A LITTLE MORE HARD WORK...

A LITTLE MORE HARDWARE...

A LITTLE MORE SOFTWARE...HOW MUCH BETTER CAN YOU MAKE A SMALL-FORM-FACTOR PC?

And then there was one: one more time

By Brian Dipert, Technical Editor

AT A GLANCE

- A PCI add-in card significantly boosted Spirit's 3-D-graphics performance and quality.
- An external analog- and digital-TV tuner made effective use of USB2's High Speed mode bandwidth and lightened the CPU load.
- Lindows.com smoothly boots, comprehensively functions, and snappily responds.
- A processor and memory upgrade unlocks additional mini-ITX-format possibilities.

When you last read about Spirit (my hand-built, mini-ITX-based living-room PC) almost two months ago, it was adroitly handling conventional computing tasks (**Reference 1**). Its 3-D graphics capabilities, however, significantly lagged behind what was required to kick my Xbox out of the home-theater cabinet. Likewise, its jerky PVR (personal-video-recorder) playback performance left my ReplayTV feeling unthreatened about its prospective obsolescence.

Time and technology predictably advance in lock step, however, and I've made progress optimizing the original system based on Via's 1-GHz C3 Nehemiah processor. Incremental hardware- and software-tweaking produces diminishing returns, however, and, beyond a certain point, *no* amount of fine-tuning and customization effort will turn a Yugo into a Ferrari. So, I'll also discuss the results I obtained when I swapped out Via's M10000 motherboard for a mini-ITX alternative from Lippert, based on an Intel 1.6-MHz Pentium M processor (**Figure 1**).

As with the Spirit project, my primary objective is to provide you with information that you can extrapolate to the set of strengths and shortcomings of each mini-ITX alternative as they relate to the various embedded systems you design in your day jobs. It's obvious from the feedback I've received, though, that many of you are *also* interested in building your own living-room PCs. I hope my observations will be of use to you in this enjoyable off-hours endeavor.

PERFECTING POLYGONS

I'm still not sure why I was unable to get the ATI Technologies All-In-Wonder VE graphics card to work in Spirit's PCI slot. Finding a compatible graphics subsystem for a mini-ITX motherboard is challenging nowadays, BIOS and software-driver issues aside, due to several hardware obstacles. The graphics industry is in the middle of a transition beyond the AGP bus to the PCI Express interface in latest generation core-logic chip sets from Intel and its competitors, thereby effectively obsoleting the even older PCI interface. Also, both the Casetronic and the Morex enclosures this project uses feed PCI cards sideways into the system from the back, through narrow openings that are only ½-in. tall (**Figure 2**). Electrolytic capacitors, fans and passive heat sinks, and TV-tuner "cans" all frequently cause boards to exceed this maximum profile.

Fortunately, several boards in Nvidia's Quadro series fit the bill. The Quadro NVS 200 and NVS 280 are both low-profile cards that rely on passive cooling. (Nvidia bases the NVS 200 on the NV17—that is, the GeForce 4 MX—core; it bases the NVS 280 on the NV18—that is, the GeForce 4 MX 400, which adds support for AGP 8× and local frame-buffer DDR SDRAM.) Nvidia

is careful to position the boards as primarily useful in 2-D applications, not wanting to cannibalize sales of the company's higher end Quadro FX line. But compared with the built-in 3-D graphics capabilities of the Via CLE266 chip set, the Quadro NVS boards more than hold their own.

By configuring Spirit's BIOS to prioritize a graphics subsystem in the PCI slot versus the CLE266's integrated graphics core, I was able to route system start-up and initial Windows splash-screen displays to the Quadro NVS 280. And, once I'd booted the operating system, a simple reconfiguration of Display Properties routed all Windows XP screens exclusively to the Nvidia board. The result? At 800×600-pixel resolution with a 32-bit color setting and antialiasing turned off, the Futuremark 3DMark 2001 scores of 2784 (with the Nvidia v6.14.10.5216 drivers in their "high-performance" mode) and 2842 (with the drivers in "quality" mode) were nearly four times higher than the score I obtained with the CLE266 built-in graphics. At 1024×768-pixel resolution, the Nvidia results were approximately 4.5 times higher than the Via score. And with four-sample antialiasing turned on to improve image quality (at the expense of frame-rate performance), the Quadro 280 still handily outpaced its non-AA-equipped Via counterpart by a factor of approximately 2.5 at both resolution settings.

