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JANUARY 1994

BYTE

THE WORLDWIDE COMPUTING AUTHORITY

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Apple's Mac Does Windows

SPECIAL REPORT

ADVANCED OPERATING SYSTEMS

A look inside the next generation from IBM, Apple, Microsoft, Novell/USL, Sun, Next, and Taligent

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- 4 Cross-Platform Toolkits Reviewed PAGE 172

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ValuePoint Si	**425SX/Si**	**425SX/Si**	**433DX/Si**	**466DX2/Si**
Processor	i486SX/25MHz	i486SX/25MHz	486DX/33MHz[1]	i486DX2/66MHz
Hard Drive/Memory	120MB/4MB	212MB/4MB	120MB/4MB	212MB/4MB
Drive(s)	3.5"	3.5" & CD-ROM	3.5"	3.5"
Monitor	IBM 14V 14" SVGA NI	IBM 14V 14" SVGA NI	IBM 14V 14" SVGA NI	IBM 14V 14" SVGA NI
Operating System	IBM DOS & WINDOWS™	IBM DOS & WINDOWS	IBM DOS & WINDOWS	IBM DOS & WINDOWS
Price*/ IBM Credit Lease**	**$1,469** / $53 per month	**$1,893** / $68 per month	**$1,819** / $66 per month	**$2,328** / $84 per month
ValuePoint DeskTop	**425SX/D**	**433DX/D**	**450DX2/D**	**466DX2/D**
Processor	i486SX/25MHz	486DX/33MHz[1]	i486DX2/50MHz	i486DX2/66MHz
Hard Drive/Memory	212MB/4MB	212MB/4MB	212MB/4MB	245MB/4MB
Drive(s)	3.5"	3.5"	3.5" & CD-ROM	3.5"
Monitor	IBM 14V 14" SVGA NI	IBM 14V 14" SVGA NI	IBM 14V 14" SVGA NI	IBM 14V 14" SVGA NI
Operating System	IBM DOS & WINDOWS	IBM DOS & WINDOWS	IBM DOS & WINDOWS	IBM DOS & WINDOWS
Price*/ IBM Credit Lease**	**$1,689** / $61 per month	**$2,039** / $73 per month	**$2,504** / $90 per month	**$2,609** / $94 per month
ValuePoint Mini-Tower	**433DX/T**	**433DX/T**	**466DX2/T**	**466DX2/T**
Processor	486DX/33MHz[1]	486DX/33MHz[1]	i486DX2/66MHz	i486DX2/66MHz
Hard Drive/Memory	245MB/4MB	340MB/4MB	340MB/4MB	420MB/4MB
Drive(s)	3.5"	3.5" & CD-ROM	3.5"	3.5"
Monitor	IBM 14V 14" SVGA NI	IBM 14V 14" SVGA NI	IBM 14V 14" SVGA NI	IBM 15V 15" SVGA FS NI
Operating System	IBM DOS & WINDOWS	IBM DOS & WINDOWS	IBM DOS & WINDOWS	IBM DOS & WINDOWS
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[1] Some 486DX/33MHz chips may be manufactured by IBM. [††]ValuePoint Si systems do not include all features listed above chart. Please refer to product details listed at left, or call for more information. ValuePoint Si prices listed reflect IBM Basic Keyboard only. IBM Enhanced Keyboard available at additional cost.

L-R: Alice Robinson, Gregg McGhee, Jeff Herman and Beverly Whitman, Custom Build Technicians, IBM Personal Computer Company

425SX/Si

433DX/D

466DX2/T

ValuePoint Si - NEW!

- Newest entry-level member of the ValuePoint family
- Compact size: 14.2" W x 4.8" H x 16.5" D
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- 3 slots and 3 bays
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- A great, low-cost network client
- IBM HelpWare service and support
- IBM 14V 14" SVGA NI Monitor

ValuePoint DeskTop

- Plenty of room to grow: 5 slots (includes 1 VESA Local Bus slot), 5 bays
- A super combination of speed, power, upgradability and expandability
- IBM 14V 14" SVGA NI Monitor

ValuePoint Mini-Tower

- Convenient, compact Mini-Tower processor case measures 9.5" W x 16.8" H x 16.9" D
- Enormous room for growth: 8 slots (includes 1 VESA Local Bus slot), 6 bays
- Perfect format for high-powered computing (CAD/CAM, graphics, multimedia, etc.) or as a low-cost network server
- IBM 15V 15" SVGA FS NI Monitor

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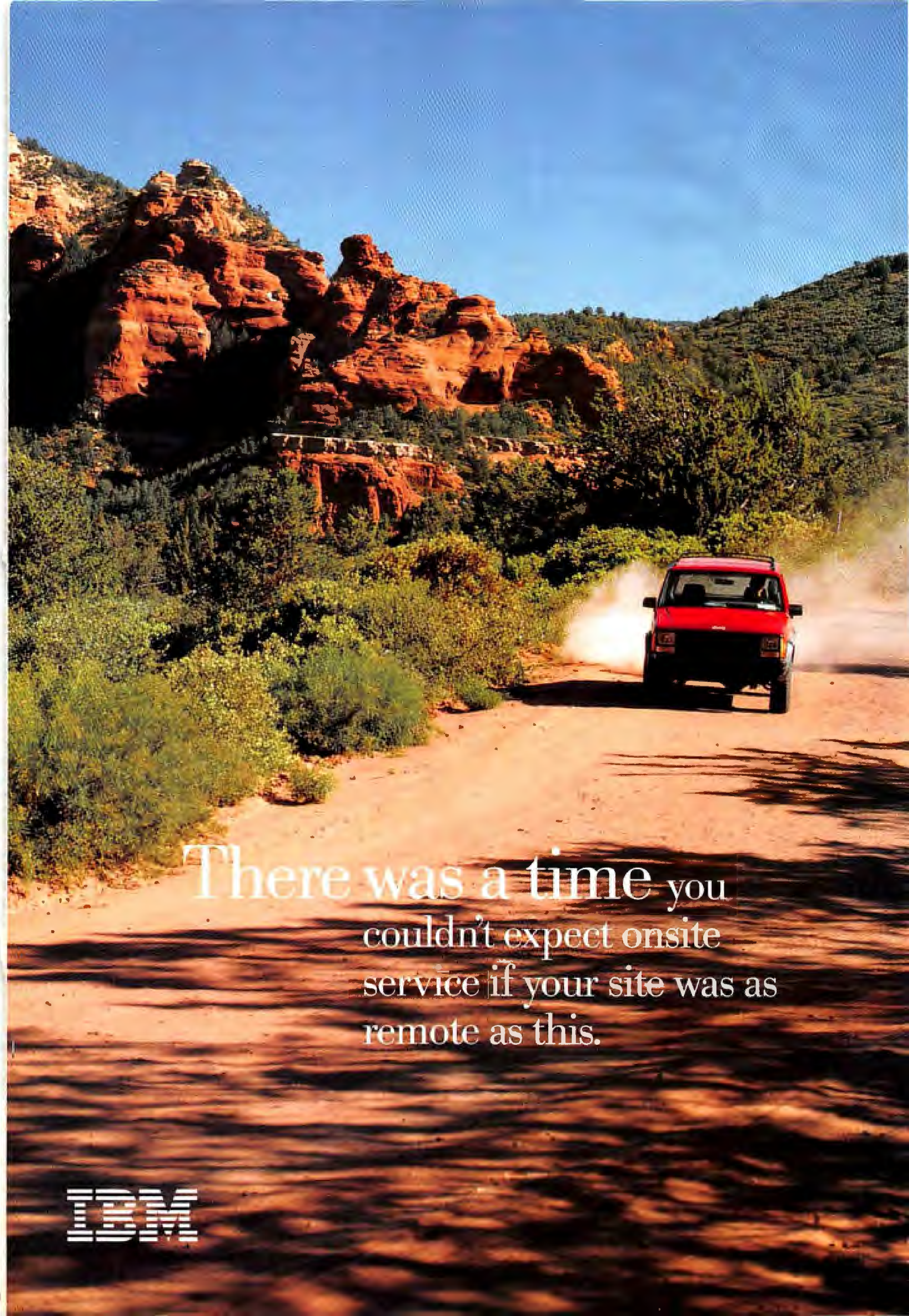
IBM


There was a time you couldn't expect onsite service if your site was as remote as this.
IBM

BYTE

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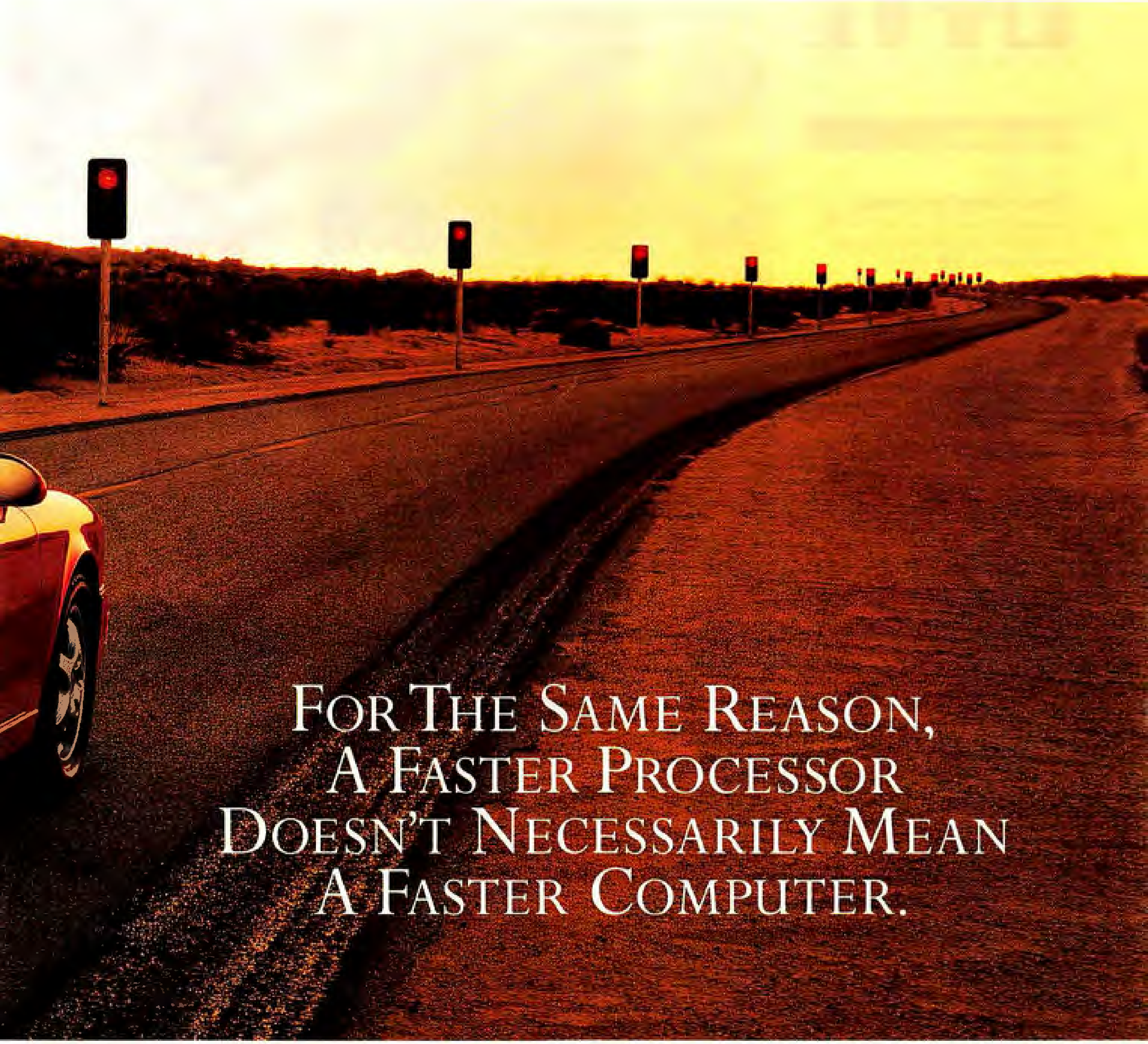
intel inside



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BYTE

JANUARY 1994 VOL.19, NO.1

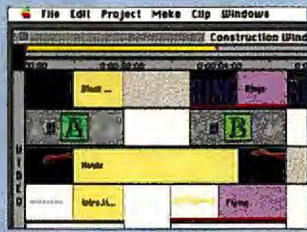
News & Views

Special Report

ADVANCED OPERATING SYSTEMS

Feature

Reviews



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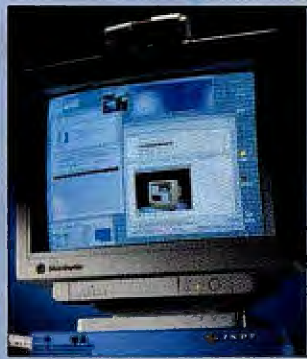

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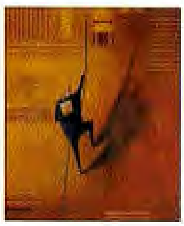
State of the Art



Opinions

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Hands On

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BYTE Contents by Platform

This page presents the articles in this issue according to their subject's relevant computing platform.

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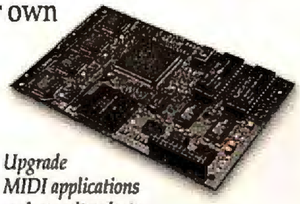

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	Sound Blaster 16 Basic Edition	Sound Blaster 16 MultiCD	Sound Blaster 16 SCSI-2
Format	16-bit stereo	16-bit stereo	16-bit stereo
Advanced Signal Processing Upgradability	Yes	Yes	Yes
Wave Blaster Upgradability	Yes	Yes	Yes
CD-ROM Compatibility	Creative Labs/Panasonic	Sony, Mitsumi, Creative Labs/Panasonic	Any SCSI or SCSI-2
Bundled Hardware		Microphone	Microphone
Bundled Software	Monologue for Windows Creative WaveStudio Creative Soundo'LE Creative Talking Scheduler Creative Mosaic	Software Toolworks Multimedia Encyclopedia HSC InterActive SE PC Animate Plus Monologue for Windows Creative WaveStudio Creative Soundo'LE Creative Talking Scheduler Creative Mosaic Creative VoiceAssist	Software Toolworks Multimedia Encyclopedia HSC InterActive SE PC Animate Plus Monologue for Windows Creative WaveStudio Creative Soundo'LE Creative Talking Scheduler Creative Mosaic Creative VoiceAssist
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Power Personal Systems

Will IBM set the standard for the next generation of desktop systems with its new line of PowerPCs?

The IBM folks at the Power Personal Systems Division are up to some pretty interesting things. As the name suggests, the division will make systems based on the PowerPC chip, which IBM codeveloped with Motorola and Apple. The RISC-based PowerPC chip consumes less power, generates less heat, runs up to five times faster, and costs much less than an Intel Pentium.

Although final systems won't be available until about midyear, IBM recently showed me several prototypes and talked about its plans. In a nutshell, the prototypes were hot (in the "way-cool" sense) and the plans are, well, visionary.

What I saw was a desktop system using a 66-MHz PowerPC 601 running IBM's "personal" AIX (a scaled-down implementation of IBM's Unix) in an unconventional way. It was surprising to see the first PowerPC system running SunSelect's Wabi (Windows Application Binary Interface) running on top of AIX and Microsoft Excel on top of that. In fact, it looked more like a Windows system than a Unix system.

To make the demonstration even more interesting, it was blazingly fast, though we have not done any benchmark tests yet. However, I've seen a lot of spreadsheets run on just about every kind of system you can imagine, and what I saw on the PowerPC was the fastest yet.

In other words, without the benefit of, say, Windows NT and applications software compiled in native code, the IBM PowerPC system promises to run Windows software faster than anything else. Given the dominance of the Windows installed base, being the fastest Windows machine is a good place to start.

On the lower end, IBM showed off an "ergonomic" desktop system that had a flat-panel display on an eye-level stand. The system unit box was too small for traditional plug-in adapter cards, but it had several PCMCIA slots instead. The ergonomic desktop was based on the somewhat slower PowerPC 603.

IBM also had a nonworking slim notebook prototype based on the PowerPC 603. Its low-power design makes the 603 chip ideally suited for portables. In contrast, the only Pentium-based portable announced, the Dolch PAC-586, consumes so much power and gets so hot that it must use a liquid cooling device on the chip.

For added measure, the prototype I saw also had a built-in CD-ROM player beneath the keyboard. Even more impressive was the video camera built just above the display. The camera was complete with a sensor so that, according to IBM, the computer would know when you leave and could power itself down.

Other goodies on the portable prototype included stereo speakers and a microphone. All of this would add to the price if IBM had to incorporate digital-signal-processing hardware for all those devices. However, IBM says it will let the PowerPC chip do all the work, and that makes a lot of sense.

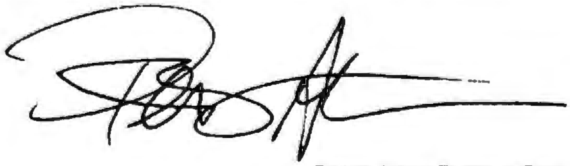
Because no additional hardware is required, IBM's PowerPC portables can incorporate speech-to-text software inexpensively. IBM already has its Personal Dictation System software, and the PowerPC could easily handle that program. Add to that IBM's ambitious plans to eventually incorporate its speech-parsing technology so that software speech "agents" can understand your commands and do tasks for you. I call those plans "ambitious" because IBM has not yet demonstrated its agent technology; when it does, BYTE will tell you about it.

Perhaps even more ambitious are IBM's plans to work with software vendors to port Windows NT, Solaris, Workplace OS, and Taligent to its PowerPC platforms. And IBM is sharing the architecture of its systems so that other vendors will make PowerPC systems, too.

The first IBM PC became a standard by happenstance. Yet that standard has been the basis of the computer industry for the last 10 years. Now, IBM has created a new box for everyone to copy, and this time IBM is encouraging third-party manufacturers to do so. That's why I call IBM's plans *visionary*.

IBM seems to have learned from the past. The original IBM PC succeeded only in part because it carried the IBM name. The greater part of its success was owed to its open architecture, which fueled competition and created de facto standards that, in turn, created a market bigger than anyone would have dreamed.

My bet is that IBM's Power Personal Systems will have an impact as great as that of the original IBM PC.



Dennis Allen, Editor in Chief
(dallen@bix.com)

THE EASIEST-TO-USE WINDOWS SPREADSHEET

What Lotus doesn't want you to know about new Quattro Pro 5.0

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2. Interactive tutorials that teach you by using *your own* data	2. *Not!*
3. Complete documentation available *online*	3. *Not!*
4. Improv-like crosstabs and data modeling tools *built in*	4. *Not!*
5. Built-in workgroup information sharing with any network or E-mail system	5. *Not!*
6. Analytical graphs to find trends in your data	6. *Not!*
7. Over 360 @functions—more than any other spreadsheet	7. *Not!*
8. Integrated user interface builder to make spreadsheet development easy	8. *Not!*
9. Complete slide show capabilities *built in*, including light table sorting	9. *Not!*
10. Database forms that let you manage data without having previous database experience	10. *Not!*

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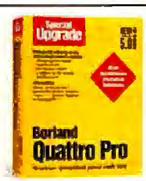

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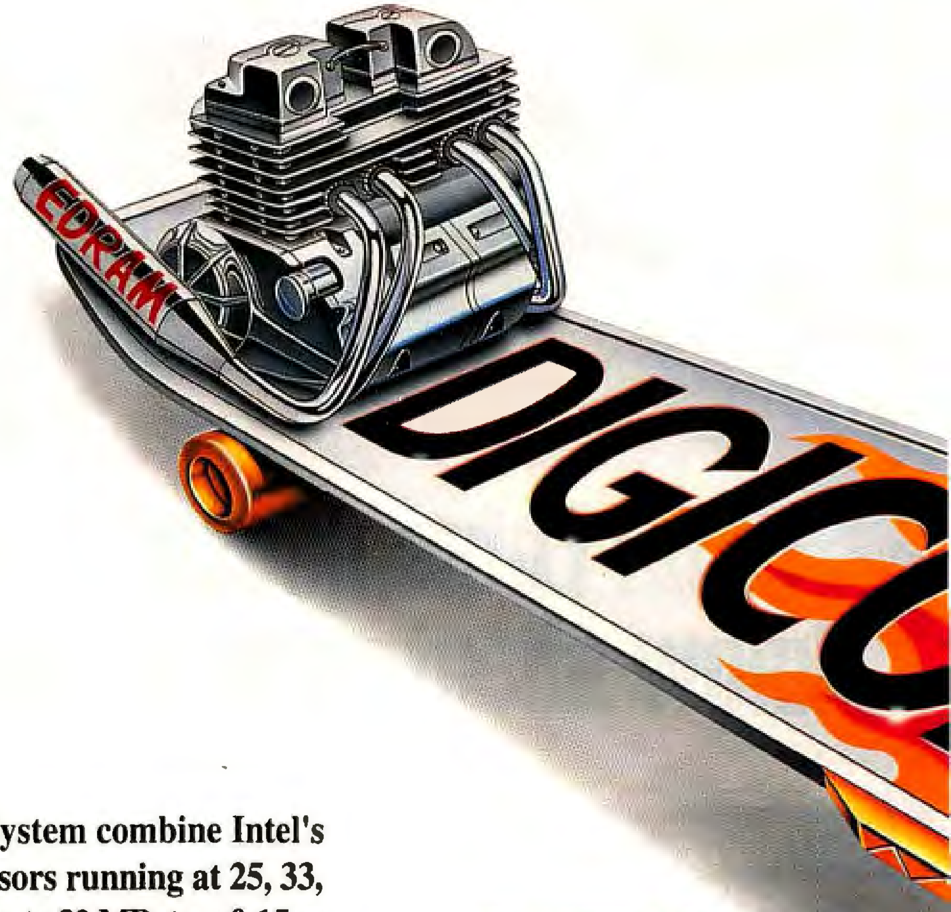

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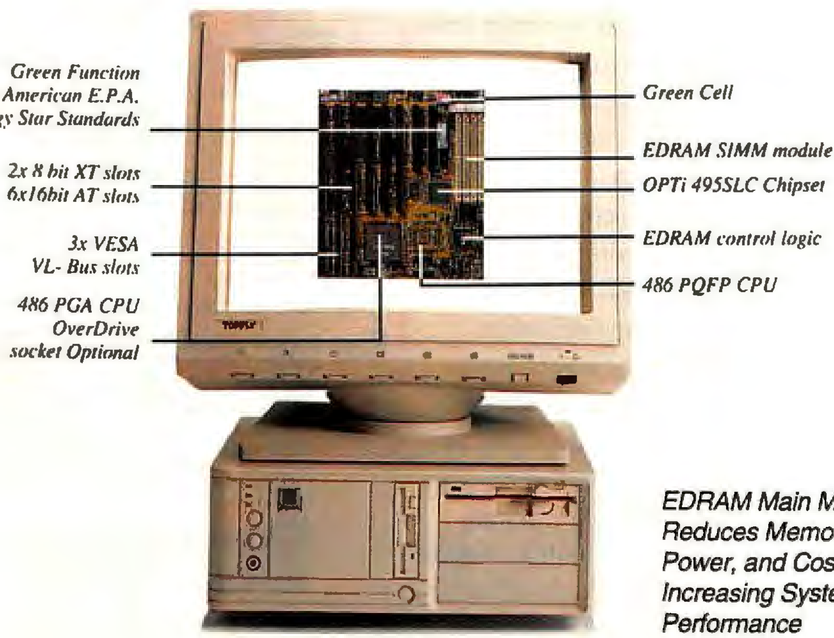
- Ready For Demands Of Multitasking Operating Systems
- 3 High Speed VESA VL-Bus I/O Slots
- 8 ISA Bus I/O Slots
- AMI BIOS



DIGIS-486EL System

EDRAM Main Memory Reduces Memory Size, Power, and Cost While Increasing System Performance

8MB SIMM module

4MB SIMM module

Personal Digital Assistants

I read with interest and fascination the excellent article on PDAs ("PDAs Arrive But Aren't Quite Here Yet," October 1993) written by Tom Halfhill. At the same time, I confess I was somewhat irritated by the absence of any reference to Psion. Psion has manufactured and sold well over 1 million handheld/palmtop computers, which is superior to many of the other companies you cited.

One area of your comparison table where we strongly ally Hewlett-Packard is in the use of pen as an input device. It will be interesting to see which way the market jumps. Psion's view is that the pen is wholly inappropriate as an input device in the consumer sector. Today's pen technology cannot deliver the level of performance or satisfaction that an "early majority" customer demands. We shall see.

David Elder
President, Psion, Inc.
Concord, MA

Our story was about PDAs and was not intended to be a general survey of widely known PDA-like devices. Of course, you may disagree with our definition of a PDA. But we believe pens are already as good as miniature QWERTY keyboards for typical PDA functions—and pen interfaces are rapidly evolving, while keyboards are not.—Eds.

I want to talk to my Newton. As a loyal Apple consumer, I bought a MessagePad only to take it back two days later because it failed to live up to the Sculley promise of an easy-to-operate, do-it-all assistant. But if Apple could merge the Intelligent architecture of handwriting recognition and communications with the voice recognition of Mac AVs, I'd want to be put on the beta-user list. Perhaps Apple could accomplish this by decreasing the size of the DSP it uses for voice in Mac AVs to fit in the MessagePad. Imagine picking up your Newton and saying, "Newton, take a memo, blah, blah, blah. Newton, fax a memo to Mr. X." If the MessagePad could accomplish these commands wirelessly, it would be a true personal digital assistant.

William Bartee
Norman, OK

Visual Basic

I really enjoyed your article "BASIC Windows Programming" (October 1993). However, your inference that Visual Basic 3.0 does not support Paradox tables is incorrect. I, too, spent many hours attempting to connect a Paradox table without success. The problem is a typo (or omission) in the provided documentation. The answer is in the VB.INI file under the "Installable ISAMs" section. The line that refers to Paradox tells you to enter the characters left of the equals sign as the connect property of the data control. You then simply follow the rest of the instructions, and your Paradox tables will work with Visual Basic 3.0 as described.

Gregory K. Grieb
Allentown, PA

Keeping Time

Michael Lombardi's article "Keeping Time on Your PC" (October 1993) was interesting, although I believe this quest for the most exacting universal time is only worthy of Don Quixote. I understand the need for precision, but I also understand the inherent relative nature of time, which is why I keep all the computers in time synchronization on my IBM LAN Server networks by running a REXX program on the domain controllers as an AT job. The nodes are brought into time synchronization when employees log on to the LAN. Because all applications are networked, employees cannot do any business-related work until they log on. As for my home computer, since I cannot watch TV and code at the same time, to give or take a couple of minutes doesn't matter.

Kenneth Reiss
Passaic, NJ

Worried

In "The State of Multimedia" (October 1993), Jerry Pournelle hit it right on the head when he said, "students will always be successful if you redefine success." Unfortunately, this isn't a problem that affects only multimedia usage in schools. It's affecting the core of our society, and I'm worried.

Robert Plaza
Houston, TX

The Battle of the Software Bulge Continues

I have a big 486 with many bells and whistles—including one of the best video cards, a caching disk controller, 8 MB of memory—and I've run into a performance barrier. Quattro Pro for Windows crawls, WordPerfect for Windows will barely fit (by itself), and Paradox for Windows crashes my machine. I almost threw my computer out the window when it took 12 minutes for Excel 4.0 to add a single column to one of my spreadsheets.

Instead, I decided to ditch my software. I reinstalled old DOS favorites like WordPerfect 5.1, Quattro Pro 4.0, SuperCalc, and the new Paradox 4.0. On a big 486, my applications fly, and I can still use Windows as a task switcher. My software may not have fancy features like DDE and OLE. But I'm getting work done!

