Start Unreal 2004 and click on Settings.
9. Under the Display tab, set the resolution to 800x600. (For the Intel-based system, we also tested at 1024x768, which we had to set here.).
10. Exit the game.

We followed this process to run the tests:

1. Double-click on the shortcut to the batch file of the test you want to run.
2. Unreal Tournament 2004 will start and run that demo.
3. After the batch file has finished, the main Unreal Tournament screen will appear.
4. Press the "~" key to launch the game console. Record the FPS score.
5. Exit the game.

Each of the timedemos produces results in frames per second; higher scores are better.

Half-Life 2

We performed the following steps on each PC to make it ready to run this test:

1. Connect the system to the Internet.
2. Install Half-Life 2 and its associated Steam application. Select all the defaults except the following:
   - In Steam, select that the user is 13 years or older.
   - In Steam, select that the Internet connection is LAN/T1 greater than 1M.
3. After you complete the installation, register and activate the game through the Steam application.
4. Reboot the system.
5. Log in to the Steam application, and close the update news window.
6. Double-click the Half-Life 2 icon. Steam will run an update to the game.
7. When Steam completes the update, click Cancel and reboot the system.
8. Copy the demo file at_c17_12-rev7.dem to the directory
   "C:\Program Files\Valve\Steam\SteamApps\<STEAM_USERNAME>\half-life 2\hl2.
9. Put the "For Benchmarking Half-Life2" shortcut onto the desktop.
10. Disconnect the network connection.
11. Reboot the computer.

We followed this process to run the test:

1. When the system boots, a message box will appear stating "connection error" and "could not connect to the Steam network". Click "Start in Offline Mode".
2. Start the Half-Life2 benchmark by double-clicking the "Benchmarking Half Life 2" icon on the desktop.
3. Half-Life 2 will start, and its game console will appear. At the bottom of the game console, type "timedemo at_c17_12-rev7.dem" to launch the demo.
4. When the demo completes, record the FPS rate from the line below the command. (This line will have the format "xxxx frames xx.xx seconds. ##.## fps x.xxx fps variability", where ##.## is the FPS rate you should record.)

The demo's result is in frames per second; higher scores are better.

Appendix A: Test system price and purchase information

We purchased the two HP built-to-order systems on February 25, 2005 via www.hpshopping.com.

Figure 10 below presents the SKU and price information for the two PCs.

System	HP Media Center PC m1050y	HP Media Center PC m1050e
Processor	Intel Pentium 4 540J	AMD Athlon64 3700+
Processor frequency (GHz)	3.2	2.4
Part number	PU060AV#ABA	PU061AV#ABA
Unit price ($)	1,449.99	1,509.99
Tax ($) [1]	0.00	0.00
Shipping ($) [2]	49.50	49.50
Total we paid ($)	1,499.49	1,559.49

Figure 10: Purchase information for the two HP Media Center PCs.

Notes:
[1] www.hpshopping.com did not charge tax.
[2] We assigned each system half of the total shipping charge we paid for this order.

On March 17, 2005, we purchased the bulk of the home audio and video equipment we used in this test at the following store:

Best Buy #299
Pleasant Valley Promenade
6254 Glenwood Avenue
Raleigh, NC 27612

For all equipment we purchased from a retail outlet, tax reflects the North Carolina tax rate of 7.0%. We also paid no shipping on any such equipment, because we picked it up at the store.

Figure 11 below presents the SKU and price information for this equipment.

Equipment	Sony DVD Dream System (Model No. (DAV-FR1)	Samsung DVD Player (Model No. (DVD-HD841)	Samsung 22" LCD TV (Model No. (LTP227W)	Sony Handycam digital camcorder (Model No. (DCR-HC41)	Canon 5.0 Megapixel digital camera (Model No. Power-shot A95)
SKU	6654845	6304046	6407809	6956421	6742117
Unit price ($)	379.99	179.99	1,199.99	549.99	329.99
Tax ($)	26.60	12.60	84.00	38.50	23.10
Total we paid ($)	406.59	192.59	1,283.99	588.49	353.09

Figure 11: Purchase information for the home audio and video equipment we used in our testing.

We purchased additional cables and other accessories for testing on March 23, 2005 and April 4, 2005 at the above store and at the following one:

Best Buy #147
Cary Crossroads Center
237 Crossroads Blvd.
Cary, NC 27511-6893

Figure 12 presents the SKU and price information for the cables and accessories.