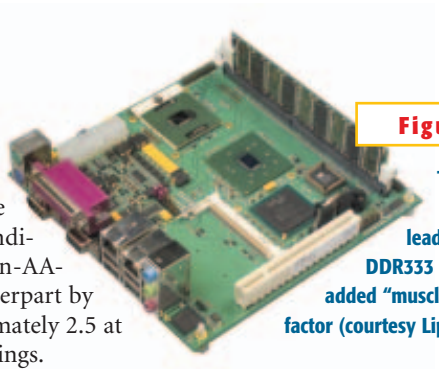


Figure 1

Thunderbird's 1.6-GHz Pentium M processor, leading-edge core logic, and DDR333 SDRAM support bring added "muscle" to the mini-ITX form factor (courtesy Lippert).

You probably noticed something strange in the Nvidia numbers: The quality-optimized score was higher than the score obtained with the drivers at their "high-performance" setting. If you visit the Web-site addendum to this article at www.edn.com, where you can access all of the scores along with detailed reports and screenshots, you'll find that there's no consistency in results with respect to this driver setting (see **sidebar** "Back to the Web"). I suspect that the driver optimizations have no effect on the now-trailing-edge DirectX 7 API features exercised by 3DMark 2001 and that the discrepancies are due to minor, normal run-to-run benchmark variance.

Speaking of APIs, although I was previously unable to run Futuremark's 3DMark03 on Spirit's Via graphics core, due to its incomplete DirectX feature set, I was able to test the Quadro NVS 280 on 3DMark03. You'll find these results, along with those for PCMark04 (in which the Nvidia-inclusive system also outpaced its CLE266-reliant predecessor, though not as dramatically, because the PCMark04 benchmark doesn't focus exclusively on 3-D functions), in the Web-site addendum. The Quadro NVS 280 did (barely) beat the 60-minute Discreet 3D Studio Max script time-out in BAPCo's SysMark 2004, which had tripped up the Via CLE266 graphics core. But the subsequent Adobe Premiere-plus-Photoshop script, which relied heavily on the still-slow CPU, once again prevented the Internet Content Creation test sequence from completing.

RECUPERATING RECEPTION

Redirecting SnapStream's BeyondTV to the Nvidia graphics board instead of the CLE266 graphics subsystem may enable tolerable MPEG-2 playback frame rates (see **sidebar** "Nearing the finish line"). By coupling the Quadro NVS 280 with the Hauppauge WinTV-PVR 250 card, to handle MPEG-2 encoding, I'd have a usable Xbox-plus-ReplayTV or -TiVo replacement. But I couldn't squeeze the resulting two-card system into the trim Morex 2699 case; it would require a larger dual-slot enclosure, such as the Casetronic Travla C137. I've also heard but have not yet confirmed that SageTV, a PVR-on-PC software suite from Frey Technologies, does a solid job of taking advantage of any available video acceleration in a Windows-based system; Linux fans should similarly try out the MythTV program.

All this talk of digitizing analog video and encoding MPEG-2 bit streams is quaint in the budding era of already-compressed digital television. Last summer, the local Public Broadcasting Service affiliate in Sacramento, CA, became the final station in my area to broadcast DTV content. Unfortunately, none of the TeraLogic (then Oak Technologies, now Zoran) Janus-inclusive HDTV PC add-in cards I possess have a sufficiently low profile to fit through the rear-entry slot of the

NEARING THE FINISH LINE

Lippert is going to let me swap my Thunderbird board at the late-March Embedded Systems Conference in San Francisco; I anticipate that the replacement motherboard will resolve the audio and graphics issues I encountered. Nvidia has provided me with a latest generation Quadro FX 600 card, derived from the company's GeForce FX 5200. Once I obtain a stable motherboard and a correctly keyed and oriented PCI riser card, I plan to install the Quadro FX 600 in Opportunity and benchmark the Nvidia board against the Intel-designed integrated graphics core.