Charles Ramcharan
North York, Ontario, Canada

Fixes

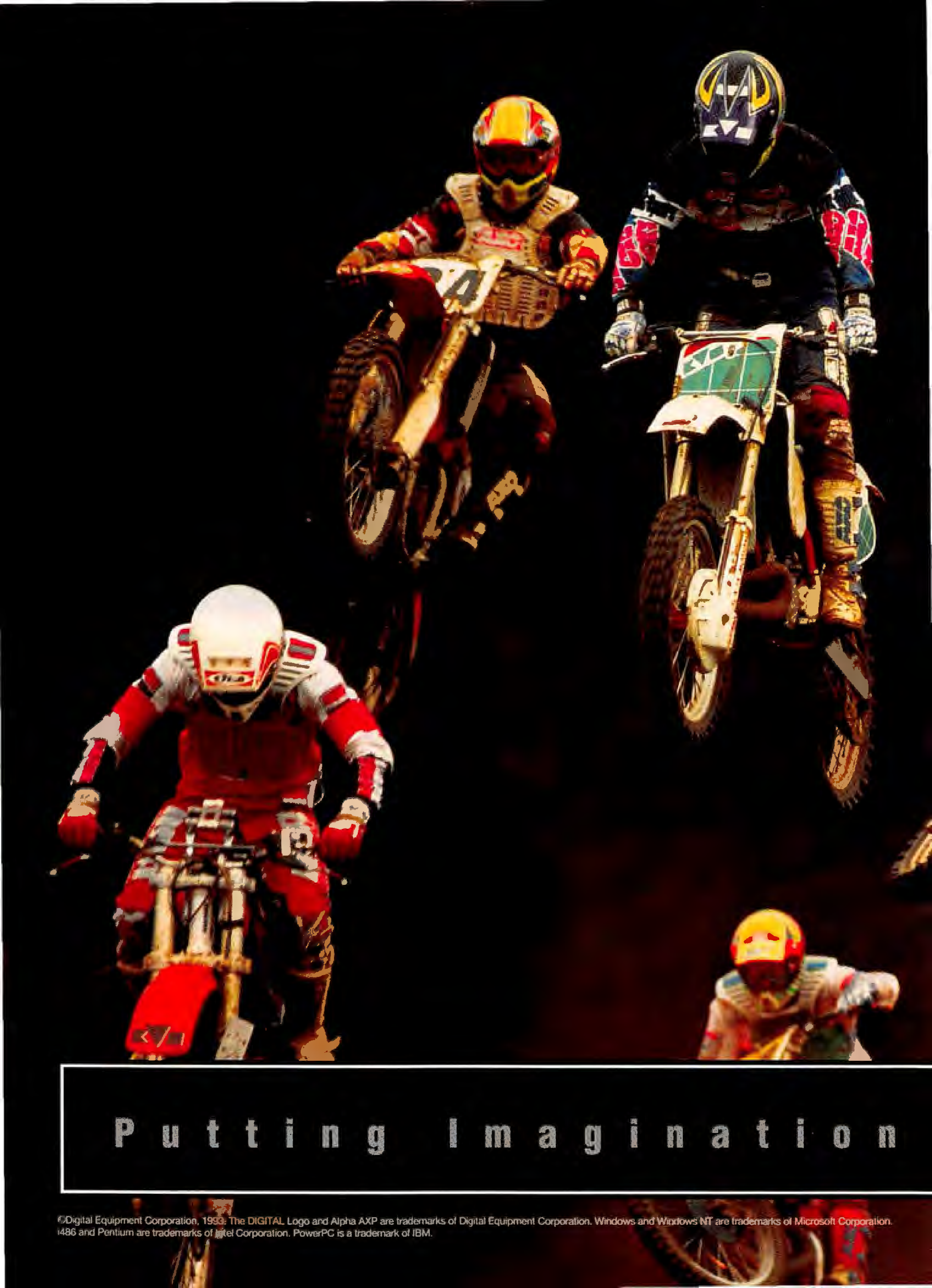
The November 1993 article "Get Your Kicks with Switched 56" might be misleading about the compatibility between ISDN and 2-wire Datapath. You can communicate among ISDN, Datapath, and Switched 56 4-wire services. At the equipment level, however, these technologies are not interchangeable.

In "Ease of Use Is Relative" (October 1993), we incorrectly identified the vendor of Pensil. The company is First Pen Systems, Inc., and Pensil is a native PenPoint object editor, not a C development tool.

On page 222 of the October 1993 issue, Jerry Pournelle stated that the Chinon drive he purchased was made by Toshiba. However, the entire line of Chinon CD-ROM drives has always been made (from design to manufacture) entirely by Chinon. ■

We want to hear from you. *Address correspondence to Letters Editor, BYTE, One Phoenix Mill Lane, Peterborough, NH 03458; send BIX-mail c/o "editors"; or send Internet Mail to letters@bytepb.byte.com. Letters may be edited.*

You Can Play Around With Windows NT On Another Microprocessor.


Putting Imagination

News & Views

WINDOWS

Chicago Enters Beta Testing

Early reports indicate that the next version of Windows is an evolutionary step up from Windows for Workgroups 3.11

BY DAVE ANDREWS

This month marks the tenth anniversary of the now-famous one-time commercial that Apple ran during the Super Bowl to introduce its new Macintosh computer to the world. Ten years later, Microsoft has entered beta testing on a new version of Windows (commonly referred to as Windows Chicago) that only now catches up to features that have been present for years in the Mac OS.

The market success of Windows 3.1 is undeniable: The Software Publishers Association says that in 1992, North American sales of Windows accounted for $1.93 billion, compared to the Mac's $990 million. Yet in terms of built-in support for networking and plug-and-play configuration, the Mac OS has often led where Windows eventually followed. The next version of Windows will attempt to remedy this situation, but it will find strong competition on the Intel architecture from IBM's OS/2 2.1, which has been shipping since June 1993.

In December, Microsoft was expected to release the first development kits to programmers who want to get an early start on developing Windows Chicago applications. (The version number has not been officially decided on, although industry insiders say Microsoft will call it Windows 4.0.) This next version of Windows is not expected to ship until sometime during the first half of this year at the earliest.

Microsoft will position Chicago as a universal client that will offer preemptive multitasking, plug-and-play identification and configuration of system-board devices, the Win32S subsystem, Video for Windows, OLE 2.0, a new interface, the full MAPI (Messaging API) 1.0 subsystem, filenames longer than the "8.3" format, and better integration with NetWare. The big question—Can the company do all this in an operating system targeted at a 386 or 486 system with as little as 4 MB of RAM?—will have to wait until the company releases this product. Furthermore, whether Chicago provides a dramatic improvement as a platform for running Windows 3.1 and DOS applications will also have to be determined later.

"The bottom line is that a very large set of services [now available in Windows NT] will be implemented in the next version of Windows," says Jeff Thiel, product manager of Windows marketing at Microsoft. "But if you're looking for a production application server, you're probably going to want to use NT." The design

WINDOWS/CHICAGO HIGHLIGHTS

Plug-and-Play: Chicago will include the Plug-and-Play BIOS, bringing the operating system closer to putting an end to the "DIP-switch blues" once and for all for users of new ISA cards. Supports automatic installation and configuration of add-on devices. Notebooks will automatically reconfigure themselves when removed from a docking station. Microsoft and IBM will likely cooperate on adding Plug-and-Play for Micro Channel cards under Windows. Plug-and-play EISA cards will also be supported.

Preemptive: Microsoft says Win32 programs running in Chicago will be able to preemptively multitask, meaning a task can interrupt a task with a lower priority instead of waiting for the lower-priority task to finish.

New interface: Alpha testers report the File Manager and Program Manager are now combined and the new interface incorporates features of the Mac, OS/2, and X Window System.

Win32S: Allows 32-bit applications to run on Windows 3.1, Chicago, and Windows NT.

MAPI 1.0: Originally slated for release in the third quarter of 1993. Allows replaceable directory service providers.

Better networking: Built-in support for peer-to-peer networking. Better integration with NetWare, thanks to Microsoft's own NetWare redirector, a 32-bit protected-mode driver that reduces the conventional memory footprint. Support for IPX lets Windows workstations communicate on either side of an IPX router.

OLE 2.0 integration: OLE 2.0 programs will be able to pass information to the Windows shell, possibly allowing thumbnail images of documents.

Enhanced-mode support only: No longer supports standard mode (won't run on 286-based PCs).

TAPI support: Better integration of Windows to the phone system.

point for Windows Chicago does indeed appear robust: Native Win32 applications will be able to take advantage of the services that full-blown Windows NT applications can use, except for Unicode, security, and symmetric multiprocessing. Of course, Windows Chicago is specifically for the Intel 80x86 platform as well.

Thiel said that any services included in Windows Chicago that are not now included in Windows NT will be added to Microsoft's portable 32-bit operating system. "Windows NT remains the full superset," Thiel says. "Any deviations from that are temporary." This means NT will soon get a new interface. The interface in Windows Chicago is much more Mac-like and combines the File Manager and Program Manager so that program groups actually map to real directories.

One indication of the strategic importance that Microsoft is placing on this next version of Windows is the way the company is conducting its beta testing. Unlike Windows NT, in which Microsoft conducted an open beta-test program, Microsoft is being very discreet with this project. "NT was a different platform. We had to build some momentum behind it," Thiel says. "Chicago is a very different situation. We have a huge installed base... we also have competition."

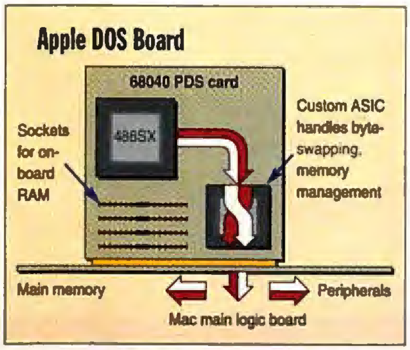
Although Microsoft officials say you won't have to exit Windows to run DOS programs, sources say the company will sell the 32-bit version of DOS that will provide the foundation for Chicago as a stand-alone product. Many of the new features in Windows Chicago (e.g., the Video for Windows run time, Win32S, and OLE 2.0) are already here today. And Windows for Workgroups 3.11 has a 32-bit file system and 32-bit network card and transport drivers.

Despite the revamped interface, it looks as though Windows Chicago represents a gradual evolution of an environment that will be judged in part by how well it competes with OS/2.

INTEROPERABILITY

Apple Provides PC on a Mac

Apple has developed a board that offers the ultimate oxymoron of software and hardware: a Mac running DOS programs. This feat is accomplished by placing a 25-MHz 486SX processor, a Chips & Technologies BIOS, a VGA chip set, and some of Apple's custom ASICs (application-specific ICs) on a 68040 Processor Direct Slot plug-in board. The whole affair is dropped into a competitively priced Quadra 610, offering the best of both worlds on one system.



Apple's board handles the endian byte-swapping needed in the combined Intel/Motorola architecture.

The DOS card can have up to 32 MB of RAM on it, or it can share memory on the Mac's main logic board. At boot time, the board is scanned for RAM. If none is found, a user-determined amount of RAM on the main logic board is dedicated to the DOS environment. Hardware transceivers in a custom ASIC on the DOS card handle the endian byte-swapping required by the different processor architectures. A memory controller in this ASIC functions to keep the address spaces of the two environments separate. Also, the Mac's SuperDrive is mapped as A by the system. The MSCDEX extension is provided so that, on a Quadra with a built-in CD-ROM drive, DOS can access DOS CD-ROMs.

The PDS board operates independently of the Mac so that DOS/Windows applications can run concurrently with the Mac OS. However, Apple has taken its integration skills to fuse the two systems into one easy-to-use whole. For example, selecting a printer via the Mac Chooser automatically selects the same printer for the DOS environment. DOS print commands are intercepted by the Mac OS and routed to the selected printer. For example, say you have a Hewlett-Packard printer connected to your Mac. You select the HP printer driver from the Chooser. Under DOS, you print an HPGL (Hewlett-Packard Graphics Language) graphic. The HPGL commands are redirected to the HP driver, which sends them to the printer. Running CorelDraw under Windows? No problem: Select a PostScript printer from the Chooser, switch back to CorelDraw, and print. For serial work, you can assign COM1 to, say, the Mac's modem port and COM2 to its printer port.

Switching between the Mac and DOS environments is easy. With a single monitor on the Mac, you press a user-selectable hot-key sequence, which toggles you from the Mac Desktop to a DOS screen. Pressing the same key sequence again swaps you back. If the Mac has two monitors, you can pick which monitor shows the Mac Desktop, while the other displays the DOS/Windows environment. Support for 14- and 16-inch VGA and Super VGA monitors is provided.

DOS files are maintained inside a container file that has the structure and organization of a DOS hard drive (a trick pioneered by Insignia Solutions' PC emulator). However, Apple lets you "mount" this file as a Mac volume that you can double-click on to open and examine DOS files and subdirectories (i.e., folders). DOS file extensions can be mapped to the appropriate Mac applications, such as .XLS to Microsoft Excel and .DOC to Microsoft Word. With the file-extension mapping in place, double-clicking on a DOS file launches the corresponding Mac application. (Remember that many of today's cross-platform applications use the same file format, so this little trick works transparently to the user.) Cutting and pasting between Windows and Mac applications is supported.

You can configure the system to start DOS when the Mac boots or on user demand. When you shut the Mac down, the Mac OS checks to see if the DOS environment is active and will give you a warning to shut down DOS before proceeding. A single Control Panel lets you set up the DOS environment (e.g., its memory size and serial-port mapping). Not supported now are NetWare operations and Sound Blaster I/O.

Apple sees several target audiences for this product. First, the home office, where multiple users have different platform needs (e.g., the kids using Macs at school, the parents using DOS at the office). Second, the small office, where folks don't have an expert to maintain their systems, and they don't care to wrestle with the technology. At the same time, these folks might need to run several vertical DOS applications. Finally, for training and education, where tight budgets require the most bang for the buck.

The board will cost $500 without memory. MS-DOS 6.2 will be provided, along with utilities like Double Space. A complete Quadra 610 with a keyboard, a 14-inch monitor, 8 MB of RAM, a 160-MB hard drive, built-in Ethernet, and a DOS card should cost about $2000. Resellers might bundle Windows with the system. Ironically, the ability to run DOS or Windows applications on the Mac may be the ultimate Trojan horse that garners the Mac market share.

—Tom Thompson

The new **HP DeskJet 310** *printer.*

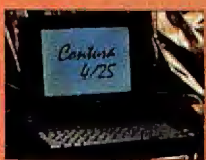
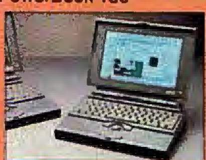
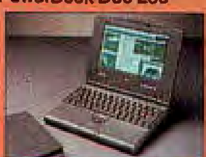
Desk

Buyers Flock to Better Notebook Displays

On this chart, a StoreBoard ranking of the five top-selling portable PCs in units sold over a recent five-month period, a number of points are worth noting. First, it's a surprise that any system with a color active-matrix display would rank here at all, as does the Compaq LTE Lite 4/25C. Second, our survey is a small sign that major system vendors on the PC side are overcoming supply problems. Compaq is among these vendors, and the IBM ThinkPad 720C ranks in the top 10, although it is not listed here. The presence of three PowerBooks in the top five is no surprise, given the runner-up Readers' Choice award BYTE readers gave this line last spring. Infocorp analyst Kim Brown estimates that 2 million notebooks with dual-scan, passive-matrix displays will ship in the coming year—one of them, the Contura, already leads the pack in sales. Passive-matrix screens should find continued competition from active-matrix screens. A report by Frost & Sullivan, noting that in June 1993 the U.S. Department of Commerce ended tariffs on imported active-matrix screens, predicts lower prices for active-matrix screens and fewer backlogs.

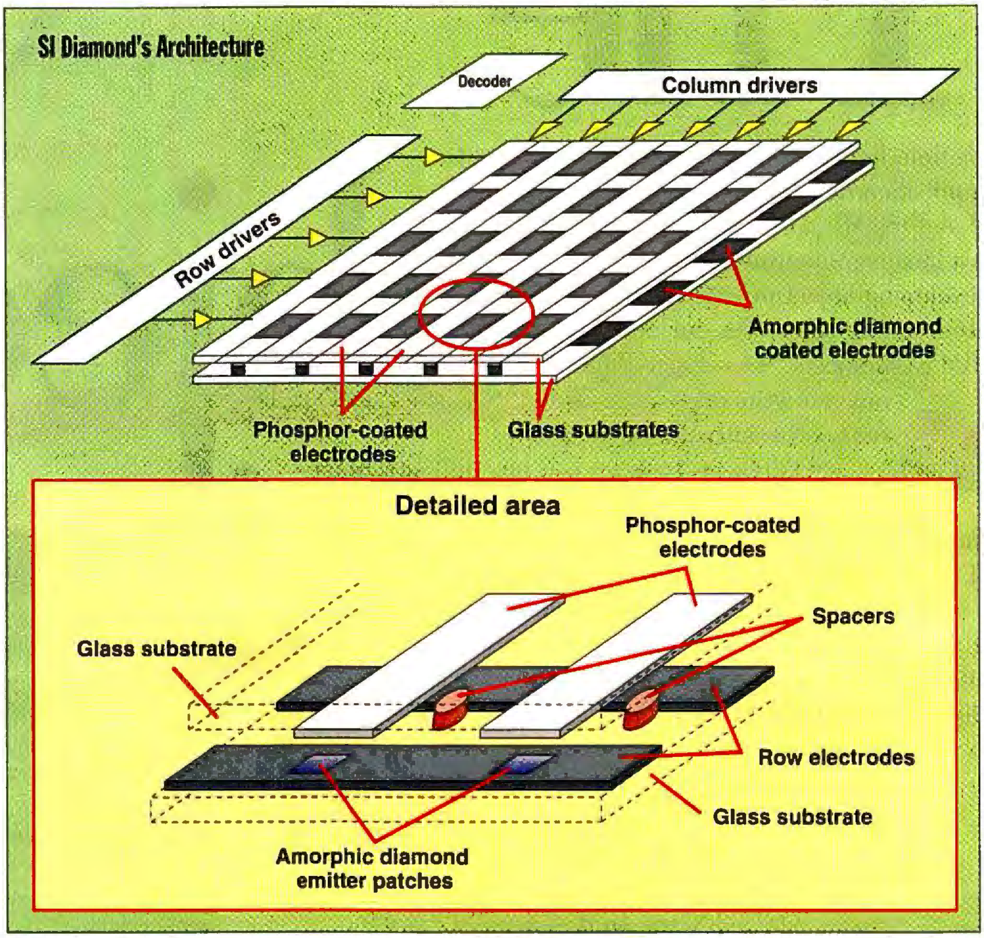
Prices given are estimated street prices. For Apple, they range according to configuration. The "Possible features..." column represents BYTE editors' most reasonable presumptions as to what the next generation of these systems might offer, based on established vendor patterns and market pressures. (StoreBoard ranking information courtesy of Computer Intelligence-Infocorp of Santa Clara, California.)

—Ed Perratore

Product	Basic features	Introduction date	Introductory price range	Current price range	Notable features	Possible features of succeeding-generation model
Compaq Contura 4/25 	486SL-25 CPU, dual-scan monochrome VGA passive-matrix display, 4 MB of RAM, 120- or 209-MB hard disk	3/8/93	$1999 (120 MB) $2299 (209 MB)	Same	Hibernation, auto-shutdown on low battery, fax modem, cellular data hookup to Motorola or Nokia phones, three-year warranty	486SL-33 CPU, EasyPoint built-in trackball, active-matrix display standard, improved docking station capabilities
Apple Macintosh PowerBook 180 	Motorola 68030-33 CPU, active-matrix gray-scale display, 4 MB of RAM, 80- or 120-MB hard disk	10/19/92	$4109–$4469	$2479–$2969	8-bit Apple Sound Chip, security slot for third-party locking devices, two-level keyboard tilt adjust, disability access, 68882-33 math coprocessor	Modular system design, PCMCIA slots, rumored low-voltage Motorola 68040 CPU
Apple Macintosh PowerBook 160 	Motorola 68030-25 CPU; STN gray-scale display; 4 MB of RAM; 40-, 80-, or 120-MB hard disk	10/19/92	$2429–$3149	Model 165: $1869–$2449	Same as Model 180 minus math coprocessor	Next-generation model is PowerBook 165, with 33-MHz 68030
Compaq LTE Lite 4/25C 	486SL-25 CPU, active-matrix color, 209-MB hard disk	11/9/92	$4099 (120 MB) $4399 (209 MB)	Same	Standby up to 80 hours, hardware/software security, hot keys for system functions, three-year warranty	Decreased weight, multimedia features, improved APM, greater telecommunication options
Apple Macintosh PowerBook Duo 230 	Motorola 68030-33 CPU, STN gray-scale display, 4 MB of RAM, 80- or 120-MB hard disk	2/9/93	$3219	$1969–$3179	RAM capacity of 24 MB, 4.2-pound weight, Duo MiniDock option, up to 4½ hours of battery life	Modular models, PCMCIA slots, and low-voltage Motorola 68040 CPU, or even PowerPC 603

DISPLAY TECHNOLOGY

Competition for Active Matrix



SI Diamond's FED uses a diamond coating, which is inexpensive to manufacture, for the field-emitter surface, unlike more conventional metal field emitters. The company claims that because of its physical properties (in particular, nonconductivity), diamond is a superior field emitter and eliminates the need for insulators and resistors.

The 1990s may be the decade of mobile computing, but so far, computing "anywhere, anytime" has been limited by LCDs that don't provide enough contrast for use in a wide variety of lighting conditions, even with power-consuming backlighting. In addition, LCDs are temperature-sensitive, requiring warm-up time and providing slow response in cold temperatures.

One of the most promising technologies to solve some of these problems is the cold-cathode FED (field-emission display). BYTE covered cold-cathode FEDs a while back (see "LCDs and Beyond," February 1991 BYTE). At that time, the forecast was for working products to come out in about two years. Almost three years have passed and there are still no commercial FEDs, but 1994 may finally be the year, as several projects are under way to develop them.

Cold-cathode FEDs operate on the same principle as the CRT, but rather than using a bulky high-voltage electron gun, FEDs use an array of low-voltage electron emitters to excite light-emitting phosphors that illuminate the screen.

Cold-cathode FEDs produce far brighter contrast displays than LCDs, are insensitive to temperature, and consume substantially less power than backlit LCDs such as active- and passive-matrix displays (a 10-inch full-color FED would consume less than 5 W of power).

Three companies in the U.S. are working on cold-cathode FEDs. In addition, a French company, Pixel International, has demonstrated a 6-inch prototype cold-cathode FED.

A small company in Houston, Texas, SI Diamond, is working on an FED using a diamond coating for the field-emitter surface, unlike more conventional metal field emitters (see "SI Diamond's Architecture").

The company's design does not call for traditional, expensive diamonds, however. Instead, the diamond material will be manufactured through a process in which a high-intensity laser transforms graphite (i.e., soft carbon) into diamond.

SI Diamond is working with Microelectronics and Computer Technology (Austin, TX) to develop the FED. The company hopes to have a 1- by 1-inch prototype display early this year and 6-inch and larger displays later on.

The other companies working on FEDs in the U.S. are Micron Display Technology of Boise, Idaho, and Silicon Video of Cupertino, California. Silicon Video has some former employees of Coloray, which, before it went out of business, was the primary developer of FEDs in this country. Micron is working on a metallic-emitter design, while Silicon Video would not disclose the nature of its design. Silicon Video's Bob Dubak said, the current crop of competitors' FED prototypes require expensive drivers for switching voltages on and off and also suffer from nonuniformity in the displayed image. Dubak says that Silicon Video is working on lowering switching voltages to 50 or 60 V rather than 250 V, which is the minimum in other designs.

In any case, we should be seeing some prototypes from all three companies this year. Says David Mentley of Stanford Resources, a display consulting firm in San Jose, California, FEDs "can put pressure on active-matrix displays."

—Nicholas Baran

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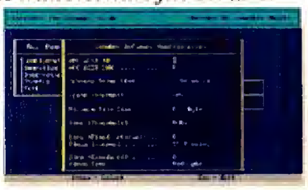

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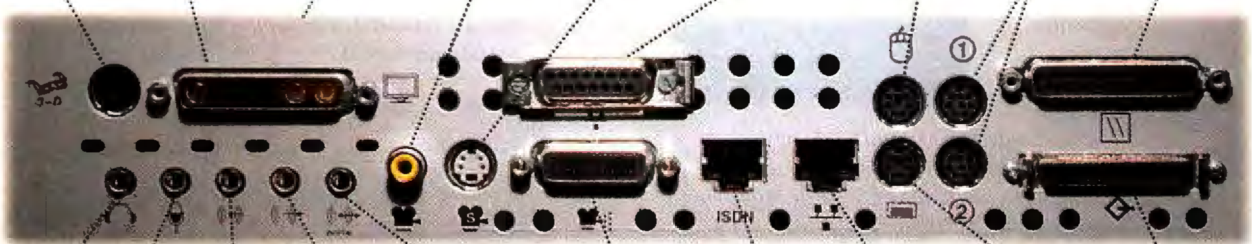

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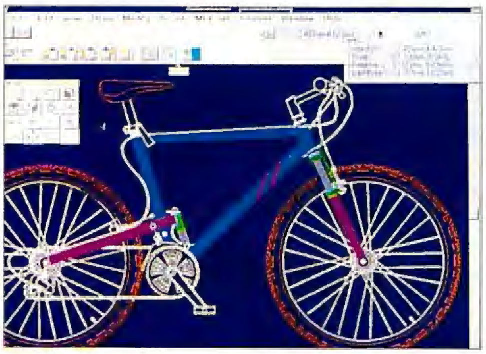
BUSINESS SOFTWARE

Graphics Gets Down to Basics

Give the people what they need. That's the philosophy behind several new Windows drawing programs designed for people whose artistic capabilities are nil, yet who still need to quickly create professional-looking diagrams and charts. You won't find some of the high-end features (e.g., support for Bézier curves, gradient fills, or special text effects) in ShapeWare's Visio 2.0 or Micrografx's SnapGrafx that you find in free-form, professional drawing programs. Instead, these programs are for business users who are often called on to create network diagrams, flowcharts, project time lines, and organizational charts for incorporation into reports or presentations.

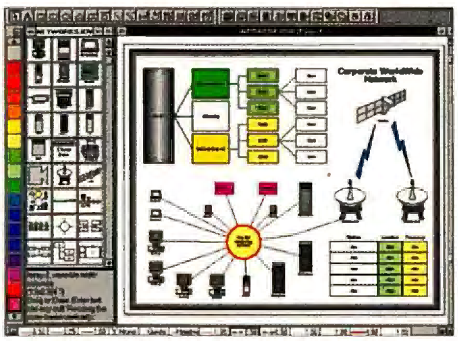
This diagram of a sports play was made in 3 minutes in SnapGrafx. Once the first player was placed and sized, every new player selected from the template sized itself accordingly.



Along with its high-end CAD features, AutoSketch includes predesigned templates.

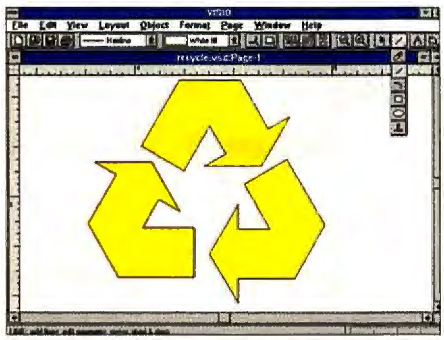
"To a large degree, the target users of Visio 2.0 are quite different than those of CorelDraw," says Morgan Brown, Visio product manager, noting that with a professional drawing program, you're more likely to create unique artwork or designs. "Visio is a program that helps you quickly draw the basic types of drawings that are used in a company. Prepress color processing is not something our target users are going to do," he says.

Both Visio and SnapGrafx use templates to jump-start you into the graphics creation process. Instead of having to create and link the arrows, symbols, and text boxes that you will use in an organizational chart or network diagram, the templates do much of that work for you. Each template provides a library of predrawn shapes and a framework for performing a specific task so that objects interact as you would expect them to. For example, in the creation of a flowchart, when you move a box, the link moves with it; when you select a shape and begin typing, the text is automatically inserted. Although these hand-holding features are not as dazzling as those that you might find in a 24-bit color paint program, they help in speeding the process along. You can use either of these programs to create respectable drawings in just 5 minutes.



IntelliDraw 2.0, expected to ship in December, will ship with general and dedicated templates for constructing diagrams, such as this network chart.

While the two programs were developed to fulfill the need for quick-and-clean graphics, Visio 2.0 is more extendable than SnapGrafx. Visio 2.0 is an OLE 2.0 object and a container that also supports OLE 2.0 automation. In addition, ShapeWare has developed a catalog of optional symbol libraries for specific industries or themes. However, because of SnapGrafx's template gallery, which shows up each time you start the program, SnapGrafx makes it easier for you to get started on your drawing.



This recycling symbol was created in Visio 2.0 in about 20 minutes. The predrawn arrows were modified using the line tool and fragment command and then rotated using the rotation tool. The program's grid helped in aligning the arrows.

Gordon Sellers, product manager for SnapGrafx, says Micrografx designed the program to appeal to everyone in a business, from administrators to the company president. "There is a huge group of people [in business] out there who have very specific needs," he says. He said that although suites of applications are a great way for companies to buy their spreadsheet, database, word processor, mail, and presentation programs, these packages don't sufficiently address all the common business graphics needs.

Other companies have noticed this untapped market as well. AutoDesk's AutoSketch 2.0, a 2-D CAD program for creating technical illustrations, also includes predesigned templates to minimize repetitive tasks. IntelliDraw 2.0, Aldus's full-featured drawing program for the Mac and Windows, offers predefined templates and collections of smart objects. Microsoft has acknowledged that a number of people use presentation programs to create organizational charts. The company is including a special version of Banner Blue's Org Plus as a standard feature in PowerPoint 4.0 for Windows, which is expected to ship this month.