Cables and accessories	Acoustic Research S-Video cable (AP021)	Acoustic Research Digital Optical Audio cable (AP081)	Acoustic Research RCA "Y" Adapter (AP042) x 3 @ 13.49 each	Acoustic Research Stereo Audio (AP031)	JVC 60 minute Mini Digital Video Cassette 2 pack (MDV60ME2HT)	Recoton 16-guage speaker wire (SWR16100)
SKU	4118029	4118154	4117672	4117556	5311815	1742948
Unit price ($)	22.99	26.99	40.47	14.99	14.99	19.99
Tax ($)	1.61	1.89	2.83	1.05	1.05	1.40
Total we paid ($)	24.60	28.88	43.30	16.04	16.04	21.39

Figure 12: Purchase information for cabling and accessories we used in our testing.

On April 4, 2005 and April 6, 2005, at the same two stores, we purchased an additional receiver to accommodate the AMD audio interface and an RF Modulator to connect our DVD player to the AMD and Intel TV tuner cards using the cards' coax connection.

Receiver and RF Modulator	Sony Home Theater Receiver (STR-DEF98)	Dynex RF Modulator (WS-007)
SKU	7118371	5806345
Unit price ($)	189.99	21.99
Tax ($)	13.30	1.54
Total we paid ($)	203.29	23.53

Figure 13: Purchase information for the second receiver and RF modulator we used in our testing.

Appendix B: Test system configuration information

This appendix provides detailed configuration information about the two test systems.

System	HP m1050y Media Center	HP m1050e Media Center
General		
Processor and OS kernel: (physical, core, logical) / (UP, MP)	1P1C2L / MP	1P1C1L / SP
Number of physical processors	1	1
Single/Dual Core processors	Single core	Single core
Processor HT Status	N/A	N/A
System Power Management Policy (AC/AlwaysOn, AC/Adaptive, DC/AlwaysOn, DC/Adaptive, Other)	AC / AlwaysOn	AC/AlwaysOn
CPU		
Segment (S=Server, D=Desktop, M=Mobile)	D	D
Vendor	Intel	AMD
Name	Pentium 4	Athlon64
Code name	Prescott	Clawhammer
Model number	Pentium 4 540J	Athlon64 3700+
Stepping	1	A
Socket type and number of pins	LGA775	Socket 754
Core frequency	3200	2400
Front-side bus frequency	800	800
L1 Cache	16KB + 12KB	64KB
L2 Cache	1MB	1MB
Platform		
Vendor and model number	ASUS - Puffer	ASUS - Salmon
Motherboard model number	Intel® 915G	K8S-LA
Motherboard chipset	Intel® 915G	SiS760
Motherboard chipset codename	Grantsdale	Salmon
Motherboard revision number	0qq1112RE101PUFFE00	0qq1112RE101SALMO00
System/motherboard serial number	MXP51100XZNA550	MXP51100XWNA550
Bios name and version	American Megatrends, version 3.12	Phoenix Technologies, version 3.07
BIOS settings	Setup Default	Setup Default
Chipset INF driver	Not available because the vendor installed the drivers	Not available because the vendor installed the drivers
Memory module(s)		
Vendor and model number	Samsung-M3 68L6523CUS-CCC	Samsung-M3 68L6523CUS-CCC
Type	PC3200 DDR-SDRAM	PC3200 DDR-SDRAM
Speed (MHz)	400	400
Speed running in the system (MHz)	200	200
Timing/Latency (tCL-tRCD-tRP-tRASmin)	3-3-3-8	3-3-3-8
Size	1024MB	1024MB
Number of sticks	2 X 512MB	2 X 512MB