I also plan to put the Quadro FX 600 into Spirit and see how much incremental performance I can eke out of that system, with its comparatively trailing-edge CPU. Will the CPU's inability to feed it polygons and other graphics information fast enough hold back the state-of-the-art graphics board's potential? We'll find out.

I also plan to hook up and testdrive Creative Labs' Audigy2 NX; I'm particularly looking forward to trying out its support for DVD-Audio discs (Figure A). And I'd like to revisit BeyondTV on the Nvidia graphics card and try out SageTV.

Finally, I'd like to further explore Lindows and other Linux distributions on Spirit and Opportunity and maybe even build yet another system based on Transmeta-powered mini-ITX hardware, as my bandwidth allows. Visit the Web-site addendum to this article at www.edn.com for all the details.

Figure A

The Creative Labs Audigy2 NX external USB audio peripheral supports the high-resolution, multichannel DVD-Audio format.

Casetronic or Morex cases (**Reference 2**). However, at January's Consumer Electronics Show in Las Vegas, a Sasem representative at the InterVideo booth gave me my first demonstration of Sasem's OnAir USB HDTV tuner (**Figure 3**).

OnAir USB HDTV includes two antenna inputs: one for analog and digital television and the other for digital-only reception. It also provides dual-channel analog audio inputs, along with composite-video and S-Video inputs. When it receives a digital broadcast, it demodulates the signal into corresponding audio and video bit streams and sends them over a 480-Mbps USB 2.0 connection to the PC for decode and playback in conjunction with InterVideo codecs. Incoming analog-video and analog-television broadcasts get digitized and MPEG-2-compressed (at several user-selectable quality-versus-size settings) by circuitry inside OnAir USB HDTV, thereby unburdening the PC's CPU, before the peripheral sends the data to the PC over the High Speed USB connection.

OnAir USB HDTV's hardware, which includes an IR remote control, seems from all indications to be solid. Software issues currently prevent the device from reaching its full potential, but the product is new, and in time, the manufacturer will likely iron out the wrinkles. Sasem's user-interface application randomly crashes when you use it with the Nvidia graphics card, and it consistently crashes (regardless of whether DirectX VA is enabled) when it attempts to display a broadcast channel in conjunction with the CLE266 graphics core. Although you can schedule recording start and stop times, there's currently no integrated program guide, although OnAir plans one. Time-shifting currently works only with analog television broadcasts; audio/video synchronization is a hit-and-miss affair; and the Korean-to-English translations of some of the words and phrases in the user interface and help documentation are interesting, to say the least.

When OnAir USB HDTV works, though, it produces stunning results. Sasem provides a time- and file-size-limited high-definition video player, along with two short video clips, that you can freely download from the company's Web site and use to test whether your system has enough horsepower to handle HDTV playback. Spirit undershoots the minimum recommended processor specifications (if you translate the 1-GHz C3 Nehemiah to its 500-MHz Pentium III equivalent) in the Sasem documentation. However, I saw no dropped frames when playing back the reference clips or watching DTV through the Nvidia graphics card, thanks to its full-featured video-decoding pipeline, including motion compensation, iDCT, and color-space conversion. The Sasem video player consumes around 90% of the CPU during high-definition-video playback through the Nvidia hardware.

Figure 2

The Morex International model 2699 mini-ITX case (resold by Casetronic) (a) offers a slim profile; the Casetronic Travla C137 trades off a *slightly* larger footprint and profile in exchange for additional expansion capabilities (b).

In contrast, the Windows Task Manager perpetually pegged 100% when I tried to play the video clips through the CLE266 graphics core, and the on-screen presentation was very jerky. This inconsistency between the two graphics subsystems is baffling, because the CLE266 also touts a full-featured MPEG-2 decoding engine. Perhaps the CLE266 video

BACK TO THE WEB

Please go to the Web version of this article at www.edn.com to see the results of subsequent testing I did on various hardware and software configurations. I'll make available the various reports, screenshots, and other files generated by the benchmarking software I ran, as well as direct links to the benchmark reports I published on Futuremark's Web site.

decoding hardware runs too slowly, or perhaps Via's DirectX VA driver is incomplete (which might also help explain my BeyondTV problems). Turning the attention to analog video on OnAir USB HDTV, CPU usage ranges from 30 to 60% during playback on the Nvidia graphics subsystem, depending on the quality mode. And, because video encoding takes place on dedicated hardware, the incremental CPU-usage "hit" for time-shifting and, therefore, simultaneous video encoding and decoding, is imperceptible.