—Dave Andrews

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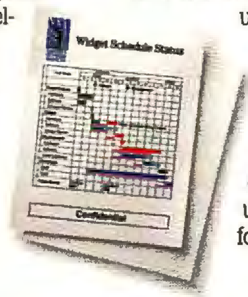

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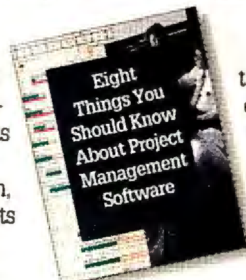

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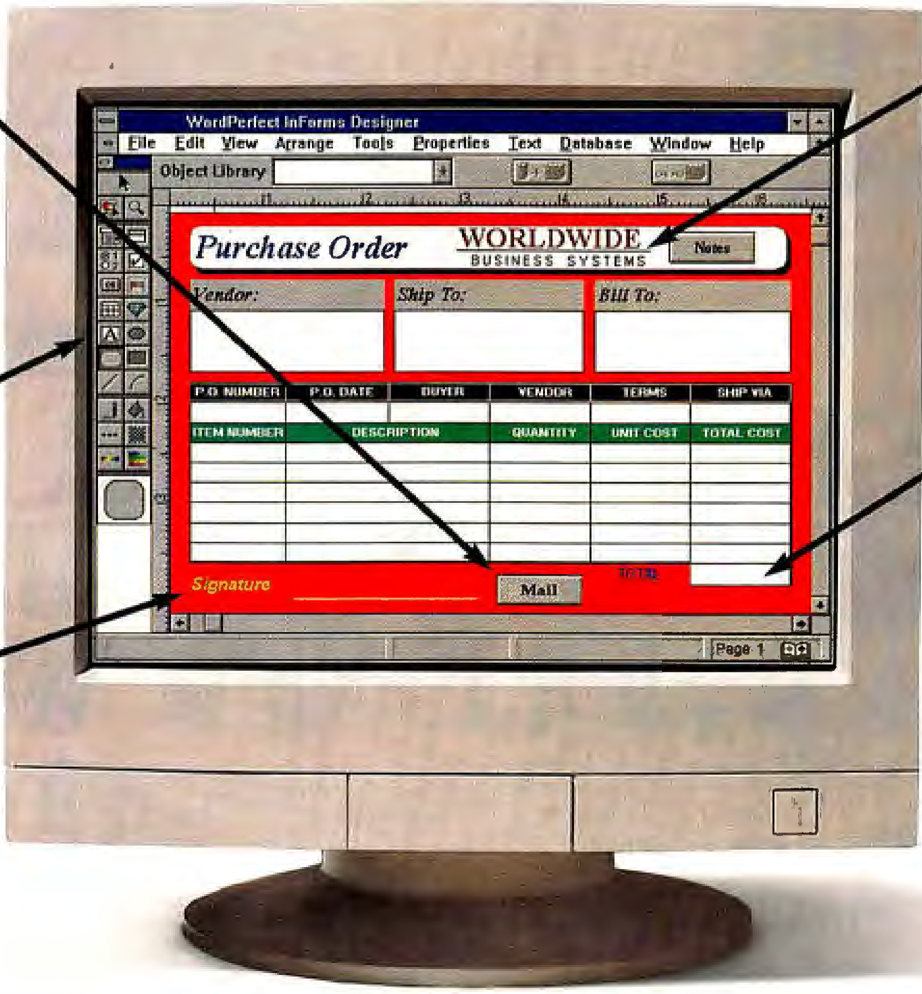

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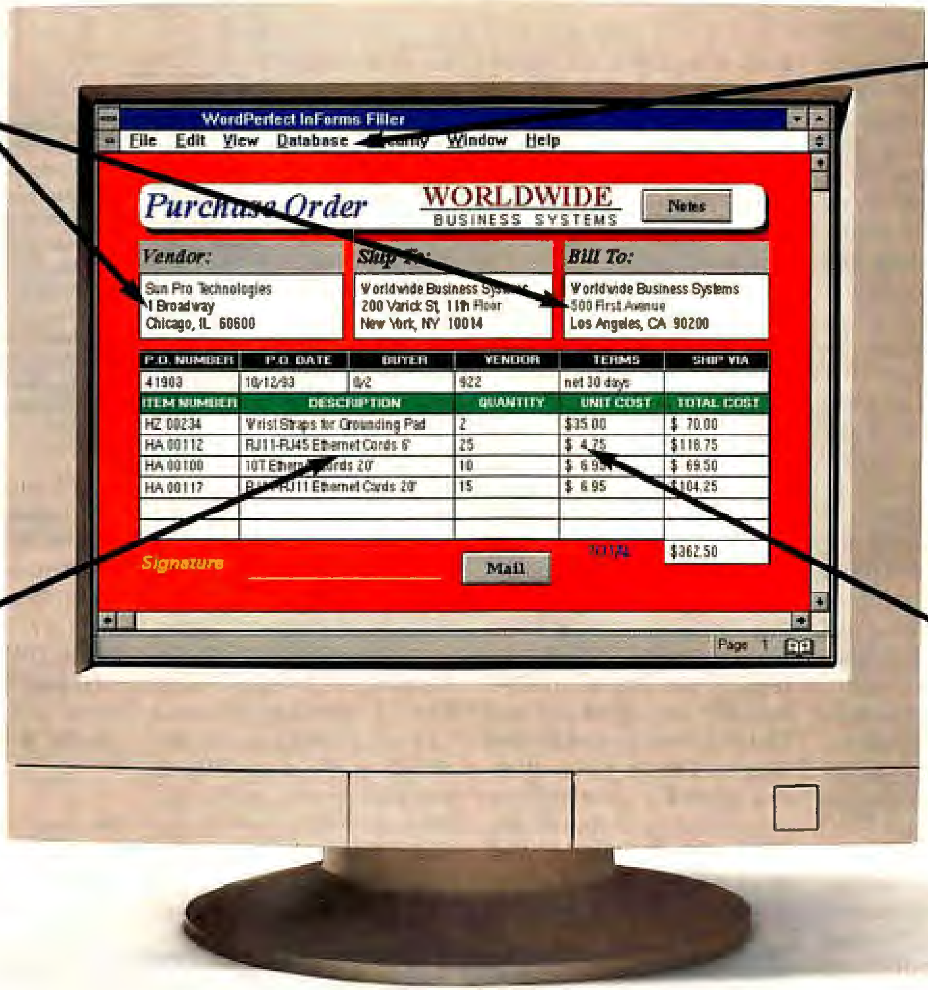

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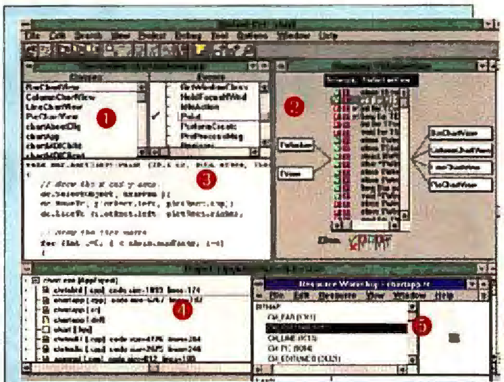
PROGRAMMING

A Giant Leap for Borland C++, a Small Step Past Visual C++



❶ The new ClassExpert is an integrated browsing and editing tool that lets you rapidly develop new classes in applications built with AppExpert.
❷ Borland's improved class browser filters class members to let you view large classes more easily.
❸ This editor window is part of ClassExpert, but it's inherited from the full IDE editor, which includes new capabilities like Brief and Epsilon emulation.
❹ BCW 4.0's project manager handles shared code resources (source tools) and outclasses the project support provided by Visual C++.
❺ Borland's superior Resource Workshop improves with added resource previews and thorough integration with ClassExpert.

When Borland C++ for Windows 4.0 makes its debut, it will be the best Windows development system on the planet—but just by a hair. BCW 4.0 inherits and improves on the best features of its predecessor, its OS/2 sibling, and arch rival Visual C++ to create an unsurpassed environment for building 16- and 32-bit Windows applications. But while the innovations are great, the end result is a tool that's only marginally better than Visual C++. Also, given the similar capabilities and great complexity of both packages, the advancements in BCW 4.0 will prove a boon primarily to those already committed to Borland C++ and OWL (Object Windows Library) development.

The most obvious enhancements to BCW 4.0 are Experts, high-level, rapid application-development utilities that are similar to the Wizards of Visual C++. The AppExpert generates a complete framework for an OWL-based application (or DLL) given only a few selections in a small set of dialog boxes. The resulting application can be incredibly sophisticated, optionally including a ready-to-run MDI (Multiple Document Iinterface), a toolbar, a status line, print previews, and built-in help.

The ClassExpert is a combination browser and editor that works with AppExpert applications, letting you quickly derive new classes from OWL's comprehensive set and easily define new member functions. The ClassExpert is fully integrated with Borland's Resource Workshop, so deriving a new class from OWL's TDialog instantly pops you into the resource editor, where you build the dialog-box template. Changes you make in the resource editor are reflected in the source files you edit within the ClassExpert.

Underlying the Expert technology is OWL 2.0, a heavily revamped version of Borland's high-level class library. OWL 2.0 adds Doc/View support, VBX control classes, and a host of new high-level classes (e.g., print and print preview). But OWL's most significant change is that it no longer requires the Borland-specific dynamic-dispatch virtual tables that formed the heart of OWL 1.0. That makes OWL 2.0 potentially portable to any C++ compiler and opens the door for OWL on platforms beyond Windows, making it an attractive target for those building cross-platform applications. OWL's first step outside Windows will be to Novell's AppWare Foundation, a move that should be realized by this summer.

Compared to other Windows C++ implementations, BCW 4.0's compiler is the most advanced. It supports the most recent recommendations of the ANSI C++ committee. New language features in BCW 4.0 include ANSI C++ exceptions and string classes, and run-time type information support.

BCW 4.0 targets both Win16 and Win32, includes Win32s, and can run (minus the IDE) on Windows NT. For the moment, it betters Visual C++ 1.0 with more advanced C++ features and a slightly better IDE; it also nicely fills the gap between the 16-bit and NT-hosted 32-bit versions of Visual C++. But its real challenge will come when Microsoft fills that gap on its own with Visual C++ 1.5, which will include Microsoft Foundation Classes 2.5 and its attendant high-level ODBC (Open Database Connectivity) and OLE 2.0 classes. At that point, OWL's potential as a GUI-independent platform may be the only quality that really sets BCW 4.0 apart.

—Steve Apiki

Borland C++ 4.0, $499. Borland International, Inc., P.O. Box 660001, Scotts Valley, CA 95067, (408) 431-1000.

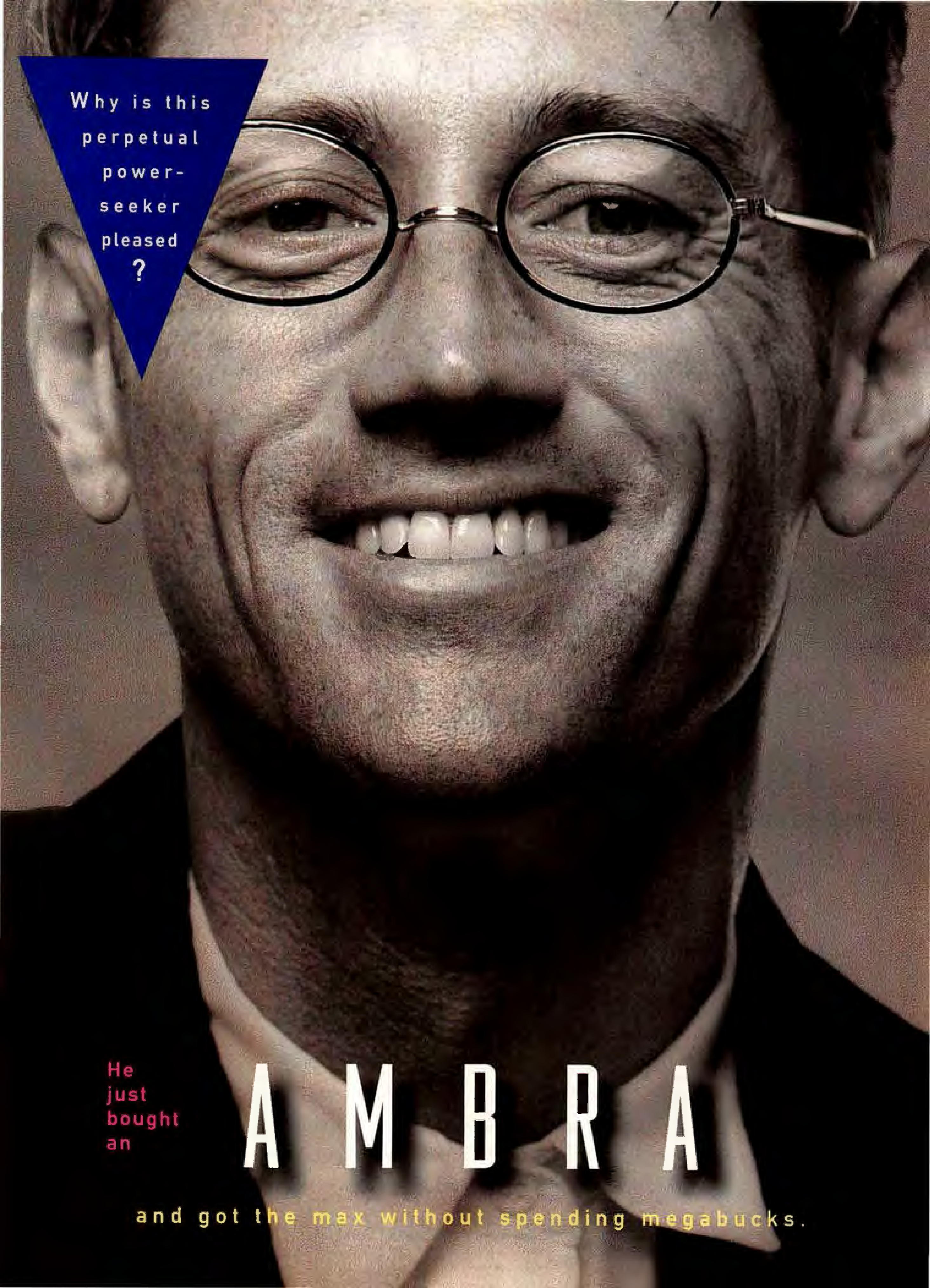
LAPLINK CUTS THE CABLE

Traveling Software and National Semiconductor have developed a wireless product that uses radio-transmission technology and intelligent software to let you automatically connect two computers and synchronize their files before you've even taken off your coat. Called LapLink Wireless with AirShare, the hardware/software package lets you link portable and desktop PCs without having to physically connect them.

Due to the package's on-connect option, you can configure the AirShare software to automatically begin synchronizing files at speeds of 115 Kbps once you walk within the range (about 30 feet indoors) of the target PC. Thus, you can begin sharing files simply by walking near the target computer. You can also use the package to print documents directly from your portable to a local or network printer.

LapLink Wireless includes two AirShare radio modules that weigh about 3 ounces each. The package is slated to ship in the first quarter and will cost $299.95. —Dave Andrews

LapLink Wireless with AirShare, which has a range of about 30 feet indoors, lets two computers automatically synchronize and share files using a wireless radio connection.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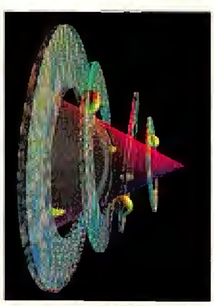

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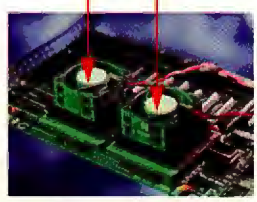

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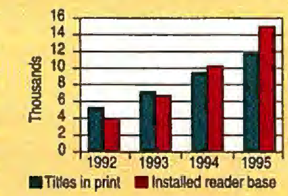
CD-ROM DRIVES

Speedy CDs Improve Video Performance

When it comes to moving data from disc to screen, CD-ROM drives have never been fleet-footed performers. However, CD-ROM may finally be finding its legs. Faster double-speed CD-ROM drives are now the norm, even among low-cost models. And Pioneer, NEC Technologies, and Plextor (formerly Texel), are upping the ante again with triple- and even quadruple-speed CD-ROM readers.

OPTICAL PUBLISHING FORECAST



The number of CD-ROM titles in print will grow from 5283 in 1992 to a projected 11,765 in 1995, or a growth of 222 percent, according to CD-ROM industry market researcher InfoTech (Woodstock, VT). But sales of CD-ROM readers will grow even faster, with a projected 374 percent growth in the same time period.

Pioneer already sells its external DRM-604X quadruple-speed CD-ROM reader. NEC has announced 3X and 4X drives. The new MultiSpin 3X drives ($455 to $600) transfer data at 450 KBps, compared to the 150-KBps rate of the first CD-ROM readers. The MultiSpin 4X Pro ($995), which NEC says it is targeting at software developers and power users, bumps the data transfer rate to 600 KBps, or fully twice the throughput of today's double-speed CD-ROM drives.

The higher transfer rates of these new models mean that the drives can more quickly read into memory large blocks of data—the kind needed for showing photo-realistic pictures, full-motion video clips, and crisper animation sequences. Plextor's quadruple-speed drive should be available by the middle of 1994.

While any CD-ROM title with such multimedia elements should run noticeably smoother, NEC is working with a host of publishers to produce new discs or updated versions of earlier titles that take particular advantage of the higher data transfer rates. Companies participating in NEC's Strategic Software Partnership program include Broderbund, Corel, Grolier, Knowledge Adventure, Macromedia, Spectrum HoloByte, and Time Warner Interactive.

Not all CD-ROM applications will benefit from the boost in data transfer rates, however. Searching through a disc full of text information (e.g., a Yellow Pages directory or a database of magazine articles) won't be much faster on a triple-speed drive. That's because finding data on the disc to begin with remains a relatively leisurely process. Both the MultiSpin 3Xe (external) and 3Xi (internal) drives have access times of 195 milliseconds, as does the 4X Pro model. A fourth model, the 3Xp (personal), has an access time of 250 ms. That's roughly 10 times slower than the access times of typical hard drives.

Still, for the sort of glitzy titles that dominate the CD-ROM field, triple- and quadruple-speed readers are a boon. And there may be higher speeds ahead. "There's no limit to how fast you can spin the disc," notes Dan Johnson, a MultiSpin product manager at NEC. The challenge, he says, is in developing a faster spindle motor and better error-correcting code [in the drive's firmware] and then dispersing the extra heat it produces.

NEC has been experimenting with CD-ROM drives running at six to eight times the original speed. But at some point, says Johnson, CD-ROM capacity may become a bigger issue than transfer speed.

—Christopher O'Malley

OPEN SYSTEMS

Novell Opens Unix

LONDON—Novell has transferred the Unix trademark to the international X/Open standards organization. The transfer, which was announced last October, when combined with other standards efforts, may yet result in multiple implementations of Unix that conform to a single specification.

Novell's transfer of the Unix trademark to X/Open is, said Kanwal Rekhi, executive vice president of Novell's Unix Systems Group, the next logical step for Unix. (In September, over 75 companies, including Sun, Hewlett-Packard, DEC, IBM, Novell, and SCO, agreed to adopt a single set of 1170 API calls.) X/Open will be responsible for certifying that vendors' operating systems meet the Spec 1170 definition of Unix.

The idea behind the common API is to let developers write to a single set of memory, file-system, and other kernel-level calls so that they need to do only a source-level recompilation to support another Unix platform. With multiple compatible implementations of Unix, vendors will then compete on the basis of price, quality, service, and reliability, or as X/Open's president and CEO Geoff Morris said, "a single specification, a single brand, and as much innovation as the industry can deliver."

The movement toward a unified Unix will continue throughout this year. SunSoft, IBM, and SCO officials say they expect to have versions of Unix that comply with Spec 1170 this year. But Morris said that the suite of software tests to verify Spec 1170 compliance will likely not be available until the end of the year. Until then, there is an interim specification that says companies must use USL operating-systems technology, conform to SVID (System V Interface Definition), and conform to XPG3 (X/Open Portability Guide) or XPG4.

Novell will not give up its right to license Unix System V source code to other vendors, but once the test suites are available, Unix vendors will no longer be required to use Unix code developed at USL/Novell.

—Dom Pancucci

BREAKTHROUGH!

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Performs any action a remote host can do	Performs any operation available to a network node
Requires understanding of remote control to use	Transparent, same as LAN operation

Mobile workers who want to access data that resides on a remote PC or LAN now have a wide variety of solutions for their communications needs, thanks to new programs that combine several functions in one package. Companies like Ocean Isle Software (Vero Beach, FL) and Triton Technologies (Iselin, NJ) that sell remote-control packages are adding LAN-redirection capabilities to their packages, giving you the ability to dial into your PC on the LAN and access its network services at a cost of $250 or less.

Such packages don't offer the full range of security or simultaneous multiuser access as dedicated products like Shiva's $1699 NetModem/E (see "Network Modems Dial in, Dial out, and Route Packets," November 1992 BYTE). But they offer an inexpensive communications solution for the user who wants to update and transfer files from one system to another.

One common solution for connecting nonnetworked users has been remote-control products like Norton-Lambert's Close-Up or Symantec's Norton PC Anywhere. With remote-control software, you take over a remote PC system as if you were sitting at its keyboard. You can view the remote PC's screen from your own PC, and your keystrokes and mouse actions can control the remote PCs' applications, which is why remote-control programs are often used for technical support and LAN troubleshooting.

Remote-node products take a different approach. In products like the NetModem/E, USRobotics' Communication Server 386, and DCA's Remote LAN Node software, a remote-access server attached to the LAN captures network packets and forwards them to the remote system. There, a network driver presents the network packets to the system as if they had been received directly from a LAN. This permits the remote system to perform any network operation (e.g., disk, printer, or E-mail) that is possible when attached locally. But remote network operations are somewhat slower than a LAN-attached node because modems usually operate at less than 5 percent of the speed of an Ethernet network.

A third category of software is typified by the LAN-redirection portions of Triton's Co/Session, Ocean Isle's ReachOut, and Traveling Software's CommWorks communications package. These software packages provide remote access without directly giving full access to a remote LAN. Steve Dulaney, product manager of CommWorks, says that unlike products like the NetModem/E, which can support multiple simultaneous users, the LAN-redirection portion of CommWorks is more for making one-to-one connections. But, once you've connected to your PC on the LAN, he says, "Every drive is available, even if it happens to be a network drive." For small workgroups, products in this category provide an inexpensive alternative to more expensive dedicated solutions.

Increasing modem speeds coupled with decreasing costs should improve the usefulness of remote-node products. Inexpensive integration with operating-system software will increase the acceptance of remote-node technology among users. Remote control still is the number-one choice for applications such as remote technical support and training.

—Matt Trask

EUROPEAN COMMUNICATIONS

Falling Prices Boost ISDN

MUNICH—Businesses in Germany are increasingly turning to ISDN for their telecommuting needs. ISDN's ability to establish connections in about 1 second, combined with compression and bridges that can harness many 64-Kbps lines into one channel, make it an attractive LAN-to-LAN networking solution. "Telecommuting applications are, for the moment, the killer applications for ISDN," says Christian Luhrs, director of marketing for CPV-Stollmann (Hamburg).

One segment of the market ISDN has not yet widely penetrated is the home-to-office arena, partly because ISDN is too expensive for many users. But Telekom, a German phone company, is expected to reduce the cost of ISDN access this year.

Acotec (Berlin) offers ISDN for Windows, a program that lets Windows for Workgroups users establish LAN-to-LAN and PC-to-LAN connections over ISDN. Christian Zillich, Acotec's director of marketing, reckons that Telekom is activating 15,000 ISDN accesses a month. He says, "Five years ago, when ISDN started, people asked, 'Where are the ISDN end terminals?' There are 35 million PCs in Europe. These are the engines."

—Dave Andrews

Advancements in full-motion data compression continue to improve the performance of videoconferencing programs that run over 64-Kbps ISDN lines. For example, Teles (Berlin) has developed Teles.Vision, a videoconferencing program for Unix that lets you view up to four participants (out of a total of 20) simultaneously and share documents over ISDN. However, differing national ISDN standards in Europe often make it difficult to set up a videoconference involving several countries. For this reason, 26 public network operators from 20 European countries have agreed to a common ISDN called Euro-ISDN. The first products and services to support Euro-ISDN will appear this year.

INTEL TECHNOLOGY BRIEFING

PERFORMANCE MEASUREMENT

TRUE TESTS OF SPEED

PUTTING PCs TO THE TEST.

At Intel, we've become experts at measuring PC performance. The reason for this is quite simple. We need ways to accurately measure performance in order for our engineers to develop faster processors. That's why we've worked with other companies in the industry to develop measurement tools. You can use these same tools to choose the right PC.

MEGAHERTZ. LIKE RPMs?

One common misperception is that you can compare PC performance by comparing megahertz ratings or clock speeds. This is like comparing the performance of engines with RPMs instead of horsepower. For example, although a small 4-cylinder engine may operate at high RPMs, it isn't as powerful as a big V-8 at lower RPMs. That's why the industry created benchmarks.

PERFORMANCE BASICS.

There are four different types of benchmarks. You should be sure you're comparing the same types of benchmarks when comparing PCs. One kind measures the performance of an entire system. Another only measures subsystems.

In addition, benchmarks can be built two different ways—using commercial software applications or synthetically with code that's written to represent applications. While most applications are several megabytes in size, some synthetic benchmarks are only a few kilobytes. This allows them to fit in internal processor caches. So they exaggerate processor performance and don't reflect real-world results.

SYSTEM BENCHMARKS.

To compare the performance of an entire computer, you should use a system benchmark. This type of benchmark demonstrates how the individual subsystems in a PC work together to achieve overall performance for your applications.

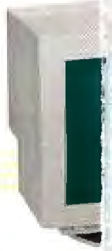
One example of a benchmark that does this accurately is BAPCo's SYSmark93* for Windows.* It's an applications-based benchmark made up of best-selling Windows applications including word processing, spreadsheets, databases, software development, graphics and desktop publishing.

BAPCo is a non-profit organization comprised of 21 hardware and software member companies throughout the industry, including Intel. To ensure real-world performance results, BAPCo surveyed users about how they are actually using these applications and incorporated these results into their benchmarks. (See the charts on back.)

SUBSYSTEM BENCHMARKS.

These benchmarks stress a single aspect of a PC's performance. They help manufacturers "tune" each subsystem in a PC to work together and achieve the fastest overall speed. Viewed alone, however, they are not an accurate measure of how a computer will perform overall.

Because the microprocessor is the subsystem most responsible for a PC's performance, you should choose it first using a tool like the iCOMP™ index. The other subsystems should then be chosen based upon your software's needs. (See the diagram this page.)



SUBSYSTEM PERFORMANCE

HOW TO MEASURE THE SPEED OF THE SUBSYSTEMS IN A PC.

VIDEO

VIDEO PERFORMANCE IS DETERMINED BY THE GRAPHICS CHIP SET AND WHETHER OR NOT IT'S ON A LOCAL BUS. ZIFF DAVIS LABS' WINMARK TEST IS A GOOD MEASURE OF THIS PC SUBSYSTEM.

MEMORY SUBSYSTEM

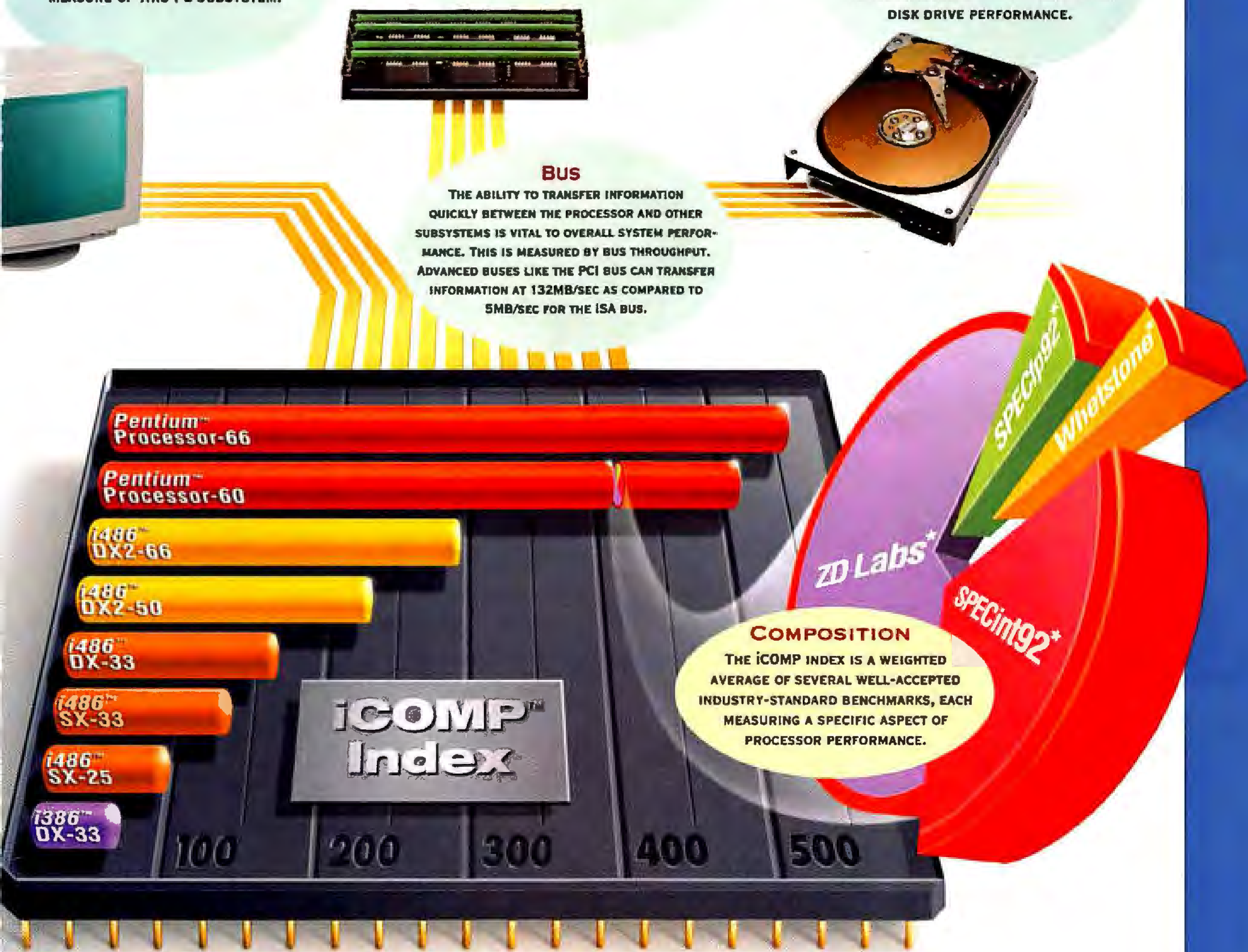
MEMORY PERFORMANCE IS DEPENDENT ON CACHE SIZE AND ARCHITECTURE WHICH DETERMINE WAIT STATES. BECAUSE IT IS LINKED TO THE MICROPROCESSOR, IT IS BEST MEASURED BY A GOOD CPU BENCHMARK LIKE SPECINT92, LANDMARK 3.0 OR ZD LABS' PC BENCH 7.