Chip organization (Single-sided, Double-sided)	Single-sided	Single-sided
Channel (Single/Dual)	Dual	Dual
Hard disk		
Vendor and model number	Seagate ST3200822AS	Seagate ST3200822AS
Size	200GB	200GB
Buffer Size	8MB	8MB
RPM	7200	7200
Type	Serial ATA 1.5	Serial ATA 1.5
Controller	Intel 82801FB (ICH6)	Intel 82801FB (ICH6)
Driver	Windows XP driver version 5.1.2535.0	Windows XP driver version 5.1.2535.0
Operating system		
Name	Windows XP Media Center Ed.	Windows XP Media Center Ed.
Build number	2600	2600
Service pack	SP2	SP2
File system	NTFS	NTFS
Kernel	ACPI Multiprocessor PC	ACPI Multiprocessor PC
Language	English	English
Microsoft DirectX version	DirectX 9.0c	DirectX 9.0c
Graphics		
Vendor and model number	ATI Radeon X600 Series	nVidia GeForce FX 5700
Chipset	ATI Radeon X600 PRO (0x3E50)	nVidia GeForce FX 5700
Chipset codename	RV380	NV36
BIOS version	113-AA14300-106 256MB 450E/290M BIOS	4.36.20.21.39
Type (P=PCI Express, A=AGP 8X, I=Integrated)	P	A
Memory size	256MB	256MB
Resolution	1280 x 720 x 32 bit color	1280 x 720 x 32 bit color
Driver	ATI Technologies, version 6.14.10.6483	nVidia, version 6.6.7.2 (updated to 7.1.8.4 for PCMark04 tests)
Other information	Hauppauge WinTV PVR PCI II (see details below)*	Hauppauge WinTV PVR PCI II (see details below)*
Sound card/subsystem		
Vendor and model number	Realtek HD Audio	Realtek ALC658C 6-channel
Type (P=PCI, I=Integrated)	I	I
Driver	Realtek Semiconductor Corp., version 5.10.0.5028	Realtek Semiconductor Corp., version 5.10.0.5730
Network card/subsystem		
Vendor and model number	Realtek RTL8139 Family Fast Ethernet NIC	Sis 900-Based PCI Fast Ethernet Adapter
Type	Integrated	Integrated
Driver	Realtek Semiconductor Corp., version 5.505.1004.2002	SiS, version 1.16.08
Optical drive(s)		
Vendor and model number	HP DVD Writer 640c (CD 48x Rd, 24x RW, 48x Wr) (DVD 16x Rd, 16x Wr)	HP DVD Writer 640c (CD 48x Rd, 24x RW, 48x Wr) (DVD 16x Rd, 16x Wr)
Type (CDROM, CDRW, DVD-ROM, DVD-W)	DVD-RW	DVD-RW

Interface (I=Internal, E=External)	I	I
USB ports		
Number	6	6
Type	2.0	2.0
Monitor		
CRT/LCD type (P=Plug & Play, T=TFT, R=Reflective)	P	P
CRT/LCD refresh rate	60 Hz	60 Hz
Other information	Samsung 22" LCD TV, Model No. LTP227W	Samsung 22" LCD TV, Model No. LTP227W
Video and Audio Input Recording		
Vendor and Model Number	Hauppauge WinTV-PVR-250MCE	Hauppauge WinTV-PVR-250MCE
Type	PCI Express	PCI
Driver	Hauppauge, version 2.0.18.22316	Hauppauge, version 2.0.18.22316
Inputs	S-Video, coax TV, coax FM, audio component	S-Video, coax TV, coax FM, audio component

Figure 14: System configuration information for both test systems.

Appendix C: Test content

We used the following commercially available content in our tests:

- CD playback: Pearl Jam, *Rearviewmirror* (Greatest Hits double CD)
- DVD audio playback (sound quality is DTS 5.1, 96 kHz, 24-bit sampling)
  - Queen, *A Night at the Opera* (DVD-A, DTS 5.1, Dolby Digital 2.0)
  - Yes, *Fragile* (DVD-A 5.1 and 2.0, Dolby Digital 5.1, DTS 5.1)
  - Emerson, Lake, and Palmer, *Brain Salad Surgery* (DVD-A 5.1 and 2.0, Dolby Digital 5.1)
- TV viewing: A college football DVD of the University of Miami vs. the University of North Carolina game on October 30, 2004. This DVD is a rebroadcast of the live video feed from a local broadcast and was filmed in standard definition.
- DVD movies:
  - *The Fifth Element*, Superbit Version (sound: DTS 5.1)
  - *Star Wars II: Attack of the Clones* (sound: Dolby Digital EX. 5.1)
  - *The Incredibles* (sound: Dolby Digital 5.1)
- High-Definition DVD: *Mysteries of the Nile* (a DVD that came with each system)
- Games:
  - Doom 3 version 1.1
  - Unreal Tournament 2004
  - Half-Life 2 custom