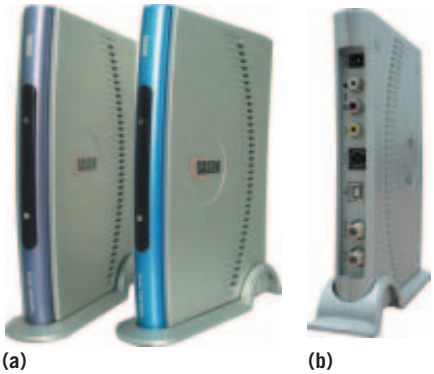
During my initial Spirit project, I proposed that switching from Microsoft's Windows XP Professional to a less "bloated" operating system, such as an embedded Windows OS variant or Linux, might significantly improve Spirit's perceived performance. A few weeks ago, a Linux-proficient friend and I spent an hour or so trying to boot Lindows 4.5 on Spirit but made little progress. We were working with the LindowsLive version of the operating system, which launches directly from the CD instead of requiring previous installation to the hard drive. The upside of the CD-based approach is that you're up and running quickly, and without potentially corrupting any information on the hard drive. The downside, though, is that if the driver suite on the CD doesn't support a particular peripheral installed in or connected to the computer, you can't use the peripheral.

That limitation bit us during my first Lindows experiment, specifically with respect to the D-Link USB2-based external Ethernet adapter I was using to get around Spirit's power-supply limitations. Because I had again hooked the 320W external ATX power supply up to the system, though, I went with a hunch, re-enabled the M10000's integrated Ethernet controller, and again ran LindowsLive through the CLE266 graphics core. Success! The operating system booted in less than 4 minutes and seems to be fully functional (albeit, perhaps, not performance-optimal, because Linux drivers are available for download from Via's Web site, and I doubt that the latest versions of all of them are on the Lindows CD).

I easily connected to other clients on my LAN, as well as to the Internet; the Windows-reminiscent user interface quickly got me up the Lindows learning curve. I was alarmed to discover that I could access and alter the contents of my D-Link Central Home Drive and Toshiba SG10 network appliance server, both of which are also Linux-powered, without first needing to enter the user-name and password information that Windows clients require. D-Link confirms that this behavior is "by design," but Toshiba has no comment (**Reference 3**).

Excel spreadsheets, Word and Acrobat PDF documents, ASCII text files, and JPEG and TIFF image files all launched uneventfully into OpenOffice and the other applications resident on the LindowsLive build when I double-clicked on them through Lindows' network browser. I'm impressed, and I encourage you to download your own free copy of LindowsLive or another Linux distribution and testdrive the operating system for yourself. My Linux-savvy compadre will soon be back in town, and I hope to work with him and PowerQuest's (now Symantec's) Partition Magic to install Lindows and an optimized peripheral driver suite on a separate hard-drive partition for additional testing. I'll report subsequent findings through this article's Web-site addendum.

Hardware augmentation and software optimization may get you far down the road toward platform-implementation success, but you'll eventually be unable to circumvent the limitations of a performance-deficient processor. It was with no shortage of anticipation, therefore, that I began working with Lippert's Thunderboard



(a) (b)

Figure 3 OnAir USB HDTV's hardware acceleration and High Speed USB interface elegantly partition various TV- and other audio- and video-related-system tasks (a); its back panel provides abundant connectivity options (b) (courtesy Sasem).

mini-ITX board, which contains a 1.6-GHz Pentium M CPU (a fanless 1.3-GHz variant is also available), along with the Intel 855GME chip set. Continuing the NASA Mars Rover-inspired naming theme I began with the Spirit project, I've dubbed this system Opportunity. I currently have the Thunderbird motherboard, an Infineon 512-Mbyte PC2700 SDRAM DIMM, and a new Maxtor 300-Gbyte, 5400-rpm hard-disk drive installed in the Morex 2699 case I used for Spirit, retaining Spirit's Toshiba optical drive.