DISK DRIVES

MANY OF TODAY'S HARD DISKS INCORPORATE DISK CACHES WHICH INCREASE THROUGHPUT. YOU CAN SIMPLY COMPARE ACCESS TIMES OR USE MOST PC UTILITY PROGRAMS TO ACCURATELY TEST DISK DRIVE PERFORMANCE.

BUS

THE ABILITY TO TRANSFER INFORMATION QUICKLY BETWEEN THE PROCESSOR AND OTHER SUBSYSTEMS IS VITAL TO OVERALL SYSTEM PERFORMANCE. THIS IS MEASURED BY BUS THROUGHPUT. ADVANCED BUSES LIKE THE PCI BUS CAN TRANSFER INFORMATION AT 132MB/SEC AS COMPARED TO 5MB/SEC FOR THE ISA BUS.



COMPOSITION

THE ICOMP INDEX IS A WEIGHTED AVERAGE OF SEVERAL WELL-ACCEPTED INDUSTRY-STANDARD BENCHMARKS, EACH MEASURING A SPECIFIC ASPECT OF PROCESSOR PERFORMANCE.

THE iCOMP™ INDEX. COMPARING INTEL MICROPROCESSORS.

MEGAHERTZ RATINGS ARE NOT AN ACCURATE MEASURE OF MICROPROCESSOR PERFORMANCE. OTHER ELEMENTS HAVE AN EFFECT ON SPEED. FOR EXAMPLE, AN INTEL486™ PROCESSOR HAS LARGER CACHES, FLOATING POINT OPERATIONS AND THE ABILITY TO EXECUTE ONE INSTRUCTION IN A SINGLE CLOCK CYCLE. THESE ADVANCEMENTS MAKE IT RUN FASTER THAN AN INTEL386™ PROCESSOR. EVEN IF BOTH PROCESSORS ARE RUNNING AT 33MHZ.

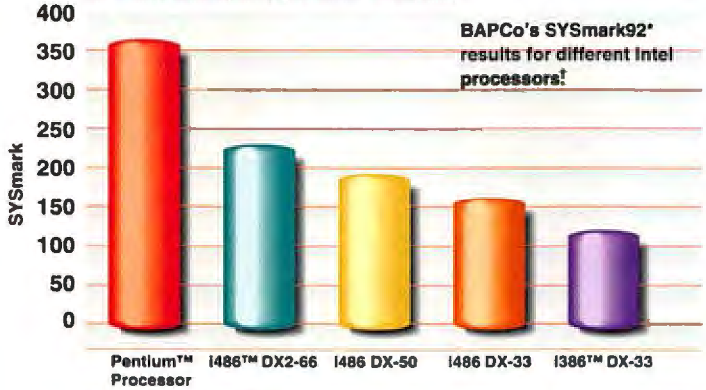
THAT'S WHY INTEL DEVELOPED THE iCOMP™ INDEX. IT'S AN EASY, RELIABLE WAY TO COMPARE THE RELATIVE PERFORMANCE OF INTEL PROCESSORS.

iCOMP STANDS FOR THE INTEL COMPARATIVE MICROPROCESSOR PERFORMANCE INDEX. IT IS NOT AN INDUSTRY BENCHMARK. RATHER, IT'S AN INTEL-DEVELOPED TOOL FOR COMPARING THE PERFORMANCE OF OUR MICROPROCESSORS.

THE iCOMP INDEX REPRESENTS INTEL PROCESSOR PERFORMANCE ON TYPICAL DESKTOP APPLICATIONS, SAVING YOU THE TIME OF READING AND UNDERSTANDING MULTIPLE BENCHMARKS. PLUS, IT'S "FORWARD LOOKING." IT WEIGHS 16-BIT PERFORMANCE 70 PERCENT AND 32-BIT PERFORMANCE 30 PERCENT. THUS, IT REPRESENTS TYPICAL USAGE DURING THE NEXT THREE TO FIVE YEARS.

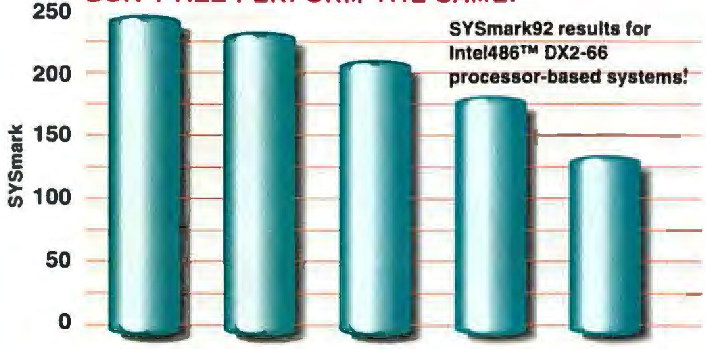
System Performance

In general, the faster the processor, the faster the computer...



As you can see, these bus system benchmark results are similar to the iCOMP™ index results inside. This shows how the iCOMP index can be used to easily compare the performance of computers with different processors.

However, PCs with the same processor don't all perform the same.



All Intel486™ DX2-66 processor-based systems.
[1]Source: BAPCo's SYSmark92 complete report.

The overall performance of a PC depends upon the entire system—not just the microprocessor. That's why it's important to choose a PC with well-tuned subsystems.

Not all PCs are created equal.

It has been said that a chain is only as strong as its weakest link. Although the processor is the vital component in a computer, other subsystems can have a dramatic effect on overall performance. In fact, depending upon subsystems like disks, memory and video, the performance of PCs with the same processor can vary by up to 100 percent. Even with the same components, system performance can be enhanced through disk caching software and BIOS enhancements.

Subsystems should be chosen based upon your software:

- Video—Better video subsystems will boost the performance of Windows and graphic-intensive applications.
- Disk—Faster disk drives will boost the performance of applications like databases.
- Memory—A better memory subsystem, a more efficient cache and faster RAM speed increases the performance of all applications, especially calculation-intensive ones like spreadsheets.

For more information on the iCOMP™ index and performance measurement, call 1-800-955-5599.

We've prepared a detailed package including more information on the iCOMP index, the different kinds of benchmarks, and even specific benchmark results. Simply call us today and ask for literature pack #73. We'll send it all to you absolutely free.

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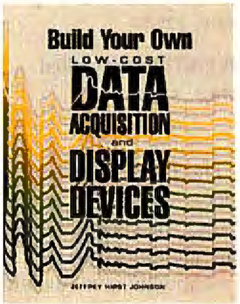
Low-Cost Data Acquisition



HOWARD EGLOWSTEIN

One of the most frequently asked questions in the Internet PC newsgroups is, "How do I get access to the serial/parallel ports on my PC?" Products such as LapLink and the many parallel-port tape/disk drives on the market make using these ports look easy. But building your own data acquisition interfaces is far from trivial, unless you have a good reference like Jeffrey Hirst Johnson's *Build Your Own Low-Cost Data Acquisition and Display Devices*. Johnson starts at the beginner's level, explaining the basics of data transmission and exposing the inner secrets of your PC's serial and parallel ports.

Along the way, you'll learn how the PC's interrupt system works and that the standard, yucky old parallel port on the original IBM PC is capable of 8-bit bidirectional data transfer without any modifications. Several different approaches to using the printer port come up in discussion. I've seen some of these used in commercial products but have never seen such a thorough discussion of all of them in one place. Plenty of working code is provided in assembly language and Turbo Pascal.

You'll also learn about ADCs (A/D converters) and the complementary D/A conversion process and put them to use building your own digital multimeter. The design includes remote control of and acquisition from the multimeter through your (you guessed it) serial and parallel ports. Perhaps you don't need to build a PC-controlled mousetrap but simply want to know how those LapLink guys can move data so quickly. This book will tell you all you want to know and more. ■

BUILD YOUR OWN LOW-COST DATA ACQUISITION AND DISPLAY DEVICES
Jeffrey Hirst Johnson
Tab Books
ISBN 0-8306-4348-6
$19.95

BYTE Lab testing editor Howard Eglowstein has built a notebook battery-testing device—affectionately called Thumper—for the BYTE Lab. You can reach him on the Internet or BIX at heglowstein@bix.com.

WHAT ARE OPEN SYSTEMS?

OPEN SYSTEMS: THE REALITY by Terry A. Critchley and K. C. Batty
Prentice-Hall, ISBN 0-13-030735-1, $40

As Critchley and Batty demonstrate at the beginning of their book *Open Systems: The Reality*, the one thing that seems too open is the definition of the phrase *open systems*. The definition that you receive may be nothing more than a rephrasing of "Buy our system; we are open for business." But as the authors point out, actual standards have been written that specify what open systems can mean in a valuable way.

This book traces the history of each standard and organization. It also gives an overview of what each standard involves. Of particular note is the history and charter of X/Open and the OSF (Open Software Foundation). Now that the Unix trademark is controlled by X/Open, there will be more pressure to move to Unix certification rather than just being satisfied with Posix compliance. *Open Systems: The Reality* is written for information systems managers as well as the technical people who plan on implementing edicts for open systems. It provides an overview of the subject while still providing enough technical content that you can understand the differences between competing standards.

—Ben Smith

AN IMPROVED ENCARTA

MICROSOFT ENCARTA 94, $395

Last year, the Encarta electronic encyclopedia set a standard for multimedia CD-ROM. Now, Microsoft has topped itself with Encarta 94, a significant improvement of an already-great Windows product.

Encarta is based on the full text of the 29-volume *Funk & Wagnall's New Encyclopedia*, but this is just the starting point. Microsoft has added video and audio clips, animations, photos, interactive maps, and more around an easy-to-use interface. You can find any of the 25,000 articles using keyword searches or by browsing through category lists.

The real power of the product, however, lies with its interactive nature. Visual cues such as highlighted text, menu buttons, and icons lead you through the components of a given topic (e.g., text, video, and map) or through various levels of related topics. Exporting text is a simple matter of copying it to the Clipboard.

With many multimedia CD-ROM titles, the various elements seem to have been put together with baling wire and chewing gum. Transitions are choppy, and the interfaces are often confusing. This is not the case with Encarta 94. You can navigate smoothly and logically from text to video to other hyperlinked references and back again without getting lost.

The material is up to date, as you would expect with an electronic medium. The ever-changing boundaries of Eastern Europe and the former Soviet empire are mostly current, for example.

To get the most out of Encarta, you need an MPC 2–compatible system (although it will run on MPC 1 systems). This means you need at least a 486SX CPU, a double-speed CD-ROM drive, and a good sound board and speakers.

As a general reference for the home or small business, Encarta 94 is a great value. It is not, nor is it intended to be, the last word on any given topic it covers, but you will be entertained by the way in which the information is presented.

—Michael Nadeau

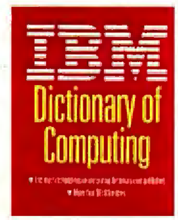
DUELING DICTIONARIES

IBM DICTIONARY OF COMPUTING compiled and edited by George McDaniel McGraw-Hill, ISBN 0-07-031488-8, $39.50

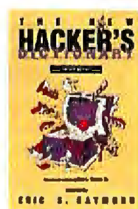
THE NEW HACKER'S DICTIONARY, SECOND EDITION compiled by Eric S. Raymond MIT Press, ISBN 0-262-68079-3, $14.95

You *can* judge a book by its cover. The *IBM Dictionary of Computing* is just what you'd expect: a serious, "just the facts, ma'am" reference on computer terms. The second edition (which adds 250 definitions and updates another 150) of *The New Hacker's Dictionary*, however, knows how to have fun with the language.

The two, in fact, have little in common except the word *dictionary* in their titles. That's OK, though, because each serves a different purpose. The 18,000-definition *IBM Dictionary* is as solid and up-to-date a reference on the vocabulary of computing as I've seen. It does cater to IBM-specific terminology, as you would expect from the title, but not at the expense of jargon at large. *The New Hacker's Dictionary* is a colorful celebration of hacker slang and contains few of the terms in the *IBM Dictionary*.



One word you do find in both is *bug*. The *IBM Dictionary* defines it as "an error in a program." *The New Hacker's Dictionary* devotes over a page to it, describing not only its roots in hackerdom, but also pointing out that a bug was considered a flaw in something prior to the age of computers. This historical perspective exists throughout the book and makes *The New Hacker's Dictionary* both a good recreational read and a reference.



Anyone who deals with technical literature will find the *IBM Dictionary of Computing* indispensable. Anyone interested in hacker culture will enjoy browsing through *The New Hacker's Dictionary*. I intend to hang onto both.

—*Michael Nadeau*

FOR FIRE WALKERS ONLY

SENDMAIL by Bryan Costales, Eric Allman, and Neil Rickert O'Reilly & Associates, ISBN 1-56592-056-2, $32.95

It all started as a student's programming project in the early 1980s at the University of California at Berkeley; it ended up being the worldwide standard for Internet mail routing. The program is called `sendmail`. At last, there is comprehensive documentation on how to administer it—*Sendmail*, the book.

The program and its rule description file, `sendmail.cf`, have long been regarded as the pit of coals that separated the mild Unix system administrators from the real fire walkers. Now, `sendmail` syntax, testing, hidden rules, and other mysteries are revealed. Costales, Allman, and Rickert are the indisputable authorities to do the text. ■

—*Ben Smith*

1993 BYTE AWARDS

Of the many computer-related products and technologies that debuted in 1993, only 71 earned BYTE Awards. These winners set the standards for innovation and price/performance, and a few are harbingers of things to come.

Every year, thousands of new products and technologies appear. Some fade into obscurity while others become commercial successes, but only a very few represent important breakthroughs in innovation. These latter products and technologies often serve as industry catalysts; they point the way for other innovative products.

BYTE editors are in a unique position to observe and evaluate these breakthrough products. Multiplatform in nature, BYTE has no inherent biases toward any one operating system or CPU. We rate the products, using a nomination and voting process, based on their level of innovation and market impact. (For a full description of the selection process, see the text box "How BYTE Selected the Best" on page 48.)

BYTE Awards are three-tiered. The Award of Excellence is the highest honor, followed by the Award of Distinction and the Award of Merit.

Reading the Tea Leaves

There are three strong trends reflected by this year's voting: a platform shift in terms of both CPU and operating system, CD-ROM's coming of age, and the changing face of communications. The latter includes both wireless connections and videoconferencing.

By far, 32-bit processors and operating systems dominated the voting. The three top vote-getters were the IBM/Apple/Motorola PowerPC 601, IBM's OS/2 2.1, and Intel's Pentium processor. Microsoft's Windows NT was not far behind. Furthermore, other products and technology for supporting a 32-bit environment—Microsoft's OLE 2.0 and the PCI 2.0 bus standard—were Award of Excellence winners. The Silicon Graphics Indy, a 64-bit Unix workstation, was also ranked highly.

Companies considering a platform shift want to do so with minimal expense and stress. This means maintaining the ability to run important in-house and commercial applications that are already developed and owned. NT and OS/2 offer compatibility with Windows and DOS applications, and the Pentium and PowerPC processors provide the horsepower to drive the new 32-bit applications in addition to existing applications.

Eventually, though, existing applications need to move to new hardware and operating-system platforms. The tools to do the job are also among our award winners: They include Watcom C/C++ 32, Borland C++ 3.1, Microsoft Visual C++ for Windows 1.0, and Symantec's C/C++ 6.0.

This trend was very predictable. Processor-performance improvements are outpacing price increases by a wide margin, and today's graphical applications always find a way to use the extra power. Couple a Pentium or PowerPC with OS/2 or Windows NT, and you have an extremely powerful multitasking system that has the ability to run non-native applications at a respectable speed.

CD-ROM Shows Its Stuff

CD-ROM has been around since the mid-1980s, but until recently its use has been relegated to niche applications. Two events have helped to change this: the advent of recordable CDs and a quantum leap in the quality of consumer and business titles. You can now expect, for example, tightly integrated and intelligently designed multimedia software. Four award winners exemplify why CD-ROM is becoming so popular.

Two software titles, Voyager's A Hard Day's Night and Microsoft's Encarta 1994 Edition, show off the potential of CD-ROM as an ideal multimedia medium. This is not just due to the inherent ability of CD-ROM drives to play multiple data types; a great deal of credit goes to the developers at Voyager and Microsoft for creatively putting those abilities to use. Both effectively use audio, video, hypertext, and more to significantly enhance the delivery of information.

We also gave awards to two CD-ROM drive products. The JVC Personal RomMaker is an affordable CD-R (compact disc recordable) drive. The product brings greater ease of use and reliability to the medium—qualities badly needed for CD-R to gain wide acceptance. Affordable recordable drives open up a lot of possibilities for corporate in-house publishers. For them, CD-ROM is now a viable medium for internal or external data distribution.

Speaking of getting data out to the troops, Pioneer's Award of Merit–winning DRM 604X is a slick six-CD-ROM minichanger designed for network use. Featuring a 600-KBps transfer rate, this product is a fast means of sharing CD-based data among a staff's members.

New Ways to Communicate

The way in which people use computers to communicate is changing in two ways. "Anytime, anywhere" communications is here, enabled by small, wireless devices such as the new PDAs (personal digital assistants) that were announced in 1993. These devices are designed to act as mobile nodes for faxing, E-mail, and paging.

From a product standpoint, we thought that the current crop of PDAs were seriously flawed. However, we did give Apple an Award of Excellence for some of the technology embedded in its Newton MessagePad. Specifically, its Newton Intelligence operating system is a strong backbone on which to build a powerful communications and computing device.

Though not technically a PDA, the Award of Merit winner Eo Personal Communicator 440 is an impressive example of what a small communications device can do today. It serves as your own personal cellular phone, portable fax machine, and daily organizer, all wrapped in an easy-to-use package.

continued

PHOTOGRAPHY: SCOTT PARKER / AVIS STUDIO ©1994

How BYTE Selected the Best

The BYTE Award winners were selected through a democratic process. All BYTE editors, including staff, consulting, and contributing editors, participated. BYTE licensees around the world (who reprint BYTE editorial material in the native languages of their respective countries) also participated.

The process begins with nominations. To be eligible, a product or technology must have been introduced since the previous year's award process ended (i.e., early October) and be likely to ship to users by the end of the current calendar year. We judge the likelihood of a nominee's shipping based on the vendor's announced shipping date and the apparent maturity of the product or technology. Nominated products must have been covered or have planned coverage in BYTE.

A nominated product should be one that breaks new ground in terms of new technology, performance, price, or innovative use of existing technology. An editor can nominate only products that he or she has had hands-on experience with and is reasonably sure will perform as advertised.

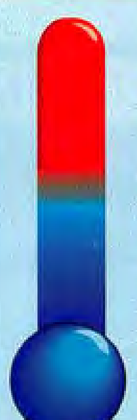
After the nomination process, every editor and licensee receives a ballot listing all the nominated products and technologies. Each voter then selects what he or she believes to be the 10 most significant products of 1993; a voter may pick fewer than 10 if he or she chooses.

Awards of Excellence, Distinction, and Merit are assigned based on the number of votes received. Cut-off points for each award are determined according to how the votes are distributed along a curve.

Powering the Eo is AT&T's ATT92010 Hobbit processor, an Award of Distinction winner. The Hobbit is a powerful RISC processor designed specifically for small communications devices such as the Eo. It can crank out 13 MIPS or more, yet run comfortably for an hour or more on battery power.

The other side of the communications trend is visual. Thanks to Apple and Silicon Graphics, you can now buy a PC with built-in videoconferencing capability. Videoconferencing is not for everyone—yet. We believe, however, that the Silicon Graphics Indy and the Mac Quadra 840AV, along with the Mac Centris 660AV, are milestone products. People will look back on them as the beginning of a trend to integrate video capabilities on the desktop.

THE CHANGING CLIMATE



Heating Up
PDAs
RISC
32-bit operating systems
Subnotebook PCs
PCI
CD-ROM
Color printing
C++

Cooling Off
Pen computing
CISC
16-bit operating systems
Notebook PCs
VL-Bus
Floppy disks
Monochrome printing
C

The Biggest Innovators

A few companies stood out as leaders in innovation for 1993. At the top, Microsoft tied with Apple for the highest number of awards: seven. All of Microsoft's awards were for software products—three for operating systems, and two each for applications and development tools. Four of Apple's awards were for systems.

IBM made a strong showing with five awards, for products ranging from its Continuous Speech Series speech-recognition technology to its OS/2 2.1 operating system. The company continues to show leadership in notebook PCs, winning awards for the ThinkPad 750C and ThinkPad 500. The PowerPC 601, which IBM co-developed with Motorola and Apple, was the biggest overall vote-getter by a wide margin.

Also making strong showings were Adobe, Silicon Graphics, and Hewlett-Packard. Adobe shines in the area of graphics software, winning awards for Photoshop 2.5 for Windows and Macintosh and Premiere 3.0 for Macintosh. Its Award of Excellence–winning cross-platform document-interchange software, Acrobat, promises to revolutionize electronic publishing.

Silicon Graphics is also known for graphics, but from the hardware side. Videoconferencing capability aside, its Indy is a powerful, inexpensive graphics workstation. The RealityEngine^2 is very expensive at about $80,000, but nothing else comes close to delivering its graphics and video capabilities on a workstation-class system.

Hewlett-Packard won three awards, all Awards of Excellence. As you would expect, two of those winners were printers: the LaserJet 4L and the DeskJet 1200C. HP's innovative OmniBook 300 subnotebook was the company's other winner.

Past and Future Predictions

Last year, we predicted that Mac software would rebound in the award standings but still not overtake Windows. Windows applications garnered more than three times the number of Mac awards last year. This year, Windows applications received less than twice as many awards as Macintosh applications. As we said then, Windows had a lot of momentum—and it still does—but the Mac hardware and operating system offered some technological advantages to software developers.

We also told you to look for the next-generation notebooks and subnotebooks. This year, twice as many portable systems as desktop systems won awards. Most of them were notebooks or subnotebooks. This generation of award winners is more powerful than the previous generation and is easier to use.

What do we predict for next year? Look for powerful new portable and desktop systems based on this year's award-winning processors. At this writing, the first PowerPC systems have been announced. System vendors should soon start taking full advantage of Intel's Pentium as well. Low-power versions of these processors will inspire a new generation of notebook PCs.

We also expect to see new applications (as well as ports of old ones) for Windows NT, OS/2 2.1, and other 32-bit operating systems running on RISC-based processors. These applications could create new performance standards, especially for graphics-related functions.

Wireless communications is another area to watch. Wireless technology is advancing rapidly, and some of the regulatory and structural barriers to using it are beginning to fall. In 1994, you might see the first wireless products and services that are practical for everyone to use.

—Compiled by Michael Nadeau

continued

SINCE OUR UPS COSTS LESS, LET'S FORGET ABOUT PRICE FOR A MINUTE...MAN

BECAUSE WHEN THE POWER DIPS, ITS NOT WHAT YOU PAID FOR YOUR UPS THAT'S IMPORTANT, ITS WHAT IT DOES

SO LET'S TALK ABOUT FEATURES...

The MINUTEMAN ALLIANCE A500 keeps your network safe from brownouts, the most common power problem. Our line-interactive technology continuously monitors and provides an automatic boost whenever power dips. This important feature prevents frequent battery usage, saving the battery for more severe power problems.

Other important features that make the MINUTEMAN A500 stand out are a 500 VA rating, extensive status indicators and a Test button so you can confirm that the UPS is doing its job. A Site Wiring Fault Indicator is included to let you know if there is a problem with grounding or other on-site electrical wiring problems that could be catastrophic.

The Alliance A500 is compatible with MINUTEMAN's LanMaster unattended shutdown software for all operating systems to further protect your network, even when you're not there.

If all UPSs were priced the same, the choice would be easy based only on features. But when you compare prices, the choice becomes even more obvious.

We don't believe you'll pay 25% more for a product that gives you less. Call our POWER HOTLINE now and find out how to get more UPS for less.

MAKE THE COMPARISON YOURSELF

Model	Minuteman A500	APC BK600	Tripp Lite Omni 500
PRICE	$299	$399	$379
Price per Watt	.92	1.00	1.08
VA Rating	500	600	500
Line-Interactive	YES	NO	YES
Waveform Output	Simulated Sinewave	Simulated Sinewave	Simulated Sinewave
LED Status Indicators	YES 4-LED's	NO	YES 4-LED's
Site Wiring Fault Indicator	YES	YES	NO
Test Button	YES	YES	NO

Product and company names mentioned herein may be trademarks or registered trademarks of their respective companies

$25,000

yes NetWare Tested and Approved

MICROSOFT COMPATIBILITY TEST LAN MANAGER VERSION 2.1

MINUTEMAN
UNINTERRUPTIBLE POWER SUPPLIES
1-800-238-7272

Minuteman's product line includes UPSs and Voltage Regulators ranging from 300VA to 10 KVA. International models are available.

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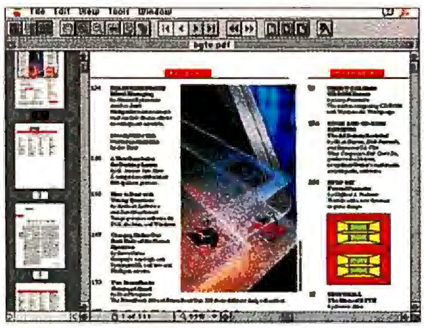
Adobe Acrobat

Adobe Systems

Adobe's PostScript PDL (page-description language) has become the lingua franca of the printer world. That is, numerous applications on a variety of platforms can obtain consistent output on a PostScript printer. With Acrobat, Adobe strives for the same grand unification for electronic documents. Acrobat accomplishes this by leveraging off proven technologies such as EPS (Encapsulated PostScript) and Multiple Masters fonts.



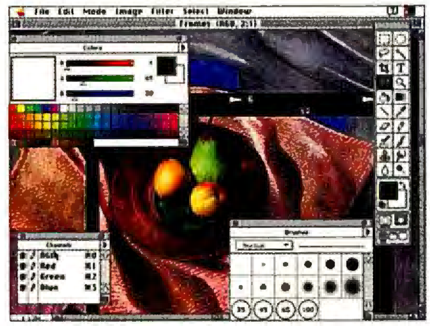
Getting your electronic documents into Acrobat format requires no rocket science. Just print your document into an EPS file, run an Acrobat Distiller application to compress the data, and tack on a Reader application. Versions for DOS, Windows, and the Mac are available.

If your computer system lacks the fonts that were used to create the original document, the Reader's Multiple Masters technology will render an approximation of the missing font with appropriate weight and spacing. Acrobat provides text searching and hypertext linking to assist users looking for information in large documents.

Compression is outstanding, shrinking a 20-MB PageMaker file down to under 4 MB. Creating thumbnail pages, hypertext links, indexes, and text annotations with Acrobat is a no-brainer.

Adobe Photoshop 2.5 for Windows and Macintosh

Adobe Systems

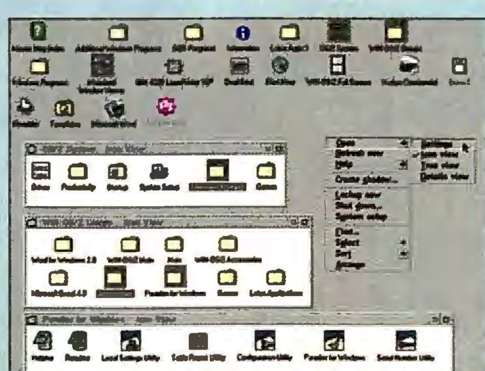


Adobe Photoshop, long the leading Mac application for professional image editing, is now available for Windows. Both versions boast significant improvements over release 2.0. Experienced darkroom workers as well as neophytes will appreciate the new dodge-and-burn tool, which simulates the traditional lightening and darkening manipulations employed when enlarging. Brushes can be modified with any selected shape, and the new pen tool gives more precise control over the shapes you select.

A quick-mask mode lets you work with a semitransparent film overlaid on your image and then quickly change the mask into a selection. A new preview window makes it easier to tinker with color corrections and other variables. Photoshop's open architecture allows plug-in software to augment existing features, such as accessing a digital signal processor to speed up image processing. And a host of special-effects filters let you add pizzazz to a lackluster image. The new Photoshop will definitely be welcomed by Windows users.

OS/2 2.1

IBM



The latest revamp of OS/2 has solved most, if not all, of the problems plaguing the long-in-coming version 2.0. Chief among these, the lack of high-resolution video drivers, is a thing of the past owing to the inclusion of several drivers for Super VGA, XGA, 8514/A, and other display modes. Another revamp, the 32-bit graphics engine, first surfaced in a Service Pak that was shipped between versions 2.0 and 2.1; it appears here in optimized form.

There's lots more. Dual-threaded DOS-session support, APM (Advanced Power Management) support, PCMCIA drivers, multiple-session Windows support (a faster Windows than Windows at running applications), a rewritten VCOM.SYS serial-port handler, and built-in multimedia support in the form of MMPM/2 1.01 are other improvements in an operating system that is finally winning some of the vital support it needs and, as of this version, truly deserves.

"Running OS/2 2.1 on an 8-MB machine that hasn't a prayer of running Windows NT, I find that it delivers many of the same benefits: robust multithreading and multitasking, a comprehensive 32-bit API, an advanced file system, and competent support for Windows 3.1 software. Software developers have known for years that OS/2 is a far more productive environment than DOS plus Windows. With the polish and maturity of version 2.1, more and more users are discovering the same advantage."

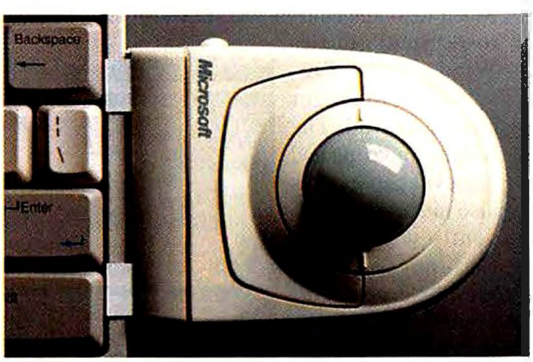
—Jon Udell

HP DeskJet 1200C

Hewlett-Packard

With a good balance between price and output quality, HP's reliable and flexible DeskJet 1200C ink-jet printer is the best package for bringing affordable color printing to most offices. The 300-dot-per-inch color ink-jet prints on a variety of media,

YOU CAN'T CONTROL YOUR BOSS, YOUR WORKLOAD, YOUR WEIGHT, YOUR BACKHAND, YOUR WEEDS, YOUR DOG, YOUR LIFE. AT LEAST NOW YOU CAN CONTROL YOUR CURSOR.



At Microsoft, we feel there are enough things in the world that follow their own unpredictable path.

So we redesigned just about every aspect of the new Microsoft® BallPoint® mouse to let you regain control of your portable computer.

We started by changing the weight of the ball. We improved the smoothness of the tracking mechanism. We reshaped our mouse to fit your hand better. We even added software features that make it easier to find and control your cursor.

All of which means, in simple terms, that the cursor will now do what you want it to do.

And which is why, in independent tests, people worked 35% faster with the BallPoint mouse than with other leading portable and built-in pointing devices.

Of course, you should try it yourself. So pick up a BallPoint mouse at a computer store today.

And have one aspect of your life firmly, and comfortably, in the palm of your hand.

Microsoft
Making it easier

from plain paper to color transparencies, with an image quality that is hard to beat at a cost per page of as little as 8 cents. With a built-in RISC processor, the 1200C also offers decent performance.

The unit looks more like a small refrigerator than a printer. But you can't argue with the DeskJet 1200C's sumptuous output, especially on coated paper. It's easily expandable in terms of memory, PDLs, and network connections. This is a printer designed to grow along with your office.

HP LaserJet 4L
Hewlett-Packard

It's hard to beat the 300-dpi HP LaserJet 4L in price/performance for the home or small office—or as the low-end executive model you choose not to share with other network users. You get plenty for the $849 list price: a small footprint and a weight of under 16 pounds, HP's RET (Resolution Enhancement Technology), a variant of PCL5 called PCL5e, and, for stretching the standard 1 MB of memory, MET (Memory Enhancement Technology).

MET conserves memory by compressing fonts before downloading them. In addition, Explorer TSR control software replaces front-panel controls and uses HP's Bi-Tronic technology to have messages such as paper-out signals break into your DOS application when appropriate. Output quality was excellent in our tests, and the printer's new Canon engine has no corona wire and fewer parts to clean than traditional laser printers.

HP OmniBook 300
Hewlett-Packard

The OmniBook 300 is equally suitable for a trip to the company cafeteria or a trip across the country, thanks to its sub-3-pound size and extra-long battery life (over 12 hours, according to our tests). Other features, such as the mechanical-arm-like mouse that pops out from the side of the machine, Windows 3.1 in ROM, and the complete lack of traditional (and power-consuming) rotating hard drives, put this machine a notch above the competition.

Bummers include the lack of support for enhanced-mode operation in Windows, which means no support for virtual memory or running DOS applications in a resizable window alongside other program windows. Nevertheless, the OmniBook 300 does a fine balancing act between cutting-edge technology and mainstream usability.

"I literally take my OmniBook everywhere I go. It is perfectly designed for use on those small tray tables on airplanes. Its 12-volt external power supply makes it easy to tie into a car's or a boat's electrical system. The OmniBook 300 is so robust that I took it to sea with me on my three-week sailing vacation. Windows and the applications software that comes bundled with the OmniBook make it an exceptional value."—Ben Smith

Indy
Silicon Graphics

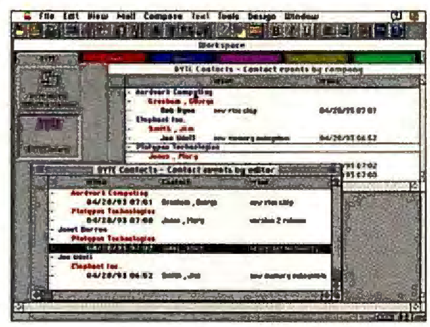
The latest descendent of the Silicon Graphics Indigo architecture is the entry-level Indy, whose $5000 price tag belies its sizzling processor and graphics performance. The real story of the Mips R4000–based Indy is media integration: It supports analog and digital audio *and* video right out of the box, and it even comes standard with a small digital-video camera. The Indy is packed with features—for instance, ports for 10Base-T, Fast SCSI, and ISDN are built in—and Silicon Graphics continues to innovate with options such as a 20-MB floptical drive. To cap it off, the system includes a new media-centric Indigo Magic user interface on top of Motif that eases the use of desktop video conferencing and speech recognition. While the Indy may not become a mass-market system, it blazes a path in multimedia computing.

"The Indy has exceptionally fast and inexpensive 2-D graphics. It is also very fast at general computing. I found that it's very easy to use despite the incredible sophistication of its peripherals, utilities, and operating-system interface. The new operating system synergistically brings together my two favorite computing environments, Unix and the Macintosh. It lives up to its slogan: Serious Fun."—Ben Smith

Lotus Notes 3.0
Lotus Development

Notes has always offered a unique and powerful blend of E-mail, conferencing, and client/server database technology. Version 3.0 adds X.500-style hierarchical naming, Macintosh client support, full-text indexing, native IPX/SPX support, smarter database replication, and a host of new macro-language functions. These new features aren't just tacked on, either; they're deeply and sometimes surprisingly integrated.

When a Notes 3.0 Macintosh client subscribes from within a shared Notes database to an edition published by a System 7 Macintosh, the edition becomes visible not only to other Macintosh clients but to Windows and Presentation Manager clients as well. The full-text indexing and retrieval capabilities also integrate intelligently with Notes. Data-entry forms double as search templates; the multi-threaded OS/2 server handles incremental reindexing gracefully as a background task. Background replication on the client side refines what was already an excellent mechanism for distributing information to users who are sometimes LAN-connected and at other times modem-connected. You



ARISTO

POOR OLD MOUSE.

Most of the time all mice are nice and fine for pointing around. But when it comes to inputting graphics or logos into any application or any CAD package, they are hopeless. They just can't – and so you can't. No way. Problem? Yes and no. It depends – you may shrug your shoulders and say "Well, I'll never do CAD and I just never want to input any sketches, logos, or photos into my computer anyway." Or – you feel that isn't good enough after all the money you have invested and all the nice things you know you could do today with your own graphics once they were in the computer.

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Here comes the mouse that lets you input all your graphics as well. How?: That's what they all want to know, but we're not telling. Its a new invention. It's a universal combination of a true mouse and an independent manual drawing board that becomes a precision full-featured digitizer tablet once you just place the mouse onto the board. It's all in one or all separate as required. Simply unplug your poor old mouse, plug in our mouse and have the real all purpose input device to your PC always at hand. At a price poor mice can afford too.

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won't find a more complete communication tool for business.

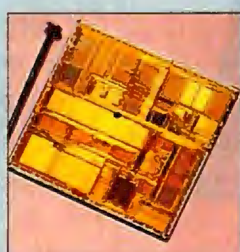
"Dialed into a Notes server from a remote laptop, automatically replicating mail and discussion databases, I began to appreciate the remarkable feats of engineering that sustain this one-of-a-kind product. Although the reach of Lotus's vision of business process automation does exceed the grasp of the current incarnation of Notes, no other product so boldly and effectively empowers users to manage distributed data."—Jon Udell

Macintosh Quadra 840AV
Apple Computer

Apple's Quadra 840AV is more than just the highest-performance Macintosh; it's also the most fully featured personal computer ever made. To supplement the system's 40-MHz Motorola 68040 CPU, Apple added a 66-MHz AT&T 3210 DSP (digital signal processor). This makes the 840AV ideal for advanced audio, video, and telephony applications, with little or no additional hardware. Full-motion video digitizing is built in, including support for NTSC, PAL, and SECAM. Composite and S-video outputs make it easy to record digitized video on a VCR. The 840AV's audio capabilities are equally impressive, and Apple's new PlainTalk speech technology provides speaker-independent continuous voice recognition for short commands.

The new GeoPort, a plug-and-play interface, allows easy connections to analog and digital phone lines for voice, fax, and data communications. Other standard features include built-in Ethernet and AppleTalk networking, 24-bit color video, and numerous expansion slots and bays. All this makes the Quadra 840AV the premier personal computer for multimedia authors, graphic designers, and power users. It's the fastest Mac on the block. Software compatibility is excellent, especially considering that the system architecture is loaded with new hardware such as DMA channels, a new video bus, and a DSP. The PlainTalk voice-recognition and video-processing features—within limits—allow this Mac to do things no other computer can do.

Pentium processor
Intel



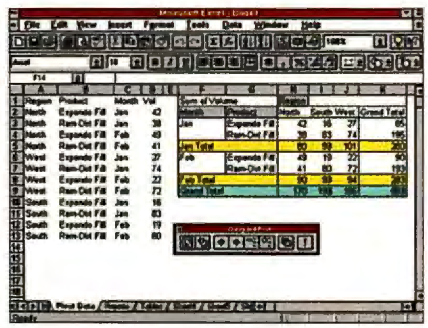
Intel has the best track record of any company in the personal computer industry. No one can match its record of consistent progress and performance.

The Pentium, with its two integer pipelines, advanced branch-prediction hardware, and sophisticated cache design, doubles the performance of the 486DX2-66 for integer operations, while its phenomenal FPU outdoes a 486's FPU by a factor of 4. More important, the Pentium reached this performance level without sacrificing compatibility with its immense software base.

Pentium gives pause to those who say that the 80x86 architecture can't compete against pure RISC designs. Intel has shown what you can do with intelligent design and hard work. The Pentium designers didn't have the luxury of starting from scratch, which makes their achievement all the more noteworthy. And despite all the hoopla about RISC performance, do you think for a moment that, if given the chance, any of the RISC vendors would fail to trade places with Intel?

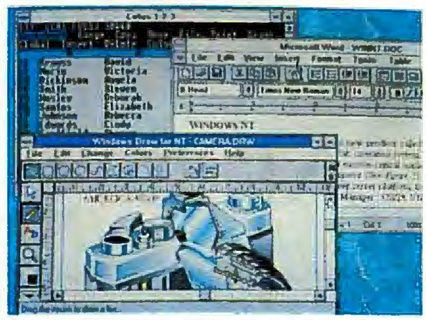
Microsoft Excel 5.0 for Windows
Microsoft

After 1-2-3 release 4 gave Lotus some momentum, Microsoft has reclaimed its preeminence in the spreadsheet market. Excel 5.0 unveils new technologies that represent the future of Microsoft applications. Microsoft's new application macro language, Visual Basic for Applications, appears for the first time in Excel 5.0. OLE 2.0 automation will work with VBA to enable a powerful environment for cross-application development.



A consistent interface will further integrate Microsoft applications; Excel's menu structure will be closely mimicked by Word for Windows 6.0 and PowerPoint. IntelliSense, another new Excel feature that will soon find its way into other Microsoft applications, makes intelligent assumptions to help automate actions such as adding a closing parenthesis to a function. Excel will also analyze your work and offer pop-up tips on how to perform operations more efficiently. Excel 5.0 fills some conspicuous gaps in the features matrix by adding true 3-D worksheets (with page tabs), in-cell editing, and custom AutoFill (for creating custom series that will automatically flow into selected blocks when appropriate). A few key improvements and promising new technologies combine to make Excel 5.0 one of the most powerful Windows applications around.

Microsoft Windows NT
Microsoft



If you were given the job of designing the ultimate desktop operating system, you just couldn't do much better than simply listing the features of Windows NT. Preemptive multitasking, multiprocessing support, the ability to run industry-standard software, built-in networking support, portability across hardware platforms, support for multiple interfaces—the

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Jerry Pournelle, *Byte*, April 1993

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These UL/CSA approved, fully tested power supplies are the best basic units available.

STANDARD 205 SLIM $89
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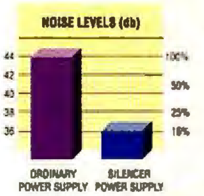

Unrattle your nerves with an ultra-quiet **Silencer** power supply. Appreciated by users **since 1986**, their high-efficiency fans and low-turbulence circuitry reduce noise by up to 84%! A must for home office or *multimedia* applications.

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Give your computer a professional, high-tech look with one of our premium-quality, **USA-made**, all-steel cases. They're rigid—unlike light-weight imports—so the PC's components are always properly aligned and grounded. You'll enjoy easy system access, and with room for up to **18 drives**, there's real expandability!

	Desktop	Tower	Monster
Exposed Drive Bays:	5	6	13
Total Drive Bays:	7	8	18
Motherboard Capacity:	1	1	2
Power Supply Capacity:	1	1	2
Cooling Fan Capacity:	2	3	6
Filtered Air Inlet:	Yes	Yes	Yes
Lockable Front Door:	Yes	No	Yes
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Eliminate the risk of network downtime or data loss due to power supply failure with the **TwinPower 900** redundant power system. It delivers high-capacity, fault-tolerant power to your entire network server. Consists of two **Turbo-Cool 450** power supplies in parallel, utilizing a special power-management interface module. A must for *mission critical* LANs.

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- 5-year warranty
- monster-case compatible

TWIN-POWER 900 .... $995

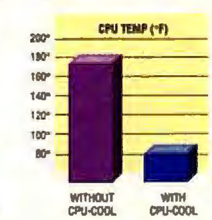
OVER-TEMP ALARM

Don't wait for the acrid smell of burnt components! With our new **110 Alert**, you'll know if your PC is overheating *before* damage occurs. Should the computer's temperature reach 110°F, a loud alarm warns you that a fan has failed or that the cooling system is inadequate to handle that extra hard drive or other peripheral you may have added. Compatible with any computer, the inexpensive **110 Alert** is compact, easy to install, and so reliable, it carries a lifetime warranty.

110 ALERT $29

CPU COOLERS

It's a fact. 486 chips run hot, often exceeding 185°F! Now, you can cool your 486 to a safe 85°-95°F with our popular **CPU-Cool**. It prevents random system errors and other heat-related problems. Consists of a mini-fan embedded in a die-cast heat sink that easily mounts on the CPU. Powered by a spare drive connector. Effective, inexpensive insurance!



- cools CPU 70° - 100°F
- prevents system errors
- adds years to CPU life
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Circle 101 on Inquiry Card (RESELLERS: 102).

list soon becomes embarrassingly long. Windows NT is the operating system the desktop computer industry has been waiting for ever since the limitations of DOS became painfully apparent with the introduction of the AT in 1984. Like no operating system before it, NT lets you take full advantage of your industry-standard hardware.

Of course, like no other operating system before it, NT also requires more hardware, which is the main reason it won't have the kind of immediate market impact that Windows 3.0 enjoyed. But make no mistake, NT is here for the long haul: It is an operating system built with the future in mind, so you should keep it in mind as you plan for the future.

"According to conventional wisdom, you shouldn't use the 'point zero' release of an operating system. But I do use Windows NT, which, in its first incarnation, has been remarkably stable and trouble-free. Seamless interoperability between Intel and RISC versions of NT, and between NT and Windows for Workgroups, make the promise of a scalable family of Windows operating systems tangibly real."—Jon Udell

Newton Intelligence technology

Apple Computer

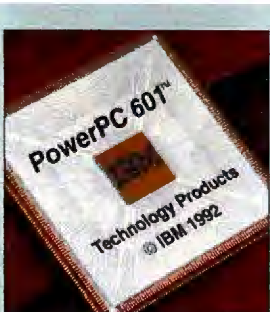
As Garry Trudeau's scathing series of Doonesbury comic strips suggested last summer, Apple's Newton MessagePad is an imperfect implementation of a PDA. The technology it employs,

however, breaks new ground in mobile computing and is a solid base on which to build better models. That technology—not the MessagePad as a whole—receives BYTE's Award of Excellence.

Newton Intelligence is an innovative, object-oriented operating system that successfully shields casual users from internal complexities. Its pen-based user interface challenges existing notions of how a computer should look and feel. Newton applications are data-centric, not document-centric; all information is tagged and stored as you enter it, and you can access it from any application.

PowerPC 601

Apple Computer, IBM, and Motorola



In late 1991, Apple, IBM, and Motorola began work on a new processor that could challenge Intel's dominance on the desktop. The first result of this effort, the PowerPC 601, lives up to its advance billing.

The PowerPC 601 is a superscalar RISC processor. It can issue and execute up to three instructions at once in its three highly pipelined processing units. It also employs a number of architectural enhancements to ensure that the processing units are kept full of instructions and data.

The result is a processor that is as fast as a Pentium for less than half the cost. The 601 has already shown up on an IBM workstation, and it will form the centerpiece of Apple's RISC-based Macintosh line, which is due out soon. As such, it will undoubtedly be the best-selling RISC processor of 1994. And it will be even more significant after IBM ports OS/2—and Motorola ports Windows NT—to the chip.

With its technical excellence and marketing promise, the PowerPC is one of the more significant technologies to appear in this decade. And it has the ability to carry us into the next decade.

The PowerPC 601 processor promises to bring the Mac into parity with the performance of Pentium systems while being a lot less expensive. It also gives IBM new opportunities with unique multiprocessor configurations.

OLE 2.0

Microsoft

More than three years in gestation, OLE 2.0 takes Interapplication Communication and compound documents to a higher level than its predecessors, OLE 1.0 and DDE. As a key element of Microsoft's vision of object-oriented software, OLE 2.0 will be harnessed by developers for commercial and in-house applications.

The specification defines a standard way of communicating and sharing objects among compliant programs; for example, you could embed a slide created in a presentations package (based, perhaps, on data residing in a spreadsheet) into a word processing document. The 2.0 release of OLE adds dragging and dropping of objects, in-situ object editing, and support for macro-like automation. Most important, OLE 2.0 is designed with an eye toward the future—specifically, toward creating a path for users and developers that leads from Windows to Microsoft's object-oriented operating system, code-named Cairo. Thus, OLE 2.0 is built to support link tracking, network remote procedure calls, and other capabilities not yet implemented in Windows.

PCI 2.0

PCI Special Interest Group

Nobody questions the need for local-bus expansion capability in PCs, particularly for boosting graphics display performance. With VESA's VL-Bus specification already providing that function, then why PCI? Because, unlike the 486-centric VL-Bus, PCI (Peripheral Component Interconnect) fully answers the local-bus design needs of new Pentium- and RISC-based systems right now. As a mezzanine bus with buffered isolation from the actual CPU local bus, PCI can support more peripherals than VL-Bus. In addition, PCI devices can work concurrently with the CPU, an important performance factor with multithreading, multitasking environments.

With data bursting and buffering, the Intel-developed PCI bus cleverly skirts the performance drawbacks to bus isolation, yielding sustained throughput as high as 80 MBps from a theoretical maximum of 133 MBps. Bus isolation also means that PCI peripherals can work with any CPU speed or design, from a 486 to a 200-MHz Alpha, an important cost factor for large systems houses planning future systems. PCI is a robust specification, tightly defined and tested with sophisticated simulation, and it also supports forward-looking features such as plug-and-play, low-voltage operation, and a 64-bit data path.

WITHOUT THIS SEAL, YOU'RE ONLY TESTING YOUR LUCK.

Nothing is more frustrating than a PC problem. It can mean hours of wasted productivity and hundreds of dollars of expense for both the user and the manufacturer. A PC with the *QAPlus* Tested™ seal means that the manufacturer uses *QAPlus*® software in a rigorous program to assure that its PCs are fully compatible and meet the highest standards of quality.

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One facet of the *QAPlus* Tested program is *QAPlus/Factory*™ which provides dynamic burn-in capabilities using state-of-the-art diagnostics. Its exhaustive testing, tracking, and reporting features facilitate the effective measure and control of production processes.

QAPlus/Factory can help eliminate product returns and repair calls due to incompatibility and marginal quality assurance testing. The bottom line is lower manufacturing and support costs, increased product quality and customer satisfaction, and a more competitive business.

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QAPlus/Factory customers can receive an on-site quality survey by our PC quality assurance expert, along with installation and training. Plus, they will be enrolled in our Priority Support Program which includes remote diagnostic troubleshooting, access to DiagSoft's BBS, and frequent product updates to support the latest technology.

THE INDUSTRY STANDARD

DiagSoft's *QAPlus* software is the de facto standard for PC compatibility and quality assurance testing. *QAPlus/Factory* is in use worldwide by leading manufacturers and integrators, such as: Digital Equipment Corporation, Gateway 2000, Intergraph, Micronics, Mylex, and Trillium Computer Resources. They help us ensure that our *QAPlus* software is on the leading edge of technology.

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The *QAPlus* Tested seal on a computer system ensures PC users they are receiving a system that has passed the most rigorous diagnostic hardware tests available. Our *QAPlus* OEM version and remote control software can also be bundled with systems to allow support personnel to remotely operate systems, and provide an even greater level of support.

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AB1193

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Aldus PageMaker 5.0
Aldus

PageMaker 5.0 narrows the gap between QuarkXPress and the competition in the high-end desktop publishing market. With this software, Aldus has addressed the issues of professional desktop publishers. PageMaker now has finer typographic and dimensional controls and supports a wider variety of text and graphics formats, including direct support of Lotus 1-2-3, Excel, dBase databases, and compressed TIFF files.

PageMaker shores up its strong support between Windows and the Macintosh with seamless file support across platforms and automatic conversion of Mac PICT files to Windows metafiles. Aldus has also enhanced performance throughout the product. Publishers of non-English languages will appreciate the $99 bundle of 19 dictionaries, which includes medical and legal dictionaries as well as 15 European and New World languages with hyphenation. PageMaker 5.0 is a powerful upgrade.

ATT92010 Hobbit
AT&T Microelectronics

AT&T's ATT92010 Hobbit microprocessor is at the forefront of a wave of new CPUs designed especially for hand-held, highly mobile communicators and computers. Known collectively as PDAs (personal digital assistants), these diminutive devices often require more raw processing power than conventional desktop PCs.

The demands of handwriting recognition, object-oriented operating systems, and innovative user interfaces are creating a niche for speedy but power-miserly CPUs. The Hobbit rises to these demands by delivering 13.5 MIPS while consuming only about 0.25 W. Together with its family of peripheral chips, the Hobbit provides a practical solution for first-generation PDAs such as the Eo Personal Communicator 440 and 880.

Banyan ENS for NetWare
Banyan Systems

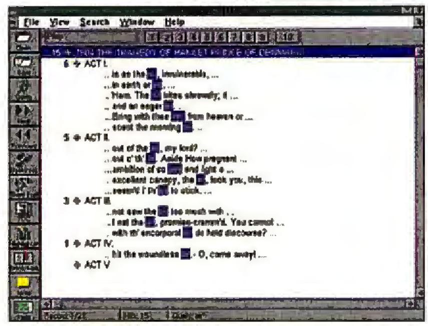
Banyan's ENS (Enterprise Network Services) brings the company's crown jewel—the StreetTalk III global directory service—to Novell NetWare. ENS extends StreetTalk support to existing NetWare 3.x and 2.x installations. With ENS, you can manage multiple NetWare servers as a single system image, leveraging the communications capabilities of Vines (i.e., X.25, TCP/IP, and SNA) to distribute that virtual network over a wide area. Applications that are Vines-aware, such as the Vines version of Beyond's BeyondMail, enjoy true global directory services on NetWare-plus-ENS.

The NetWare Directory Service in NetWare 4.0 couldn't deliver the same benefits to users on NetWare 3.x and 2.x servers even if applications supported NDS (and most don't, yet). Those legacy NetWare servers aren't going away anytime soon. Kudos to Banyan for enfolding them in StreetTalk.

ColorScript Laser 1000
QMS

The first color laser printer priced at less than $15,000, the QMS ColorScript Laser 1000 produces high-quality color documents on plain paper for less than the materials cost of dye-sublimation or thermal-wax-transfer technologies. The 300-dpi, PostScript Level 2–compatible printer outputs up to 8 pages per minute in monochrome and about 2 ppm in 24-bit color. The unit includes a range of interface ports (e.g., Ethernet, AppleTalk, and serial/parallel) and 65 typefaces. Strong network support and monochrome capabilities (i.e., low cost and good performance) make the Laser 1000 an excellent workgroup printer for mixed color and monochrome uses. Other printer vendors are expected to release color laser printers this year, but the Laser 1000 makes QMS the leader in the field for now.

Folio Views 3.0
Folio



Folio Views 3.0 isn't just a Windows port of its DOS-based predecessor; it's a massive overhaul of that popular product. No more 2-MB limit on the size of an infobase; version 3.0 boosts the capacity into the terabyte range. No more cumbersome batch-mode builder; version 3.0 can work incrementally, interactively, and in a way that enables multiple users on a network to extend a collaborative infobase without stepping on each other's changes. And, though not apparent to the user, no more monolithic indexing and search apparatus; 3.0's client/server architecture should enable the development of local or remote DOS, Windows, Macintosh, and Unix clients.

Fractal Design Painter 2.0
Fractal Design

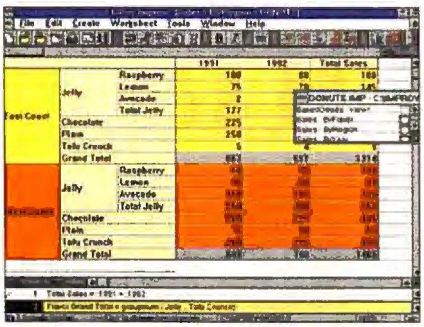
The luscious Painter 2.0 turns your Mac or Windows PC into an artist's studio, offering a wide range of media and materials for you to work with, and now also offering support for captured video frames, scanned images, color separations, and user-defined lighting. The package lets you "paint" with electronic oils, watercolors, pens, chalk, charcoal, and other media in a wide range of colors and shades on backgrounds textured to look like paper, canvas, and so on. There is perhaps no other graphics product on the market that's been so quick to produce a sense of excitement and accomplishment among both novice and expert artists.

FutureBasic
Zedcor

Zedcor's FutureBasic attempts to do for the Macintosh what Microsoft's Visual Basic does for Windows: provide an easy-to-use but powerful development environment for in-house corporate programmers, shareware developers, and hobbyists. It largely succeeds, surpassing the traditional Mac implementations of C and Pascal in terms of ease of use, and Apple's HyperCard in terms of flexibility and power.

FutureBasic is a remarkably full-featured tool that conceals

much of the complexity of Macintosh programming. Yet it's capable of producing compiled code that rivals the performance of programs written in more difficult high-level languages. It runs on a system as small as a 1-MB Mac Plus, and it supports Apple Events, Color QuickDraw, QuickTime, and the entire Mac Toolbox. Packaged with an integrated 680x0 assembler, ResEdit, and MacsBug, FutureBasic is a long-needed tool for Macintosh development.



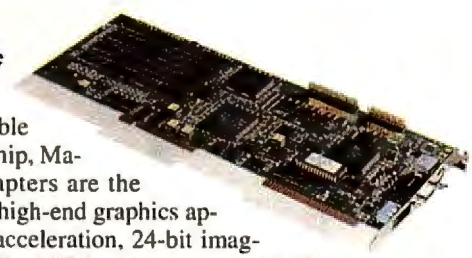
Lotus Improv 2.1 for Windows

Lotus Development

During the same year that Next finally delivered a 486 version of its object-oriented operating system, Lotus delivered a Windows version of one of the most compelling applications for NextStep, the Improv spreadsheet. Improv breaks away from the traditional row-and-column organization of spreadsheets; instead it fills the cells with the results of formulas entered in English-like syntax. The multidimensional worksheet can be reorganized by dragging and dropping labels, and data can be imported and exported from 1-2-3 and other external data sources.

MGA series

Matrox Electronic Systems



Thanks to a capable 64-bit graphics chip, Matrox's MGA adapters are the cards to beat for high-end graphics applications: GUI acceleration, 24-bit imaging, and CAD. The MGA chip supports 24-bit graphics at up to 1280- by 1024-pixel resolution and 8-bit graphics at 1600- by 1200-pixel resolution. In addition to providing the fastest Windows performance at any resolution or color depth, Matrox's MGA chip (and Matrox drivers) support CAD applications with hardware pan, zoom, 2-D acceleration, and, in some models, hardware-assisted 3-D rendering and shading.