Aside from the processor and core-logic Spirit-to-Opportunity evolution, how does Thunderbird compare with the Via M10000 board? Features exclusive to or enhanced on the M10000 include six-channel (versus two-channel) analog or S/PDIF digital audio, composite video and S-Video outputs, and built-in IEEE-1394 support. Capabilities that Thunderbird exclusively offers or improves on include support for DDR333 (versus DDR266) SDRAM, six (versus four) USB 2.0 interfaces, two (versus one) Ethernet controllers (one supporting Gigabit Ethernet), dual (versus an optional module placeholder) LVDS channels, and a mini-PCI connector (through which, with a Lippert-designed mini-PCI add-in card, I obtained IEEE-1394 support). Another important difference between the two boards is that Thunderbird's PCI interface supports only 3.3V signaling; the M10000 PCI bus employs 5V signaling.

The PCI-signaling (and therefore connector-keying) differences between the two boards, in conjunction with some layout inconsistencies, make my PCI riser card unusable in Thunderbird and has, to date, left me unable to install a graphics card in the PCI slot. At press time, Lippert-designed riser cards were en route from Germany. I've had to navigate around a few other Thunderbird hardware differences with the aid of connector adapters; the smaller USB connector on the motherboard doesn't directly connect to the Morex enclosure's front-panel USB cable, and Thunderbird doesn't provide a power connector for the enclosure's dual back-panel fans. I'm also unable to reroute Thunderbird's audio inputs and outputs from the back of the system to the front panel, as I can with the M10000 motherboard's override connector.

My experiments to date with Thunderbird have not been troublefree, but they've provided tantalizing glimpses into the impressive performance potential of its Intel building blocks. When I followed Lippert's instructions for manually installing the AC'97 audio driver, I ended up with a locked-up, corrupted system that wouldn't complete subsequent Windows boot attempts and from which (after much effort experimenting with less drastic alternatives) I could recover only by reformatting the hard drive and reinstalling Windows from scratch. This time, I first disabled the AC'97 audio in the BIOS; this workaround wasn't a problem, because I planned to rely on an external Creative Labs Audigy2 NX USB audio peripheral.

The display flickered throughout Windows installation, during system boot, and when I set it to a 1024×768-pixel resolution and did even simple tasks, such as moving the mouse. (It seems relatively stable at 800×600-pixel resolution.) And, unless I have graphics acceleration disabled or at its most rudimentary "simple" setting, I can reliably lock up or spontaneously reboot the system if I attempt to scroll down the display, using either the keyboard or the mouse, while in Internet Explorer or Windows Explorer. The combination of audio and graphics issues, none of which Lippert can replicate, lead me to suspect a hardware problem. Lippert agrees, and a replacement board is on the way.

Speed bumps aside, I was able to benchmark the Pentium M processor and its core logic in SiSoft Sandra, and I walked away impressed with the MIPS-per-megahertz capability that Intel has engineered with its latest generation mobile-CPU architecture. I tested Thunderbird both at its default 1.6-GHz configuration and, by altering the BIOS settings, a Via C3 Nehemiah-compatible, 1-GHz configuration. Screenshots in this article's Web-site addendum show how the 1.6-GHz Pentium M outperforms a 2-GHz Pentium 4 and the margin by which the 1-GHz Pentium M outpaced the identically clocked Via C3 Nehemiah.

You can confirm, by visiting the benchmark reports on the *EDN* Web site, that SiSoft Sandra's performance estimates for the 1-GHz Via C3 Nehemiah CPU were close to the numbers I saw when I benchmarked the CPU on Spirit. (In fact, SiSoft Sandra slightly overstated them.) Opportunity's cache and memory subsystem benchmarks well at both 1 and 1.6 GHz, particularly with large transfer blocks. Once again, the Maxtor hard-disk drive was a capable performer; it turned in even *higher* performance numbers on Opportunity than it did on Spirit.□

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