Other hardware operations include antialiasing of vector images and text (TrueType and Adobe Type Manager) as well as dithered 8-bit graphics that approach 24 bits at higher resolutions. Considering performance and features, pricing is competitive—from $599 to $2495, depending on memory configuration (from 2 to 4.5 MB of VRAM [video RAM] plus optional z-buffer memory) and whether 3-D support is present. The MGA series of boards also supports five different expansion buses: ISA, MCA, VL-Bus, PCI, and SBus.

"When I ran the MGA Impression through BYTE's suite of graphics benchmarks, it clearly outperformed the fastest video cards tested to date. But the real test came when I loaded some large images into Photoshop. Scrolling and zooming were almost instantaneous. Never have I been so impressed by the pure speed and exceptional quality of a graphics accelerator."

—Stanford Diehl

Microsoft Visual Basic for Windows 3.0

Microsoft

Already wildly popular among in-house corporate programmers and shareware developers, Microsoft's Visual Basic 3.0 adds several new features and custom controls that can save hours of tedious coding in other languages. Corporate developers will especially appreciate its new database engine—the same engine found in Access 1.1, Microsoft's relational database manager for Windows. That means Visual Basic inherits the ability to interact with databases stored in several common formats, including Access, dBase, FoxPro, Paradox, and Btrieve.

Thanks to a new visual data control in the toolbox, Visual Basic programmers can hook into these databases without writing any of the code that would normally be necessary. Visual Basic also adds support for OLE 2.0, which opens up some fascinating new possibilities for interaction with other Windows applications.

Paradox for Windows

Borland International

The appearance of Paradox for Windows should prove that Borland isn't sitting on its DBMS laurels. ObjectPAL—Paradox for Windows' application programming language—is a complete break from PAL. Not only is ObjectPAL easier to comprehend than its predecessor, but it more neatly accommodates the event-driven nature of Windows applications.

ObjectPAL aside, we applaud Paradox for Windows' entire object-oriented approach. Its direct support for dBase files doesn't hurt, either; nor does its variety of form-design, report-design, and graphing capabilities, which edge the package onto the same stage as some of the larger and more complex database application generators. The query-by-example crowd should be pleased: There's a home for them in Windows.

PowerBook 165c

Apple Computer

The PowerBook 165c adds the benefit of a color passive-matrix LCD screen to a notebook PC that comes equipped with a 33-MHz 68030 processor, a 68882 FPU, external video, and 4 MB of RAM. Even though the display measures only 9 inches diagonally, it can display 640 by 400 pixels and provides rich color, good contrast, and a wide viewing angle. The PowerBook 165c's power charger cranks out 24 W (up from 15 W) and can recharge the battery faster. In addition, the PowerBook 165c is less expensive than PC notebooks with active-matrix screens.

AWARDS OF DISTINCTION

RealityEngine²
Silicon Graphics

Even for a company famous for graphics, Silicon Graphics' RealityEngine² is something else again. The specifications are mind-blowing—160 MB of bit-mapped memory, 12 geometry engines, 20 pixel generators, 320 image engines—as are the results. RealityEngine² can produce true-color, antialiased, texture-mapped 3-D graphics animations in real time. You may never be able to afford a RealityEngine², but rest assured you'll be seeing more of what it can do in the years to come. If you're looking for the definition of state-of-the-art graphics, look no further than RealityEngine².

SQLWindows 4.0
Gupta

SQLWindows enjoys the rare privilege of being a SQL front end supplied by the same company that makes a killer SQL back end. Simply put, SQLWindows is full of good stuff from one end to the other: QuestWindow makes forms design exponentially simpler, TeamWindows provides the kind of project management and version control any project leader would be tickled with, and we'll never lose our respect for the application language's outline-based paradigm.

ThinkPad 750C
IBM

Faster, lighter, more powerful all around...these descriptors fit IBM PC Co. as well as one of its best products to date, the IBM ThinkPad 750C. The successor to the 720C notebook, this product takes away more than it adds. Gone are 1⅓ pounds of weight and a quarter-inch of length; among the new features are integrated audio capability and an upgraded processor, the Intel 486SL-33. The 170-MB hard drive can be easily removed in favor of a bigger one (when available), and you can swap out the floppy drive to substitute devices such as a cellular modem.

WordPerfect 6.0 for DOS
WordPerfect

With the first major update of its flagship program for DOS-based PCs in over three years, WordPerfect has satisfied the demands of its users who want spreadsheet functionality, pull-down menus, WYSIWYG graphics, and drag-and-drop image manipulation in a word processor. Although the resource requirements (16 MB of hard disk space for a full installation) are steep for a DOS-based application, WordPerfect certainly packs in the features. Advantages of WordPerfect over Microsoft Word include direct printing to fax cards, a full range of graphical image-editing operations, and word wrapping around irregularly shaped objects.

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Viper VLB

January 1994
Encarta '94
Indy
Premiere 3.0 for Macintosh
WinFax Pro for Networks

HOW TO BUY A DOUBLE-SPEED CD-ROM... WITHOUT GETTING TAKEN FOR A DRIVE.

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If you've been thinking about adding the power and excitement of an internal CD-ROM to your PC, here's some great news: thanks to our exclusive Creative Double-Speed Technology,™ *double-speed CD-ROM performance is now available at about the same price you'd expect to pay for a single-speed drive.*

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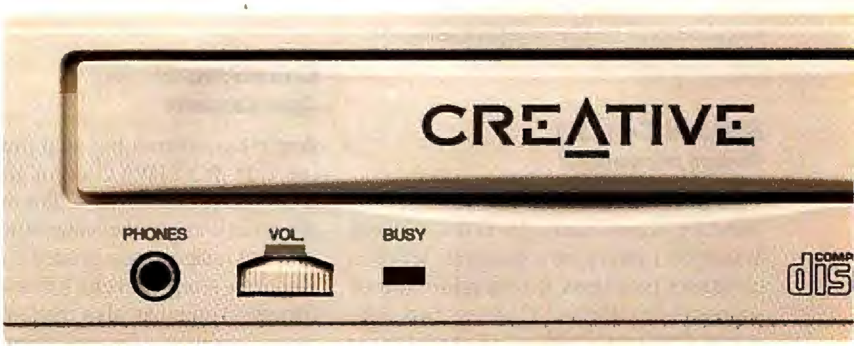

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Active Badge
Olivetti North America

Piggybacking on your company's LAN, Active Badge is a means of keeping track of people within a workgroup. It also allows your own computer's desktop to "follow" you throughout a building. Using a small transmitter that you wear, Active Badge sends your location to the network. The network can then tell others where you are or allow you to call up your own desktop on any other computer on the network. You always know who is or isn't available for a meeting, and you always have your own data at hand.

Adobe Premiere 3.0 for Macintosh
Adobe Systems

Adobe has taken an outstanding product and made it even better. Refinements include a streamlined interface, improved performance, and enhanced final quality of the video and audio. With 99 video and 99 audio tracks, you can create layered soundtracks as well as complex video overlays, titles, and special effects.

Borland C++ 3.1
Borland International

This development tool has several outstanding components. Its OWL (Object Windows Library), for example, lets you construct programs with a minimum of source code. Borland C++ has two integrated development environments: one for DOS and one for Windows. Both allow for rapid application development. (Borland announced version 4.0 late in 1993.)

Bounds Checker 1.0
Nu-Mega Technologies

This Windows debugging tool, now in version 2.0, finds tough-to-track bugs such as array boundary overruns, memory leaks, and bad parameters passed to API functions. Although it doesn't offer complete debugging services, Bounds Checker is a must-have item for every Windows programmer's toolbox.

Canon NoteJet 486
Canon Computer Systems

Buy a notebook, get a printer—that is Canon Computer Systems' solution for the need to print documents while on the road. The 7.7-pound Canon NoteJet 486 comprises a 25-MHz Texas Instruments 486SLC processor, a 9½-inch backlit monochrome VGA LCD, 4 MB of RAM, and a 360-dpi BubbleJet printer shrunk down from a Canon BJ-10ex printer design. The nickel-cadmium battery in the model we looked at was atypically underrated, printing the entire 27-page Windows Write readme file despite the battery's eight-page rating. Operation is a breeze, and print quality is easily readable.

ClarisWorks 2.0 for Macintosh
Claris

Our July 1993 review said it all: ClarisWorks 2.0 may be the only major application that many Mac users need to buy. This package seamlessly integrates word processing, a spreadsheet, a database manager, drawing software, and a communications program. It's easy to shuffle work created in one segment to another segment.

ColorSync
Apple Computer

Apple has taken a big step toward making true WYSIWYG color-matching a reality with ColorSync. Color matching—the ability to get the same colors from a scanned image onto a printed document—has been a big concern for desktop publishers. Apple has also made ColorSync open, so other color-matching software providers can supply their own modules.

Common Ground
No Hands Software

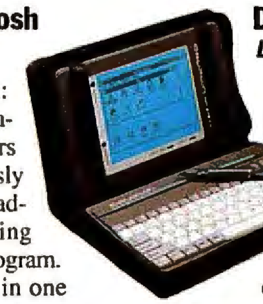
Common Ground is a multiplatform document-interchange application that offers much of the same functionality as Adobe's Acrobat. Its biggest feature, however, is that it works on low-end as well as high-end PCs. This makes Common Ground practical for many companywide document-processing projects.

Compel
Asymetrix

Asymetrix's first foray into the world of presentation software is an impressive one. Compel offers excellent support of multimedia, from the user interface to support of OLE. You can link any type of data—text, graphics, video—to a multimedia event via Compel's highly intuitive interface.

Cx486DRx²
Cyrix

Would you spend 20 minutes and between $299 and $399 to turn your 386 PC into a near-486-class system? Cyrix offers a significant performance upgrade for the millions of 386 PCs that are still in use.



Dauphin DTR-1
Dauphin Technology

With the DTR-1, Dauphin has released a highly modular subnotebook-computer that weighs under 3 pounds and can double as a pen-based system. The keyboard, though more usable than that of the HP 100LX or the Psion Series 3a, is still a little too small for most users. A recently announced upgrade to 8 MB makes the DTR-1, which runs on a 25-MHz Cyrix 486SLC processor, the smallest system to accommodate IBM OS/2 and OS/2 for Pen Operating Systems, the company says.

Delrina WinFax Pro 3.0 and WinFax Pro for Networks
Delrina

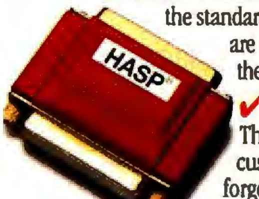
Delrina has successfully combined optical character recognition with PC-based fax. No longer do you have to store incoming faxes as image files; WinFax Pro 3.0 converts them to text and then checks the spelling of the documents.

Eo Personal Communicator 440
Eo

The Eo has somewhat of a celebrity status as the star of AT&T's TV commercials. And that scene is not staged, either—you really can fax from the beach with it, or make a cellular telephone call, for that matter. The Eo's PenPoint pen-based

When protecting your software against piracy and unauthorized use, make sure that your protection system has all the following qualities:

A GOOD HARDWARE KEY



Hardware-based software protection systems are now the standard worldwide. However, not all keys are the same. A good key should have all the following features:

✔ Compatibility and transparency. The key should work without any problem on your customers' computers. The user should be able to forget the key after connecting it.

✔ Unbreakable electronics. A customized ASIC (Application Specific Integrated Circuit) component integrated into the key will prevent reverse engineering and make cracking the hardware virtually impossible.

✔ A unique and inaccessible developer's code burnt into the ASIC. This code should never be held in the key's memory, where it can be read and altered.

✔ A Read/Write Memory inside the key should be available. The memory should be writable in the field, on any PC, without any special programming equipment.

✔ Very low power consumption, enabling the key to work even under the most adverse power conditions, on PCs and laptops, with or without a printer.

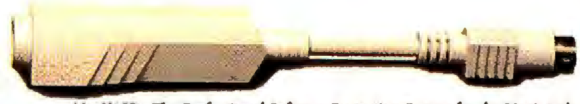
POWERFUL SOFTWARE

✔ A Linkable Protection Module with which calls can be made to the key from any point in the protected program.

✔ An "Envelope" encryption program. Such programs enhance security while making it possible to protect a software application even without its source code.

✔ Sophisticated antidebugging and encryption mechanisms.

HASP® - The Professional Software Protection System



MacHASP - The Professional Software Protection System for the Macintosh

HASP® OFFERS YOU ALL THESE FEATURES AND MORE:

HASP was designed by a team of computer experts, professional cryptologists, and electrical engineers. As a result, HASP keys are supported by what is probably the best software in the market, and the HASP system has worked on every computer it has been tried on. In addition to all the features mentioned above, HASP provides:

✔ A Full Authorization System for protecting dozens of programs using only one key.

✔ A Pattern Code Security System (PCS) which enables parallel processing of multiple calls by the Linkable Protection Module.

✔ A Virus Detection option that can be incorporated in the protected program to check whether it has been infected by a virus.

✔ Several HASP keys can be connected one behind the other. Small physical size ensures maximum convenience for your customers.

NETHASP- THE ULTIMATE SOFTWARE PROTECTION FOR NETWORKS

✔ Only one NetHASP key is needed to run a protected program from any station in a network. NetHASP provides full support for protecting DOS and WINDOWS software under network environments, including Novell dedicated & non-dedicated servers, Lan Manager, Lantastic, Banyan, DLink, and NET-BIOS based LANs.

LISTEN TO THE EXPERTS:

In all the products we tested, except the HASP, we could see through the encrypting and questioning procedures... and crack them.

CT Magazine (Germany)

MemoHASP: ...of all the protection devices tested is without any doubt, the one which combines the best features.

PCompatible (Spain)

Trying to crack a program... that was protected utilizing all of HASP's features - is like searching for the Holy Grail.

Micro Systems (France)

PC dongles... come with varying claims as to their transparency. The majority suffer from problems when a printer is connected... the DESkey and HASP-3 are not affected...

Program Now (Britain)

Of all keys tested, HASP is the most ambitious one... the quality of HASP manufacturing seems excellent.

PC Compatible (France)

An easy to use software protection system for the Macintosh, which ensures an effective defense against software piracy...

Life is difficult for pirates... MacHASP is an optimal protection method, for the programmers... and for the users...

Bit Magazine (Italy)

OPERATING ENVIRONMENTS

PC: DOS, WINDOWS, WINDOWS -NT, OS/2, SCO UNIX, SCO XENIX, INTERACTIVE UNIX, AIX, AUTOCAD, DOS EXTENDERS, LANS

MAC (ADB port): System 6.0.5 and up

NEC (Serial Port): DOS, WINDOWS

AND THE BOTTOM LINE:

We offer some of the most competitive prices in the market.

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Circle 63 on Inquiry Card.

operating system and interface feature true ease of use, and the communications applications are intelligently designed. The Eo is larger than a PDA, but that gives you the advantage of a larger display to view full-page faxed documents.

FirstClass
SoftArc

What would you say to getting top-notch E-mail and conferencing in one easy-to-use multiplatform package? SoftArc's FirstClass delivers just that. It is a rare example of a product that can increase productivity right out of the box with a minimum of fuss.

Flexscan F760iW
Nanao USA

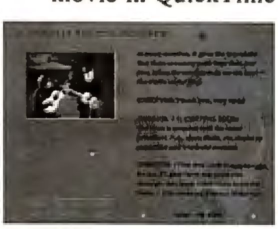
Nanao has combined one of the sharpest displays with new power-saving features. After a period of inactivity, it cuts power consumption from 160 W to 16 W. This adds up to significant savings on the electric bill of a company using scores of these monitors.

Grid Convertible 386 and 486
AST Research

The Grid came in the wake of Momenta's failed attempt to build a pen-enabled notebook PC. At first glance, the Grid Convertible looks like any other pen tablet, but the screen swivels up to turn it into a fairly standard notebook computer. In a nutshell, the Convertibles have set the standard for providing the best of both the pen and portable PC worlds in one well-designed package.

A Hard Day's Night
The Voyager Co.

Even if you're not much of a Beatles fan, you can certainly appreciate A Hard Day's Night as an innovative use of the CD-ROM medium. The title contains the entire movie in QuickTime format accompanied by the original script and a related essay. The CD-ROM allows you to watch the movie linearly or jump around to different spots.



IBM Continuous Speech Series
IBM

IBM has quietly been working on getting you and your computer on speaking terms. The ICSS is the result of those efforts. It is an OS/2- and AIX-based speaker-independent speech-recognition technology that allows you to give your system commands by talking to it. ICSS will someday reduce many common tasks, such as retrieving E-mail or loading applications, to a one- or two-word spoken command.

JVC Personal RomMaker
JVC Information Products Co. of America

This Mac-based CD-ROM recorder wasn't the least expensive one we tested, but it was the easiest to use and the most reliable. With extensive support for the Mac's HFS, the JVC Personal RomMaker delivers ultimate control for creators of Macintosh write-once CDs. The unit's dedicated hard disk, on which you assemble a CD-ROM image before committing it to write-once media, also makes for rock-solid dependability when creating generic ISO 9660 discs meant for use on any platform.

LANtastic 5.0 for Windows
Artisoft

Easy to use, easy to install, inexpensive, and full of features—what more could you ask for in a peer LAN? LANtastic's Windows support is well integrated, and you also have the option of Mac connectivity.

Macintosh Centris 650
Apple Computer

Recently renamed the Quadra 650, this system offers great performance for a low price. It makes use of interleaved memory, which improves throughput by shaving off clock cycles.

Macintosh Centris 660AV
Apple Computer

Recently renamed a Quadra, Apple's 660AV nevertheless retains its position as the best value in multimedia computers. Instead of stuffing a conventional desktop machine with numerous add-on boards, Apple created a highly integrated system with almost everything built in: an AT&T 3210 DSP to complement the 68040 CPU; a full-motion video digitizer; video support for NTSC, PAL, and SECAM; composite and S-video outputs; a new GeoPort for data, fax, and voice telephony; audio input and output; PlainTalk speech recognition; Ethernet and AppleTalk networking; and a special DAV (digital audio/video) connector for future expansion.

Microsoft Encarta 1994 Edition
Microsoft

If you own a CD-ROM drive but are disappointed in the CD-ROM software you have seen, buy a copy of Encarta '94: It will renew your faith in the medium. Superbly designed, Encarta is a multimedia version of the *Funk & Wagnalls Encyclopedia* that Microsoft has enhanced and added to. Video and audio clips, animations, maps, and hypertext links all work together in ways that just make sense and enhance your ability to absorb and understand the information they convey.

Microsoft MS-DOS 6
Microsoft

Despite reports of some users experiencing problems, Microsoft has achieved a milestone by making file compression and memory management an integral part of the operating system. Millions of users who have never used either feature can now reap their benefits. (Microsoft recently began shipping a version 6.2 upgrade.)

Microsoft Visual C++ for Windows 1.0
Microsoft

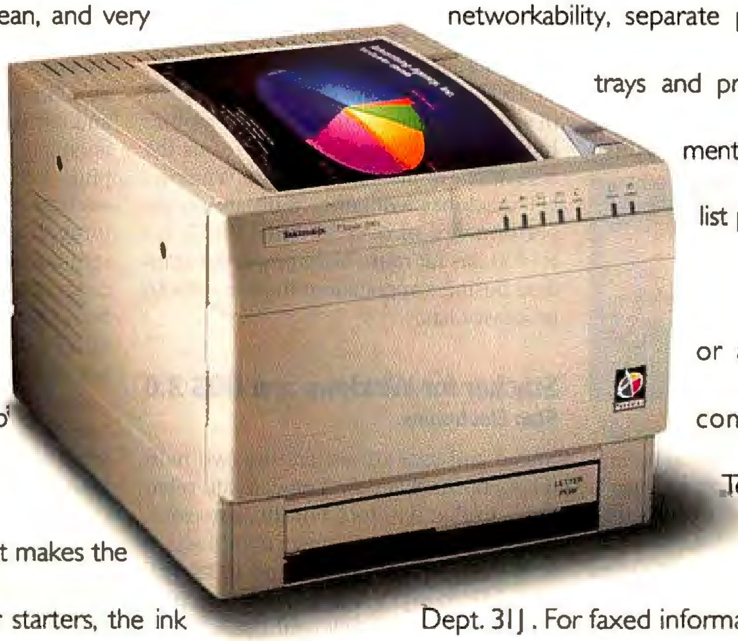
Microsoft has wrapped a wide assortment of support tools around a good C++ compiler. These include tools for building user-interface objects, "roughing out" applications, and combining executable code with the interface. At press time, Microsoft was planning to ship version 1.5 by the end of 1993.

NetWare 4.0
Novell

NetWare 4.0 represents a quantum leap in performance and ease of use over earlier versions. Also key is 4.0's X.500-style NetWare Directory Service. NDS is a database of users, data, software services, and equipment, and it can span a LAN or a WAN (wide-area network). It allows

In the dog-eat-dog world of business presentations, we just made you a pit bull with the legs of a greyhound.

In dog racing as in business, if you're not leading the pack, the view seldom changes. Meet your new leg up on the competition: the Tektronix Phaser™ 200 color printer. It's lean, mean, and very very fast. Of course, you don't have to take our word for it, *PC Computing* magazine just called it the best overall presentation printer in the business. So much for the other guys.



But what is it that makes the Phaser 200 so good? For starters, the ink coverage and image quality are, in a word, brilliant. We at Tektronix didn't get to be the award-winning leader in color printers by sitting on our hands. Then there's speed. You get all of this great color at two pages per minute, which is nearly as fast as a regular black and white printer. Can you say increased productivity?

On top of all this, the Phaser 200 is a work group printer that gives you the advantages of a laser printer. Including true Adobe® PostScript™ Level 2, networkability, separate paper and transparency trays and price (did we happen to mention the Phaser 200 has a list price of only $3,695?).

For more information or a free output sample, come into your nearest Tektronix dealer or call us at 800/835-6100, Dept. 31J. For faxed information, call 503/682-7450, and ask for document # 5001.

In closing, we just want to remind you that your competition is also reading this ad. And they're extremely hungry. So when choosing a presentation printer, the choice is quite simple. You can either eat, or be eaten. Bon appétit.

Tektronix

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administrators to get a handle on the structure of a company's network.

NextStep for Intel Processors 3.1
Next Computer

Next has taken the NextStep operating system, which many considered the best part of its ill-fated workstations, and placed it on the world's most popular hardware platform. If you want a truly object-oriented system today on your PC, then NextStep is your only option. You will also get a consistent and easy-to-use interface. (Version 3.2 started shipping in November 1993.)

Pioneer DRM 604X
Pioneer New Media Technologies

The Pioneer DRM 604X incorporates the best new CD-ROM technology into a single external unit. The drive can hold up to six CD-ROM discs in its caddy and automatically switches among them. The drive

appears on a PC or Mac system as six different CD-ROM drives, and it can be easily accessed across a network. Pioneer's Quadraspin technology achieves a true 600-KBps transfer rate, four times the standard speed, and the drive is Photo CD and MPC compatible. Try the Pioneer drive, and you'll wonder how you ever survived with a single-disc, standard-speed CD-ROM drive.

Psion Series 3a
Psion

Psion doubled the usability of its already-capable hand-held computer, and the result is an easy-to-use, fun but productive computer that slips into your coat pocket. A new zoom function and a bigger screen make it easier to read your reminders. Even better, the new voice-recording feature lets you record brief messages and attach them to alarms and events. It is well worth the $499 price that you will likely pay for the Series 3a.

Quicken 3 for Windows
Intuit

The new version of the leading personal finance program for Windows lets you manage your finances in a calendar view, so you can look ahead to see when the bills are due while planning that getaway vacation and post other reminders to yourself as well. Toss in electronic credit-card payments, improved financial planning, and better checkbook balancing, and you have a well-crafted program for the home and small-business user. We know of one person who purchased his first PC just so he could use Quicken.

R4400
Silicon Graphics

The 64-bit R4400 is the most powerful Mips microprocessor; it features significantly larger caches than does the R4000. In 1993, it made its commercial debut in such machines as the Silicon Graphics Indigo and Magnum, where it forms the core of one of the most powerful Windows NT machines available. With an integer performance of over 90 SPECint92, the R4400 has far more horsepower for standard business applications than any 80x86 processor has.

Stacker for Windows and DOS 3.0
Stac Electronics

Speed and ease of use are the two hallmarks of Stacker 3.0. You can add reliability to that list, too. For these reasons, Stacker is still the premier compression utility for both Windows and DOS systems. (In mid-1993, Stac began shipping Stacker 3.1, which integrates seamlessly with MS-DOS 6, replacing Microsoft's DoubleSpace utility.)

Symantec C/C++ 6.0
Symantec

Symantec C/C++ 6.0 used to be Zortech C/C++. If we hadn't told you that, you would probably be unaware of any connection. Symantec C/C++ is such a quantum leap beyond its predecessor that the two may as well be in separate universes. Symantec C/C++'s user interface is designed around a workspace paradigm rich with toolbars, tear-off palettes, and an underlying drag-and-drop theme that significantly reduces overall mouse travel. With MFC (Microsoft Foundation Classes) and Bedrock bundled in, in addition to the Visual Programmer, Symantec C/C++ 6.0 is a tough act to follow.

ThinkPad 500
IBM

You'd be hard-pressed to find a 4-pound subnotebook with better Windows performance than IBM's ThinkPad 500. It packs a 50-MHz 486SLC CPU made by IBM, fast video, and a speedy hard drive. An intelligently designed keyboard and IBM's TrackPoint II pointing device make the ThinkPad easier to use.

Video Machine for the PC
Fast Electronic U.S.

The Video Machine delivers a high-quality video-production system to the PC by combining video editing, digital effects, audio mixing, titling, and graphics generation into one package. A 16-bit ISA board plugs into a PC slot, and audio/video connections to external devices are handled through a 62-pin cable splitter that plugs into the board. Video Machine uses standard control protocols to drive professional computer-controlled VCRs. The full-featured video-editing software follows the popular time-line interface—you create video clips and drop them onto the time line along with titles and transitional effects. With Video Machine, you can turn your PC into a desktop video studio.

Viper VLB
Diamond Computer Systems

In a recent Lab Report on 486 PCs, we found Viper VLB video boards in many of the fastest graphics performers. This 32-bit VL-Bus card should be a top choice of anyone looking for the best in Windows performance.

Watcom C/C++ 32
Watcom International

This is not a C/C++ compiler package loaded down with application generators, class-library browsers, and all the other tools that require so many manuals that you have to get Hulk Hogan to deliver the package and Commander Data to comprehend it. Watcom C/C++ 32 is simply a very good C/C++ compiler that generates

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Dot Pitch (mm)	0.28	0.28	0.28
Maximum Resolution	1280 x 1024	1024 x 768	1280 x 1024
Maximum Refresh Rate (Hz) Non-Interlaced	160	90	90
OnView Control	Yes	No	No
Color Matching	Yes	No	Yes
Power Saving	Yes	No	Yes
Non-Glare Screen	Yes	Additional Cost	Yes
Price	$999	$1,155	$1,455

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well-optimized code for more target platforms than there is room to name. And did we mention Pentium optimizations? Watcom's got that, too, along with some of the best benchmark results the BYTE Lab has recorded to date.

WordPerfect Office 4.0
WordPerfect

Multiplatform support is at the top of the list of improvements to be found in WordPerfect Office 4.0. With this version of the software, you can coordinate an entire workgroup's E-mail, calendar, appointment list, and so on across Macintosh, Windows, DOS, and Unix systems. WordPerfect also made version 4.0 easier to use, providing mouse support for DOS applications. ■

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State of the Art

MICROPROCESSOR TRENDS

Mainstream processors are becoming faster, RISCier, smaller, and less power hungry. They are also getting better at emulating non-native instruction sets.

DICK POUNTAIN

Since the 1981 launch of the IBM PC, the whole personal computer industry has been in thrall to the Intel 80x86 architecture. The bonds loosened only slightly in 1984 by the emergence of a smaller, secondary standard around the Apple Macintosh's Motorola 680x0 CPUs. Now for the first time in over a decade, it looks like there's a real chance of the market opening up to new architectures. All in all, this is an exciting time in microprocessor development.

The effect of the Intel and Motorola standards has been good and bad, though mostly good. The good speaks for itself; the huge proliferation of DOS, Windows, and Macintosh software that we use every day came about only because there were stable platforms to attract application programmers. Standardization has allowed the PC industry to grow and keep computers affordable.

Standards Holdup

The down side is that the performance of mainstream CPUs has evolved more slowly than it might have, had it not been constrained to preserve backward compatibility with these industry standards. In particular, the two main players, Intel and Motorola, could not easily adopt those innovations that today we group under the name of RISC, because they required architectural changes (e.g., in the optimum size of register files) that were too drastic to preserve backward compatibility.

As a result, a new breed of RISC CPUs has grown up that outperform the mainstream chips; however, they have been excluded from mainstream PCs for lack of compatibility and, instead, have been confined to the much smaller technical workstation market. These chips include Sun's SPARC, DEC's Alpha, the Mips R4x00, and Hewlett-Packard's PA-RISC. Also, because the workstation market is small in volume (although not in value), the production runs on these chips aren't big enough, thus making the chips too expensive to appeal to PC manufacturers.

Now this logjam is breaking for several reasons. Most important is the decision of IBM and Apple to shuck off their 80x86 and 680x0 standards in favor of the PowerPC for future products. This will shortly make the PowerPC 601 the best-selling RISC chip on the market, although its volume will still pale compared to 486 sales.

Also, emulation is at last becoming a practical way to achieve compatibility among different processors. Emulation has been around since Alan Turing and the first days of computing, but it has always been too costly in terms of performance to be commercially viable (remember the UCSD P-System?).

Now, machines like DEC's DECpc AXP/150 (using the DECchip 21064 RISC processor) or Silicon Graphics, Inc.'s Magnum (using a Mips R4400) can run Intel 80x86 applications at acceptable speeds in addition to achieving blinding performance on native RISC code. The Magnum, for example, supplies 80 percent of the graphics performance of a 486DX/33 in running the BYTE low-level Windows benchmarks; two-thirds of the memory performance and almost five times the file I/O performance—a reflection of the amazing capabilities of the Windows NT file system.

The cumulative performance index of the Magnum running the Windows 3.1 low-level benchmarks is 2.12 times the performance of the 486DX/33 machine (see "Is There a Better Windows 3.1 than Windows 3.1?," November 1993 BYTE). Although this figure is skewed by the file I/O numbers, it indicates that you can get 486 performance from a RISC platform running some form of software emulation.

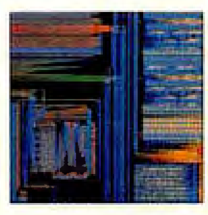
IBM and Apple are relying on emulation as a medium-term bridge from old to new platforms—while few native PowerPC applications are available—although the precise route is at present shrouded behind a swirling confusion of acronymic software layers like WABI, MAS, PowerOpen, SoftPC, and more.

Trends in operating-system design are helping make emulation feasible, too. Windows NT's HAL (hardware abstraction layer) and true microkernel architectures such as Mach greatly reduce the effort involved in porting a standard operating system to a new processor architecture, by concentrating all the hardware dependencies behind a small and well-defined software interface. Mac and Windows applications can spend anywhere between 60 percent and 90 percent of their time executing GUI-related system calls, so once these system routines are rewritten in native code only 10 percent to 40 percent of an application's code remains to be emulated.

The longer-term trend toward deeply object-oriented operating systems will insulate applications code even further from hardware. For example, Apple MessagePad applications written in Newtonscript are processor-independent, running on a software virtual machine.

This leads neatly to the third factor that's helping to erode the 80x86/680x0 dominance—namely, the newly created portable PDA (personal digital assistant) market sector. PDA applications, with their pen-based interfaces and notebook metaphors, look so completely different from desktop software that applications compatibility is not a big issue, only data portability. You won't want to run WordPerfect on a pocket organizer so long as you can transfer documents easily to and from your desktop machine. This freedom is allowing a whole new generation of tiny, low-power CPUs to struggle for supremacy (see "Intel/VLSI Join the PDA Fray" on page 101).

Of course, Intel is in no hurry to give



up a decade of dominance during which it has made a great deal of money. Even though it is denied the advantages of starting from a clean sheet, Intel's smart engineers have been able to pick enough of the good stuff out of RISC to produce the Pentium, which has had a mixed reception from industry critics; it's faster than many people believed possible from the 80x86 architecture, but it is still some way behind the RISC leaders.

Clone Wars

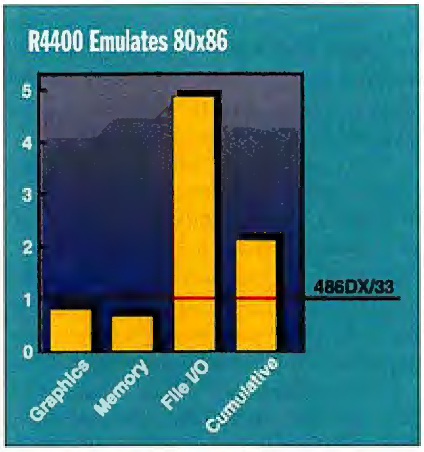
While this talk of breaking logjams is all very exciting, it's as well to remember that right now (and for some time to come) the Intel 486 is *the* industry workhorse, only recently displacing the 386 as the entry-level processor for PCs. But even here Intel's dominance is no longer complete because a pack of clone 486 manufacturers—most notably, AMD and Cyrix—are snapping way above its ankles.

Both AMD and Cyrix have developed clones of the 486 that claim to be reverse-engineered without using any of Intel's proprietary microcode, although in AMD's case, Intel is still disputing this claim in court. The cloners use various stratagems to keep an edge over Intel. Cyrix focused on pin-compatible replacement chips that enable you to skip a generation, so the Cx486SLC, DLC, and DRx2 chips fit into 386 sockets but offer some 486 features and near-486 performance. On the other hand, AMD offers same-generation-but-faster parts; for example, 40-MHz (and soon 50-MHz) equivalents for the 486SX, where Intel has to stop at 33 MHz to protect sales of its 486DX. Recently, Cyrix has changed tack to confront Intel head-on at the top of the range. Cyrix's M1 chip aims to outdo Pentium in the "stealing RISC's clothes" game.

There has been much industry speculation about what architecture Pentium's successor, the P6, will adopt. One plausible suggestion is that it could adopt a hybrid architecture in which a "pure" RISC core emulates the older 80x86 instruction set in hardware, by translating 80x86 op codes into groups of native instructions—IBM is believed to be following this course for its future PowerPC designs. The advantage of such a "Trojan horse" strategy is that you could fully support current 80x86 applications, while a new generation of software that uses the RISC's faster native instructions is developed to wean users gradually onto a new architecture.

Another possible course is to make the Pentium architecture itself RISCier, and the most obvious way to do that would be to remove the bottleneck caused by the small 80x86 register file. This is the way Cyrix plans to go with the M1, employing a file of 32 registers that can be dynamically renamed to emulate the 80x86's eight registers. This would allow up to four complete processor states to be stored at once, enabling an aggressive strategy of *speculative branch execution* (i.e., following both branch paths in parallel until it becomes clear which is the winner). Cyrix claims that this technique will keep the M1's pipelines full longer than the Pentium's, even though they are deeper seven-stage "superpipelines" (see "M1 Challenges Pentium" on page 83).

Intel is giving away little about its intentions just now. Frank Spindler, Pentium processor marketing manager, says, "We see no end in sight to what we can deliver with the Intel architecture, both within the Pentium generation and future generations of processors." In 1994, Intel will introduce a new version of the Pentium based on a 0.6-micron process technology, he adds, which will allow faster clock speeds. How much faster Intel won't say, but many in the industry expect it to be at least 100 MHz.



Running the BYTE low-level Windows benchmarks, *an SGI Magnum 75SC (Mips R4400 processor) turns in a credible performance in emulation mode against an IBM PS/2 Model 90 XP 486 (486DX/33 processor). The cumulative index is skewed by the fantastic performance of the Windows NT file system.*

Cutting Costs

With the arrival of the Alpha and the PowerPC, you've probably seen all the major new RISC architectures for some time to come. A generic modern RISC chip uses 64-bit data paths; large on-chip instruction and data caches; and separate integer, floating-point and branch-processing units that allow the issue of three instructions at once (referred to as *superscalar*). The units are deeply pipelined with instruction execution broken up into four to eight stages and often have a feed-forward scheme to satisfy data dependencies between consecutive instructions within the pipeline.

Instead of inventing new architectures, RISC vendors, detecting the scent of change in the air, are scurrying to reduce the manufacturing price of their current products (see "RISC Grows Up" on page 91). Broadly speaking, the cost of a chip in volume production is proportional to die size, so to make a chip less expensive, you use a newer fabrication process that allows smaller transistors, or you throw away some bits (e.g., from bus widths). Typical of this trend is the PowerPC 601, which is already cheaper than most 486DX variants thanks to an advanced 0.65-micron, four-layer metal process and a clever layout that reduces the space wasted by external interface pads.

Another effective approach is to attack overall system cost, rather than just CPU cost, by integrating more functions onto one chip so that fewer chips are needed to build a computer. A striking example of this is the DECchip 21066, which integrates a memory interface and PCI (Peripheral Component Interconnect) controller with an Alpha core.

Hot Chips

One question that's taxing all semiconductor manufacturers nowadays is how to reduce power consumption. Originally, it was the boom in laptop and notebook computers that made power into an issue, because the 2- to 3-hour battery life that most machines could offer was barely acceptable. Intel developed the 486SL, featuring on-chip power management and 3.3-V operation, for the portable market.

Then in April 1993, the U.S. government raised the stakes by instructing government agencies to purchase only certified energy-efficient computers; Intel killed off the 486SL and announced that SL power-saving technology would be incorporated into all its future CPUs. The new PDA market has given a further boost to the low-power quest, as these tiny machines are expected to run for weeks on just two or three penlight cells.

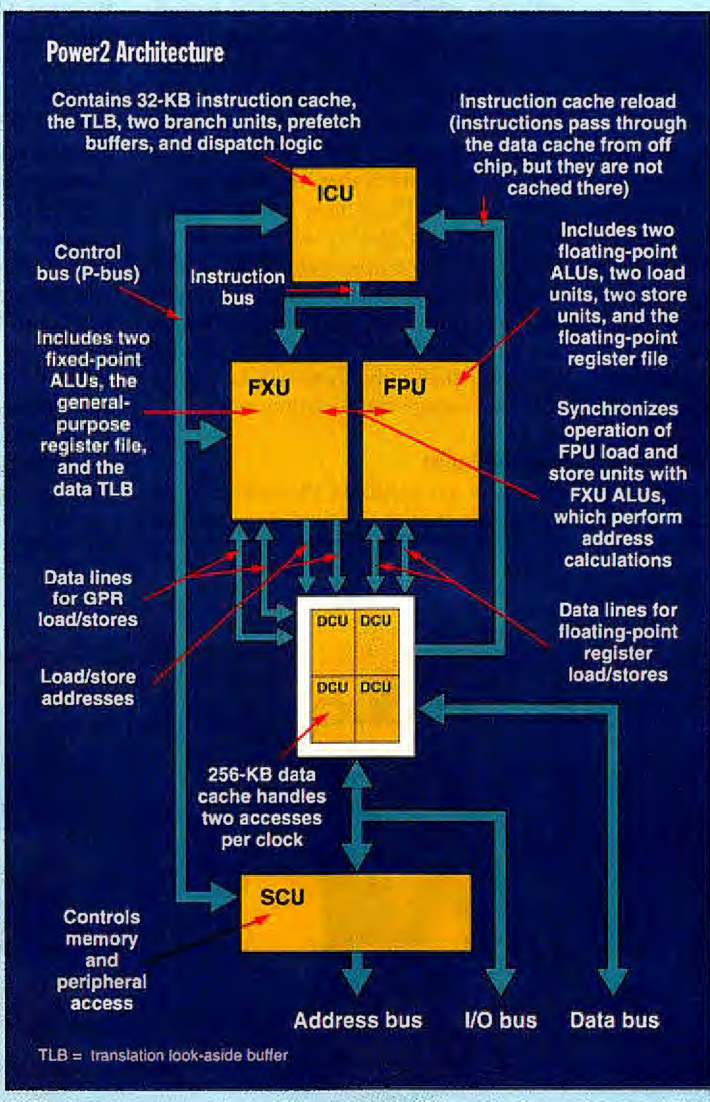
Another pressing reason to seek lower power consumption exists: Today's fastest CPUs are getting so hot that it has become

Power2 Takes the Lead—For Now

PAUL STATT

IBM's Power2 RISC processor, the successor to the Power1 found in its RS/6000 line, combines aggressive superscalar execution with a high-speed interconnect strategy. This combination delivers computing power unsurpassed by any other microprocessor. As you would expect, the Power2 is not inexpensive. It is used in three IBM RS/6000 systems that range in price from $62,500 (Model 58H) to $124,500 (Model 990). (Separate chip pricing isn't available on the Power2 since IBM installs it in IBM computers only.)

The Power2 proves that the processor with the fastest clock speed is not necessarily the most powerful. At 71.5 MHz, the clock speed of the Power2 is less than half that of the DECchip 21064 (200 MHz). Despite this, the Power2 is rated at 126 SPECint92 and 260 SPECfp92, more than double the score of the PowerPC 601 chip and a considerable floating-point advance over the 21064. Until DEC ships the 275-MHz DECchip 21064A this fall, the Power2 is the performance leader.



With six separate chips *in a single multichip module, the Power2 can, under ideal conditions, issue and execute six instructions at one time.*

Its clock may tick a lot less often, but the Power2 does plenty with each tick. Specifically, the Power2 executes more instructions in parallel than any other RISC processor: as many as six instructions per cycle. And they can't be just any old instructions; to maintain that performance, the Power2 has to mix exactly two integer instructions, two floating-point instructions, and two branch or condition-code instructions. That precise mix is required by the Power2's architecture. The Power2 is a multichip module, a high-density package that mounts individual dies directly onto a substrate that incorporates an interconnection network.

The Power2 MCM consists of three processing chips: an ICU (instruction cache unit), a fixed-point (integer) unit, or FXU, and an FPU. Four DCU (data-cache unit) chips and an SCU (system-control unit) are combined with them. Everything is joined in a ceramic multichip module that contains a total of some 23-million transistors in a block with an area of 4096 mm²; the size of a Polaroid print. (The die size of the eight chips totals 1215 mm².)

Despite its size, the Power2 makes most of its own decisions, and it needs only 512 I/O connectors. A lot of that input and output is used to transfer main-memory data into the chip cache over a 288-bit bus (256 data bits plus error-correction code) with an incredible peak data bandwidth of 2288 MBps.

The Power2 adds some valuable extensions to the Power1: quad-word load and store instructions; a hardware square root instruction; and new instructions for conversion of floating-point values to integers. The incredible power of the Power2 won't be available to PC users: IBM will market Power2 computers to the high end, while pushing the lower-cost, PowerPC in the mass market.

Paul Statt is a freelance technology writer. You can reach him on the Internet at statt@aol.com. or on BIX c/o "editors."

embarrassing. This fact was driven home the day I first opened an Alpha-based workstation to reveal a huge finned heat sink reminiscent of a racing motorcycle. These chips are dissipating up to 15 to 30 W, and further speed increases threaten to lead straight back to the age of water-cooled computers.

Steve Furber, original architect of the ARM processor family, says that as you shrink a chip design, the capacitance of the transistors decreases. But since you're switching them proportionally faster (by raising the clock frequency), the power that each transistor consumes remains the same. The transistors are now squeezed into a smaller area, so the power dissipated per square millimeter rises as the *square* of the process size. So, DEC's Alpha built in a 0.1-micron process—five to 10 years from now—would run at 2 GHz and dissipate around 3 kilowatts (excellent for making toast) if nothing else changed.

Clearly other features must change, and foremost among those is the supply voltage: Voltage and power are related by another square law, so going down from 5- to 2-V operation yields a sixfold power saving (25/4), while dropping to 0.5 V—which seems theoretically possible—would reduce power 100-fold. Furber sees a target somewhere between: "There's a very interesting breakpoint at about 0.9 V, which is where standard 1.5-V battery technology goes when it gets tired. If your logic only works at 1.5 V, you throw away a lot of battery life. I expect the people with real low-power motivation to find themselves aiming for 1 V sooner than they currently think they're going to."

To run the CPU at these lower voltages, everything in the system—memory, UARTs, video chips, and so on—has to come along, too. So the pursuit of single-cell operation for PDAs will eventually spawn a complete range of low-voltage parts, at which point there will be no reason for desktops not to follow suit.

Looking Ahead

You have more viable CPU choices available today than at any time since Intel introduced the first microprocessor back in 1971. Multiplatform operating systems, advanced emulation strategies, and new applications that don't require 80x86 compatibility have created a more open market for microprocessors than has existed since before the introduction of the IBM PC. Whether Alpha, R4x00, SPARC, or PowerPC can stay in the race with the 80x86, however, will depend on how well DEC, SGI, IBM, Sun, Apple, and the rest can package these technologies into solutions that meet customer needs as well or better than does an 80x86 processor.

Even if alternative architectures fail to capture more than 10 percent to 15 percent of the desktop market, they will provide price competition for Intel, and they will keep those 80x86 engineers busy pushing the envelope. In either case, the result will be better, more powerful desktop machines at reasonable prices. ■

Dick Pountain is a BYTE consulting editor. You can reach him on the Internet or BIX at dickp@bix.com.

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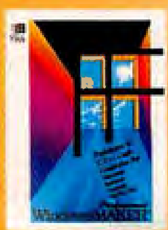

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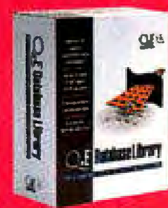

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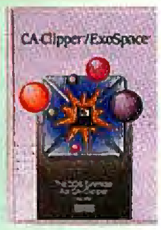

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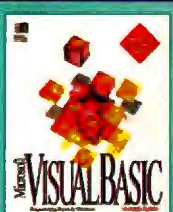

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M1 Challenges Pentium

The Cyrix M1 architecture brings more of the benefits of superpipelining and superscalar execution to 80x86 programs without requiring recompilation

BOB RYAN


PAUL ZWOLAK © 1994

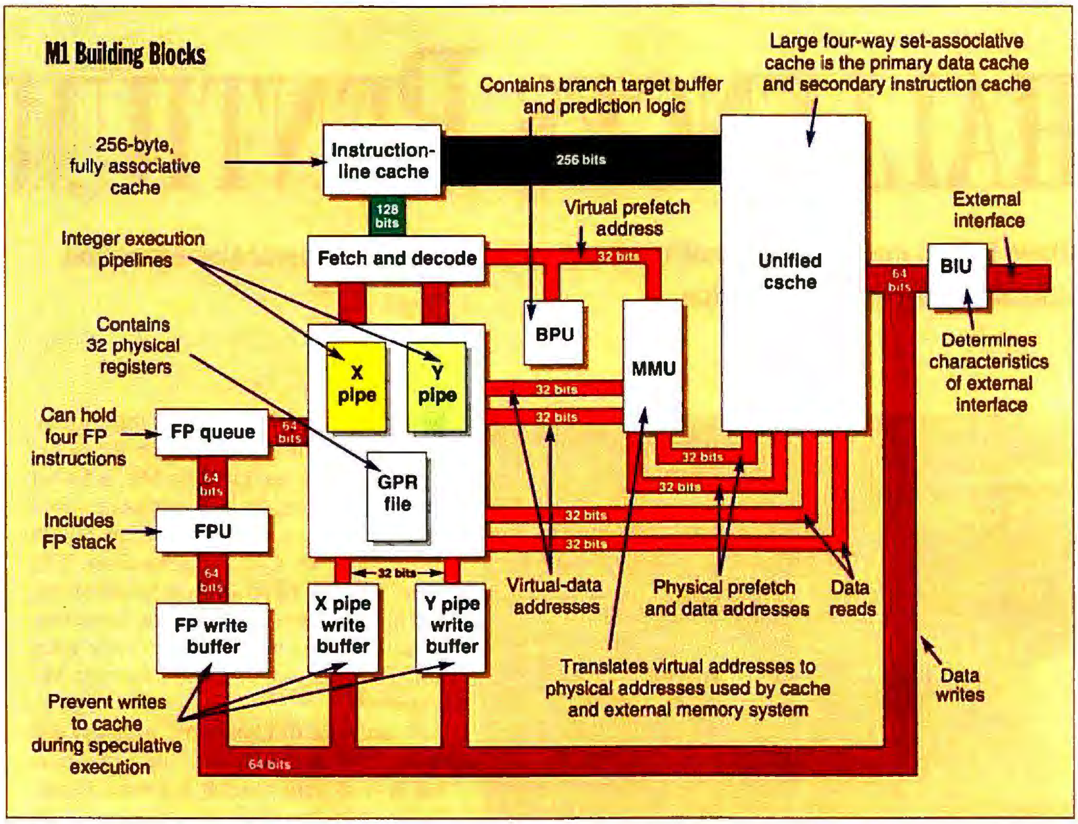
Intel's Pentium is no longer the only superscalar 80x86 processor on the block. Cyrix recently unveiled its M1, a 64-bit superscalar processor architecture designed to execute the industry-standard 80x86 instruction set. Cyrix (Richardson, TX) plans a family of processors based on the M1 architecture. At this time, however, the company is mum about exactly what time this year it will release the first M1 processor.

According to Cyrix, the greatest advantage the M1 holds over the Pentium is that it runs your current software faster. Cyrix estimates that you will receive up to 90 percent of the performance benefits of the M1 architecture when using nonrecompiled code. Intel estimates that nonrecompiled code runs 70 percent as fast as optimized code on the Pentium.

The Pentium promised the best of both worlds: RISC-level performance coupled with the ability to run industry-standard software. It delivers this, but not to all programs. To get the best performance from a Pentium, you have to recompile your software using a Pentium optimizing compiler. And because commercial developers are not in the habit of releasing their source code, this means waiting for language suppliers to create the compilers, commercial developers to use them, and software publishers to get the results into your hands.

The nature of superscalar pipelined processors makes this recompilation necessary. Because they can execute instructions in parallel, a superscalar processor works best when it can avoid situations where one instruction is dependent on the results of a parallel one. Most superscalar processors rely on an optimizing compiler to keep instructions with interdependencies from executing in parallel. The M1 employs an advanced design to eliminate these dependencies.

The M1 architecture is superscalar; it can execute more than one instruction at a time. Consequently, like the Pentium, it



Like the Pentium, *the M1 features dual-integer pipes. Unlike the Pentium, the M1 uses a unified cache in conjunction with a separate instruction-line cache. Also, the FPU on the M1 is not as aggressively pipelined as that of the Pentium.*

can execute two integer instructions at once. Unlike the Pentium, it can also execute integer instructions in parallel with floating-point ones, so floating-point execution does not stall the execution of fixed-point instructions. In addition, the M1 is superpipelined; it breaks instruction processing into more stages and finer stages than does the Pentium. This lets the M1 process more instructions at once and introduces higher timing margins per pipeline stage, which, in turn, lets the processor run at higher clock rates.

The significance of the M1 is twofold. First, it incorporates many innovations that will let your current crop of applications run much faster than they do now and make possible applications that use rich data types such as digital video. Second, if successful, the M1 will provide competition to Intel on the high end. This could result in lower prices for high-end 80x86 processors, whether Pentium or M1. The result is a higher price/performance ratio.

The Basics

The M1 consists of an IU (integer unit), an FPU, a unified cache, an instruction cache, a BPU (branch-prediction unit), an MMU (memory management unit), and a BIU (bus-interface unit). Because the specifics of these units will vary with different implementations, the discussion that follows concentrates on the principles of the M1 architecture, not on any one member of the M1 family. Cyrix plans to make specifics available when it is closer to shipping products based on the architecture.

The heart of the M1 is its IU, which, like the Pentium, contains two integer pipelines. In the M1, these are called the X pipe and the Y pipe, and they are divided into seven stages, as opposed to the five on the 486 and the Pentium. The seven stages are Fetch, Decode 1, Decode 2, Address Calculate 1, Address Calculate 2, Execute, and Writeback. By contrast, the 486 and Pentium pipelines use single stages for decoding and address calculation. A deeper pipeline lets the M1 have more instructions in various stages of processing than the Pentium or 486, but it also makes the pipeline more susceptible to hazards that can cause stalls and thereby introduce bubbles into the pipelines. (*Bubbles* are empty pipeline stages. You get optimal performance from a pipeline by keeping it full of instructions, not bubbles.) Dealing dynamically with hazard conditions is the major highlight of the M1 architecture.

The X and Y pipes are not identical. Change-of-flow, floating-point, integer multiply and divide, and so-called exclusive instructions can execute in the X pipe only. Exclusive instructions are any instructions that could fault during execution, and they typically include those that make multiple memory accesses. However, such instructions can use both pipelines to fetch their operands.

The IU prefetches instructions 16 bytes per clock from the 256-byte, fully associative instruction cache and deposits them into the 16-byte prefetch buffer in the Fetch stage. The instruction cache is small, but it is more flexible than the caches many processors use because it is fully associative; any instruction can be stored at any location in the cache, not just in a certain bank based on the set associativity of the cache.

In the Fetch stage, the prefetch address is used by the BPU to predict the direction of any conditional branch instruction in the buffer. Like the Pentium, the M1 deploys dynamic branch prediction using a branch target buffer. In addition, the BPU contains a return stack, where it pushes a target address during a subroutine call and pops it at return.

From the Fetch stage, instructions move to Decode 1, two instructions per clock. Here, the processor determines the length of both instructions. The two instructions then move to Decode 2, where the integer pipeline—a single unit up to this point—splits into the X and Y pipes.

Two major events happen in Decode 2. First, the instructions are fully decoded, and their entry points into the microcode ROM determined. Second, the M1 determines the optimum pipe for the execution of each instruction. Special logic in Decode 2 "looks down" each pipe to determine whether, for instance, the instruction in the X pipe should continue in this pipe or switch to the Y pipe. This logic helps eliminate or "squash" bubbles caused by stalled instructions. For now, Cyrix will not reveal details of this "pipeline optimization" logic.

It is also important to note what does not go on in this stage. The M1 doesn't check for dependencies between instructions. As these are handled dynamically and could in fact change due to some of the advanced techniques used in the M1, there is nothing to be gained by checking for dependencies here.

After Decode 2, an instruction passes to Address Calculation 1 where addresses for operands are calculated. Here, the process gets very interesting, because you encounter the first major departure from standard implementations of the 80x86 architecture. Unlike every other 80x86 processor, the M1 doesn't have eight GPRs (general-purpose registers). It has 32. More important, the M1 contains a mechanism—register renaming—that allows software that only knows about eight registers to take transparent advantage of the 32 GPRs: The M1 doesn't mess with the logical 80x86 programming model. Register renaming has a big effect on how the M1 handles pipeline hazards that can degrade the performance of your software (see "Pipeline Hazards" on page 87).

Following Address Calculation 1 comes Address Calculation 2, which actually accesses the operands, making them available to the Execute stage. After the Execute stage comes the Writeback stage, where results are written to the register file. Most of the pipeline hazards, which can stall the M1's pipelines, appear in the last three stages.

Instant Gratification

The most common hazard in pipeline processing is an RAW (read-after-write). While an RAW hazard doesn't introduce large bubbles into a pipeline, it can have a serious effect on performance because it can occur relatively frequently. To reduce such dependencies, the M1 uses data forwarding hardware to make operands and results from executing instructions available immediately to instructions earlier in the pipeline.

Consider this RAW example: Instruction *i* copies a value from memory to a register. Instruction *j*, which follows *i* in the pipeline, adds the retrieved value to that stored in another register. Normally, a pipeline interlock mechanism would stall instruction *j* in Address Generate 2 until *i* completes execution and moves to the Writeback stage, where it could then write the value to the register.

But with data forwarding, the value is immediately available to *j*. In effect, instruction *j* "reads" the result of *i*, instead of waiting for *i* to write to a register and then reading the register. This forwarding technique can bypass not only register writes but also memory writes, making data available without a wait for associated memory or register updates. It can also make data from the cache available to instructions as quickly as register-resident data.

An important note about data forwarding is that it occurs across the X and Y pipes. Thus, instructions that would normally stall in a 486 or Pentium pipeline can actually execute in parallel on the M1.

Register Renaming

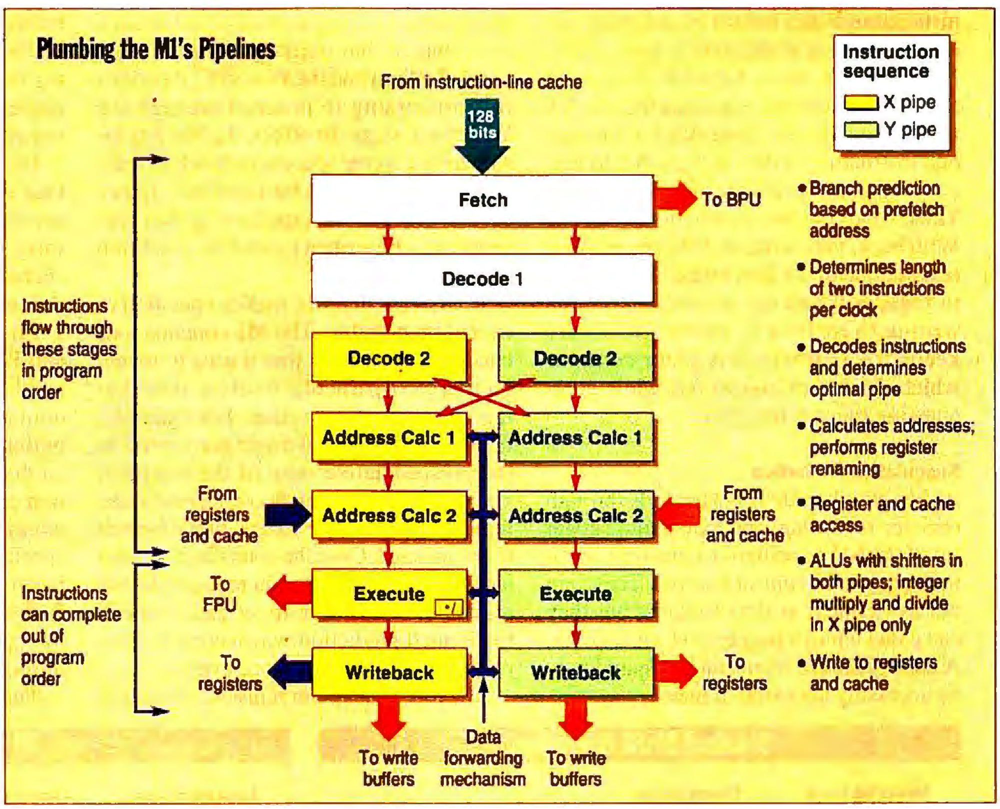
While data forwarding is great for dealing with RAW hazards, it doesn't have an effect on control hazards and can actually make possible the other types of data hazards. To handle these situations, the M1 employs register renaming.

Register renaming is transparent to software. Anytime it detects that an instruction in the Address Calculation 1 stage will write a value to a register, the renaming mechanism assigns one of the 32 physical GPRs to the indicated logical register. For example, if an instruction adds a constant to a value in memory and stores the result in register AX, register renaming will assign AX to the first open physical register.

The renaming logic uses a scoreboarding system to keep track of which physical registers are in use and which are free. If the next instruction again writes to AX, the M1 will assign a different physical register to handle that write. To see how this mechanism eliminates WAR (write-after-read) and WAW (write-after-write) dependencies, consider the two instructions in the table "Standard 80x86 Operations."

Assume the two instructions issue in parallel; the first instruction to the X pipe and the second instruction to the Y pipe.

continued



The M1 features two more pipeline stages *than does the Pentium, along with a feed-forwarding mechanism that can eliminate stalls by bypassing register and memory writes. Cyrix will not reveal details of the pipeline optimization logic that determines which pipe an instruction issues to after Decode 2; however, some things the logic might look for—and try to avoid—are conflicts in accessing resources outside the pipeline, such as the MMU and cache, and sending instructions down a pipe that already contains a long-latency instruction.*

M1	PENTIUM
• two integer pipes	• two integer pipes
• seven pipeline stages	• five pipeline stages
• unified cache	• separate instruction and data caches
• nonpipelined FPU	• pipelined FPU
• 32 GPRs with register renaming	• eight GPRs
• data forwarding prevents RAW	• relies on compiler to prevent RAW
• pipeline optimization reduces stalls	• no hardware issue optimization
• branch prediction with speculative execution	• branch prediction

Without data forwarding, this combination will result in a stall because of the existing RAW dependency on AX: The second instruction will be stuck in Address Generate 2 until the first instruction moves to Writeback.

Now, consider the situation in the table "M1 Operations," which reflects the M1's use of data forwarding and register renaming. Assume that initially, logical AX is assigned to physical register 0, and BX to physical register 1.

The data forwarding allows MOV and ADD to use the contents of the memory location at the same time, removing the RAW dependency noted above. The second instruction doesn't have to wait until the first instruction writes to logical register AX before it can use the data; therefore, both instructions can issue to the execute stage at the same time.

Without register renaming, however, you get a WAW hazard when both instructions execute together, as both instructions try to write to logical AX at the same time. The register renaming mechanism removes this hazard by assigning two different physical registers to logical AX. First, in the Address Generate 2 stage of the first instruction, it assigns logical AX to register 0. In the same stage of the second instruction, it then assigns AX to register 2, the next available physical register. Thus, when the two instructions move to Writeback, they write to different physical registers, with the first instruction writing to register 0 and the second instruction writing to register 2. Internal hardware keeps track of which register contains which version of logical AX while guaranteeing register integrity.

Speculative Execution

Although it handles data hazards through register renaming, the extended register set of the M1 is perhaps of greater benefit in dealing with control hazards. These are not as frequent as data hazards, but they can exact a much bigger performance hit. A control hazard often can be cleared only by accessing the external memory system, which consumes many more cycles than a one-stage bubble introduced by an RAW hazard.

As was mentioned above, the M1 employs dynamic branch prediction to try to keep the pipelines filled whenever it encounters an unresolved conditional branch instruction. It doesn't have to wait until a branch condition is resolved before it can continue execution. (Branch prediction is a function of Fetch, which is several stages before Execute where a condition would be evaluated.) If the BPU predicts that the branch won't be taken, it continues prefetching the current instruction stream. If it predicts that a branch is taken, it prefetches the new instruction stream and sends these instructions to the pipeline.

The M1 is not alone in letting processing proceed before a conditional branch is evaluated, but unlike processors such as the Pentium and the PowerPC, it permits this processing to proceed through the Writeback stage. In effect, the M1 lets instructions execute speculatively while waiting for a branch to be resolved. Other processors stall the pipelines so that registers can't be written to until the condition is resolved.

Register renaming makes speculative execution possible. The M1 contains four checkpoint registers that it uses to match registers to a particular machine state during speculative execution. For example, registers 3, 4, 5, and 6 might correspond to the prespeculative state of the machine, while 0, 1, 2, and 7 might correspond to the logical registers after a conditional branch is encountered. Once the conditional branch is resolved, the checkpoint registers let the machine reconstitute its original state if the branch prediction was incorrect. This reconstitution takes just one cycle.

The four checkpoint registers allow four levels of speculation. Thus, the M1 can continue processing even when it has four unresolved conditional branches pending. The only caveat about speculative execution is that no memory writes are allowed to proceed beyond the write buffers that are appended to the two integer and one floating-point Writeback stages. The M1 also allows floating-point instructions to execute speculatively while maintaining precise exceptions.

Floating Point and More

Unlike Intel with the Pentium, Cyrix did not devote major design or silicon resources to boosting the floating-point performance of the M1 to RISC-like levels. Given that Intel's own instruction profiling indicates that the average 80x86 business applications suite spends less than 1 percent of its processor cycles executing in the FPU, this neglect is understandable and defensible from a marketing standpoint. With 80x86 applications, integer performance is everything. The differences between the M1 FPU and that on a 486 include a four-instruction queue preceding the FPU, a write buffer that follows it, and enhancements to many of the floating-point algorithms.

Of greater interest are the two caches. One is a unified cache that contains both instructions and data; the other is the primary instruction cache. Thus, the unified cache is both the primary data cache and the secondary instruction cache.

The instruction cache is 256 bytes long and is fully associative, eliminating the need for any table lookup to access the contents of the cache. In parallel, the prefetch address is also sent to the MMU so that if prefetch misses in the instruction cache, it can access the unified cache without additional delay. The M1 contains special logic that preserves coherency between the instruction cache and the unified cache and between both caches and the execution pipeline, to handle problems introduced by self-modifying code.

The unified cache, which is expected to

Standard 80x86 Operations

Instruction	Operation
MOV AX,[mem]	Copy contents of [mem] to AX
ADD AX,BX	Add the contents of AX and BX and store the result in AX

M1 Operations

Instruction	Operation
MOV AX,[mem]	Copy contents of [mem] to R(0)
ADD AX,BX	Add contents of [mem] to R(1) and store result in R(2)

be at least as large as the combined sizes of the separate instruction and data caches on the Pentium (8 KB each), holds both data and instructions. It is four-way set-associative and uses a 32-byte line size. Being unified, it can dynamically balance the changing needs of a program for more or less cache memory of each type. Because it is a physical cache, TLB (translation look-aside buffer) lookup and, if necessary, address translation takes place before cache lookup. On a TLB hit, data and instructions are available immediately to the execution pipelines. A TLB miss introduces a minimum three-clock latency. On a complete cache miss, of course, the processor accesses the external memory system to bring the required instructions or data into the cache.

The unified cache has two read-write ports, so it can handle two accesses per clock. It does so by dual-porting the cache tags and TLB and by interleaving the cache memory on 16-bit boundaries. This results in a 16-level interleave factor—based on the 32-byte line size—which divides the cache into 16 banks. Thus, as long as two simultaneous accesses go to different banks, they can proceed in parallel. At least some members of the M1 family will support the MESI (modified, exclusive, shared, invalid) multiprocessing cache-coherency protocol.

The BIU determines the width of the M1's connection to the outside world, which may differ with different implementations of the architecture. Internally, data buses are 64 bits. On the instruction side, the path from the unified cache to the instruction cache is 256 bits, while that from the instruction cache to the prefetch buffer is 128 bits. GPRs and integer write buffers are 32 bits, while the floating-point stack, queue, and write buffers store 64-bit entities.

Pipeline Hazards

When an instruction stalls in a pipeline, it is held at a particular stage until an earlier instruction completes an action that will eliminate the stall condition. Hazards that cause stalls come in three classes: structural, data, and control.

Structural hazards occur when the processor doesn't have enough resources to handle a particular combination of instructions. For example, on the M1, Cyrix has included write buffers between the execution units and the cache, and a separate instruction cache between prefetch and the cache, to minimize those instances when simultaneous cache accesses (reads, writes, prefetches, flushes, and fills) overwhelm the two I/O ports the cache possesses. In dealing with structural hazards, a designer must decide whether the frequency of a particular instruction combination merits the extra transistors that would be required to handle the hazard condition.

Control hazards can occur when a branch instruction executes. If the branch goes to an address that isn't in the on-chip caches, the execution pipelines will stall for as long as it takes for the proper follow-on instructions to be retrieved from off-chip. The most difficult branches to deal with are conditional ones, where the branch is taken based on the condition of a flag or the value of a memory location or register, which usually isn't calculated until just before the conditional branch instruction executes.

In a data hazard, one instruction is dependent on a preceding instruction. For example, if the first instruction writes its results to register BX, the second instruction can't read from BX until the first finishes the Writeback stage. Because registers are read in Address Calculation 2, this introduces a bubble where the Execute stage is empty for a cycle. This is an example of a RAW (read-after-write) dependency; if the second instruction were to read BX before the first wrote to it, the second instruction would be using an incorrect value, destroying the integrity of the program logic.

Other data hazards are a WAR (write-after-read) and a WAW (write-after-write). A WAR occurs when a follow-on instruction tries to write to a register before a preceding one reads it. A WAW occurs when a follow-on instruction writes to a register before a preceding one.

Outstanding Questions

Four questions remain on the M1: Will it be compatible? When will it be available? How fast will it be? And how much will it cost? Bruce Burkhardt, director of strategic marketing for Cyrix, states that the architecture has proven compatible with 80x86 software in simulation testing. He feels that the company's experience in producing 486-compatible chips—as opposed to 486 clones—has given the company the experience it needs to implement the M1 architecture.

Burkhardt expects that systems based on the M1 will be available by the end of the year. That would indicate that Cyrix expects to sample the chip in the first half of 1994 and that the company may already have first silicon. Burkhardt declined to comment on first silicon or sampling dates. Pricing is also up in the air at this time.

Regarding performance, Cyrix expects the M1 to be faster in integer operations than the Pentium at comparable clock speeds, especially when running unrecompiled binaries. By way of demonstration, Cyrix points to the inner loop of the sieve benchmark program, which the Pentium processes in 34 clock cycles. The M1 architecture processes the same loop in 20 clock cycles by using data forwarding, register renaming, and pipeline optimization to significantly reduce the number of pipeline stalls. Cyrix is not claiming that the M1 will run all integer code 70 percent faster than the Pentium but the demonstration does identify how the features of the architecture can work to keep instructions flowing through the pipelines.

What the demonstration doesn't answer is how well balanced the M1 design is. In the Pentium, Intel worked hard on increasing the I/O bandwidth of both the instruction and data side of the processor. The M1 is more focused on the internals of the processing pipeline, although, of course, Cyrix didn't neglect I/O bandwidth issues. Only testing of a final product in a system will tell whether Cyrix has achieved that balance of processing and I/O bandwidth so necessary to a successful processor design.

Burkhardt states that the M1 is designed for speeds of 100 MHz and above. Such speeds are a competitive necessity because Intel will have high-speed Pentiums from its 0.6-micron-device facility available early this year.

The M1 is an ambitious project, one that Cyrix thinks it can pull off based on its experience producing 486-compatible processors. While it won't be possible to judge the success of the design until it is incorporated into systems, Cyrix deserves kudos for pushing the envelope on 80x86 designs in particular, and on commercial microprocessors in general. ■

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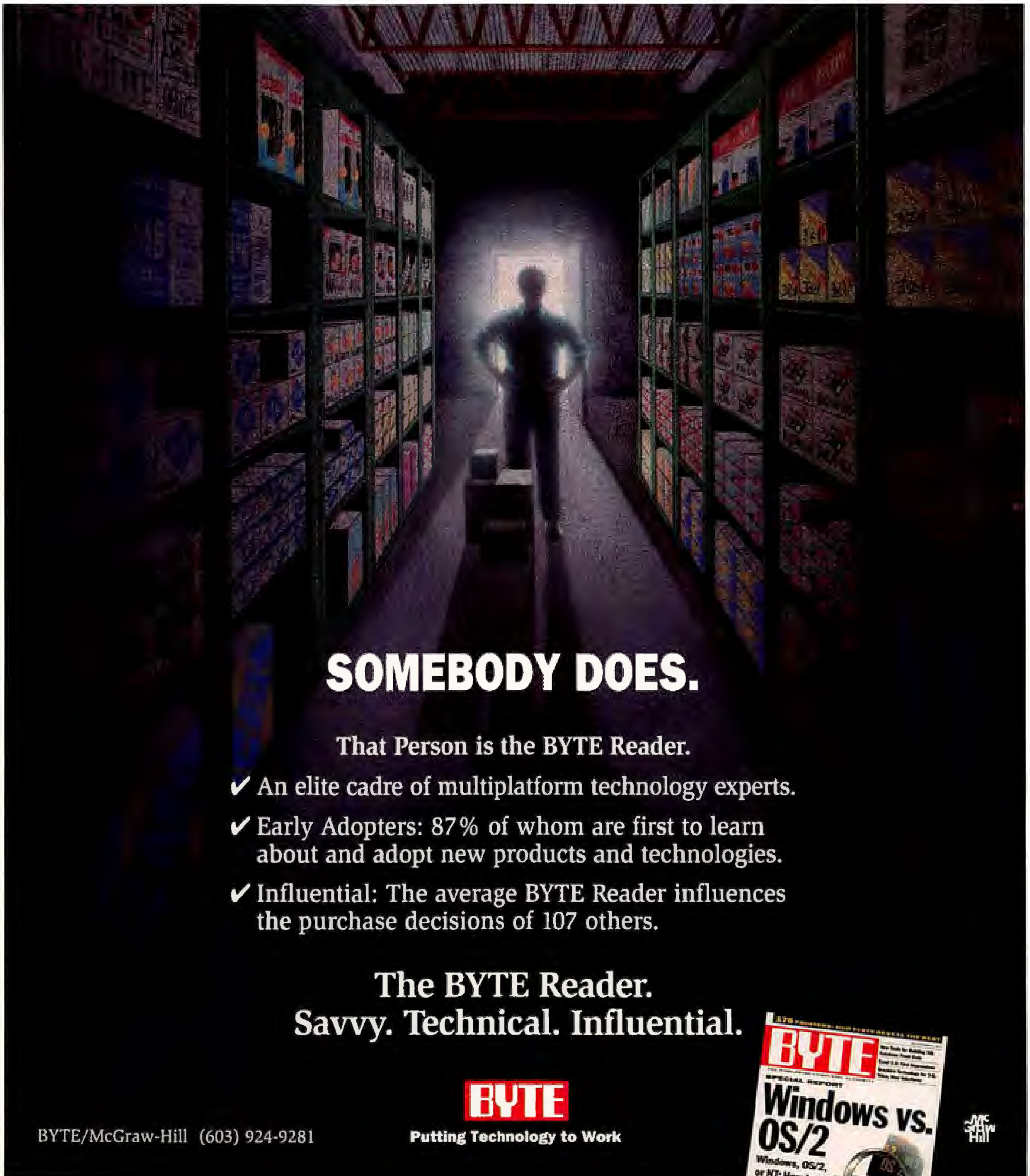

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RISC Grows Up

As RISC moves to the mainstream, vendors are broadening their offerings to appeal to various users

BOB RYAN AND TOM THOMPSON

PAUL ZWOLAK ©1994

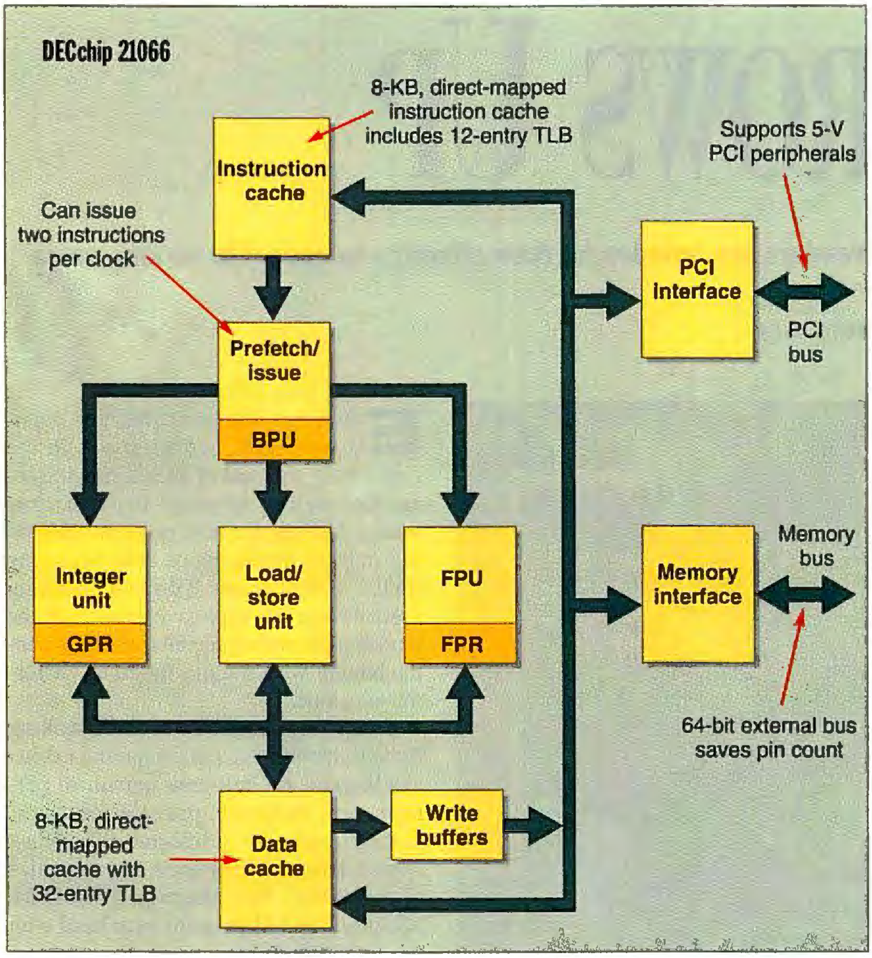
Ever since Sun Microsystems popularized RISC workstations in the mid-1980s, the goal of RISC chip designers has been unvarying—better performance. Having the most powerful chip on the market meant more than bragging rights; it meant sales. Portable operating systems and the explosive growth of the workstation market meant that many people bought workstations based on performance alone.

Today, the possibility of RISC making inroads into the desktop computing market has blunted the hell-bent pursuit of performance. Suddenly, price/performance, features, and ease of integration have assumed greater importance as companies such as DEC, Sun Microsystems, IBM, Motorola, and Mips go head to head with the Intel 80x86 juggernaut. Raw performance will get you only so far if it prices you out of 95 percent of the market.

The possibilities of RISC on the desktop has had a direct effect on RISC design. RISC designers are beginning to broaden their product offerings. This trend toward product-line diversification has manifest itself in a number of new chips from RISC vendors.

Alpha Attacks System Costs

In 1992, DEC entered the RISC market in a big way, with the Alpha, a 64-bit RISC architecture that the company claims will carry it well into the next century. Alpha hit the scene with a splash. At introduction, it was the world's most powerful microprocessor, and it remains the world's fastest single-chip microprocessor. Offered at 133, 150, and 200 MHz, the DECchip 21064 is ideal for high-end workstations and multiprocessing servers. (Alpha should retake the world's fastest bar-none crown from the IBM Power2 later this year with the release of the DECchip 21064A, a 275-MHz implementation of the Alpha architecture.) *continued*



Integrating an Alpha core *with both memory and PCI controllers yields a powerful chip that is easy and inexpensive to integrate into a system. Despite its added functionality, the DECchip 21066 requires 144 fewer pins than the 21064.*

Last year, DEC introduced the first variant of the Alpha architecture. Dubbed the DECchip 21066, the chip is designed to be the centerpiece of DEC's RISC PC strategy. It will be used in systems that run Windows NT and thus compete directly with Intel's high-end 486 and Pentium processors.

To compete with the high-end 80x86 machines, you need more than an inexpensive chip; you need an inexpensive system. The 21066 is designed with system costs in mind. It uses the 21064 core, so it is fast. It includes a memory interface—to SRAM (static RAM), DRAM, and VRAM (video RAM)—on the chip and a PCI (Peripheral Component Interconnect) controller; therefore, it has most of the logic a systems designer requires to implement a complete system. This is important since unlike the 80x86 machines, a huge support-chip industry doesn't exist around the Alpha architecture or any other RISC architecture.

In a further attempt to keep system costs down, the 21066's memory interface is 64 bits wide, which is half the width of the external memory bus of the 21064. Even though this narrower bus has a negative impact on performance, it makes it simpler to design a system around the 21066.

The 21066 is manufactured using DEC's 0.68-micron, three-layer-metal CMOS technology. The chip's size is 209 mm^2, and it operates internally at 3.3 V, although it can connect seamlessly to 5-V peripherals. Initially clocked at 166 MHz, the chip will dissipate over 20 watts of power, making it unsuitable for notebook implementations. The 21066 is priced at $424 each in quantities of 1000.

Based on simulations, DEC expects about 70 SPECint92 and 105 SPECfp92 performance from the 21066, which is a bit higher than the Pentium's 66-MHz integer performance (64.5) and nearly twice its floating-point performance. With a high degree of integration that will result in lower system cost, the 21066 will find its way into many NT servers and high-end desktops.

Integration, SPARC Style

Another company aiming to keep system costs down is Sun Microsystems, which, in conjunction with Fujitsu, has developed the MicroSparc II, a follow-on to the original MicroSparc I architecture. The MicroSparc II is an implementation of version 8 of the SPARC architecture. As such, it is compatible with the thousands of applications available for SPARC systems.

The MicroSparc II is the low end of an expanding SPARC product line. It is designed for low-cost implementations, both desktop and portable. Above MicroSparc comes SuperSparc, a superscalar SPARC implementation built by Texas Instruments for desktop systems. At the top of the line, Sun has recently announced UltraSparc, a 64-bit implementation of SPARC that Sun hopes will help the company regain some of the technical and performance luster it has lost in recent years to DEC and Mips. Like SuperSparc and the original MicroSparc, UltraSparc is being developed in conjunction with Texas Instruments.

As with the 21066, the MicroSparc II uses a high level of integration on the processor. In addition to the CPU core, it includes a DRAM controller, a graphics system interface, and an SBus controller. The primary distinction between the MicroSparc II and the 21066 is in the choice of I/O bus. DEC chose PCI, because it wants to make inroads into industry-standard desktops; PCI is establishing itself as a high-end standard, and it can be bridged to ISA. Sun chose SBus, which is found in SPARC systems from several manufacturers.

Sun is more interested in expanding its Solaris-based business than in joining the Windows NT bandwagon. The company is supporting Intergraph's efforts to port NT to SPARC, but it has announced no intention of offering NT on its own machines.

The MicroSparc II is built with Fujitsu's 0.5-micron, three-level-metal CMOS technology. It is a fully static design that operates at 3.3 V internally, and, like the 21066, it can interface to 5-V peripherals. It is designed to operate between 50 and 125 MHz. It is a large chip, packing 2.3-million transistors onto a die that measures 233 mm^2.

The MicroSparc II is a single-issue CPU, with instructions executing in either the integer or floating-point pipelines. To help keep floating-point instructions from blocking the integer pipeline, the FPU contains a three-entry instruction queue. The FPU is IEEE 754–compliant and can execute floating-point multiply instructions in parallel with other floating-point instructions. The integer pipeline consists of five stages and is preceded by a four-entry prefetch buffer.

Besides the integrated memory and bus controllers, the biggest difference between the MicroSparc I and II is the size of their respective caches. The MicroSparc I has a 4-KB instruction cache and a 2-KB data cache, where the MicroSparc II has a 16-KB instruction cache and an 8-KB data cache. Unlike most other new RISC chips, the caches are virtually addressed, meaning that lookup occurs using the virtual address, not the physical address generated by the MMU (memory management unit). In other words, the MMU is downstream from the caches.

This method eliminates any latency the MMU introduces before cache lookup, but it does require special logic to handle coherency problems when two or more virtual addresses map to the same physical address. In fact, this arrangement is a holdover from when the SPARC architecture was implemented on several chips. Then, the penalty for going off-chip to access the MMU was too high to implement physical caches (where cache lookup occurs after address translation).

In addition to using a 3.3-V power supply, the MicroSparc II is fully static. It also uses power management to conserve power. It can cut power to the caches by 75 percent when they are not being accessed, and in standby mode, it can stop the clock to all logic blocks. At 85 MHz, it is expected to consume about 5 W.

Sun expects the MicroSparc II to power both low-cost, high-volume desktop systems and SPARC portable systems. With the highest degree of integration yet seen in a SPARC processor, the MicroSparc II should significantly reduce costs to system vendors, while making it easier for them to design a system. The chip will sell for less than $500 each in quantity.

Portable PowerPC

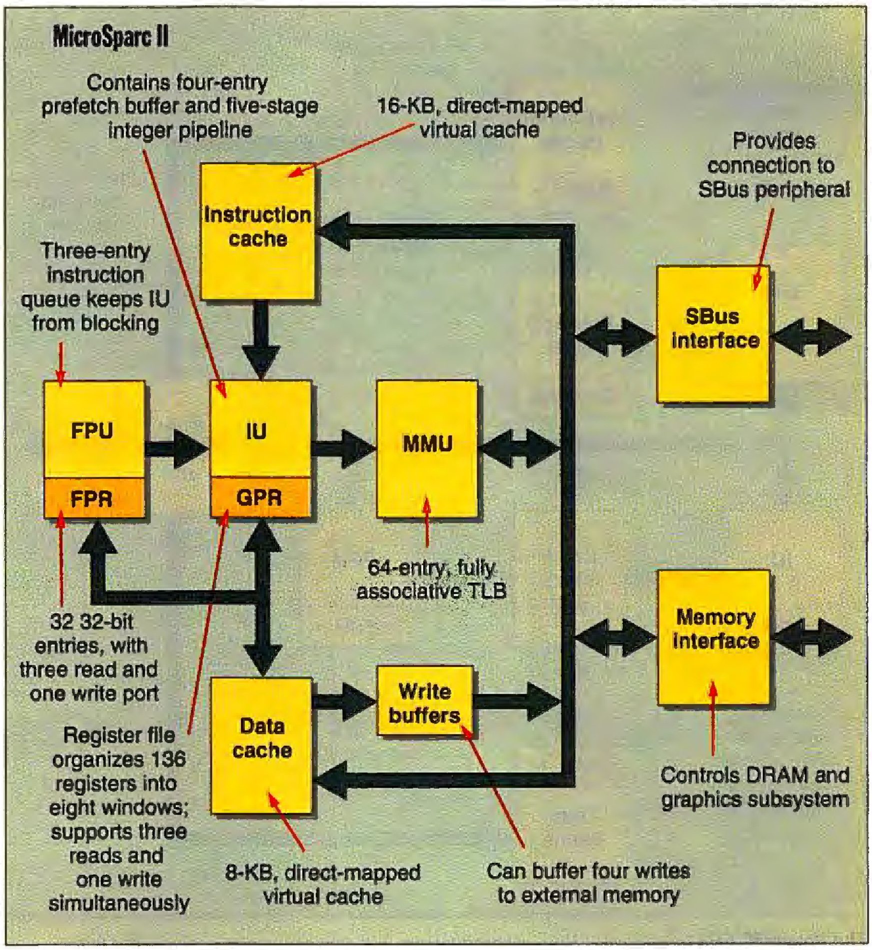
At the Microprocessor Forum last fall, IBM and Motorola announced that they had produced first silicon of the PowerPC 603, the second member of the PowerPC family. The goal of the PowerPC 603 is to provide high performance while consuming little power, making it ideal for notebook computer designs.

The 603 uses 3.3-V, 0.5-micron, four-level-metal static CMOS technology to pack 1.6-million transistors onto a die that's 85.1 mm². By contrast, the PowerPC 601 uses 3.6-V, 0.6-micron static CMOS technology to place 2.8-million transistors onto a die that's 132 mm². Like the 601, the 603 implements a 32-bit version of the 64-bit PowerPC architecture, with a 32-bit address bus and a 32- or 64-bit data bus. The 603 uses the same superscalar design with a three-instruction dispatch.

However, the 603 differs from the 601 in a number of areas. First, the 603 uses a Harvard architecture: It has two separate 8-KB caches, one for instructions and one for data. Each cache has its own MMU. Both caches are two-way set-associative and use a least recently used algorithm.

Next, the 603 has five independent execution units. As with the 601, the 603 has a BPU (branch-prediction unit), IU (integer unit), and FPU. However, the 603 features a new load/store unit and an SRU (system-register unit) that is used to implement dynamic power management. The load/store unit handles data transfers between the data cache and the GPRs (general-purpose registers) and FPRs (floating-point registers). The SRU executes special-purpose-register and condition-register instructions.

The 603 will be available as 66- and 80-MHz parts. Maximum power consumption should be only 3 W at 80 MHz. A variety of power-saving techniques incorporated in the design should actually enable typical power consumption to hover around 1 to 1.5 W. This compares well with popular notebook CPUs such as the Intel 486DX/33, which can dissipate up to 3.2 W. The power-saving techniques used include a PLL (phase-locked loop)



The MicroSparc II *brings SPARC integration to new levels. With four times the cache memory of the original MicroSparc, it promises to at least double its performance.*

RISC COMPARISON
With prices below $500, these RISC chips can compete head-on with the top end of the 80x86 line.

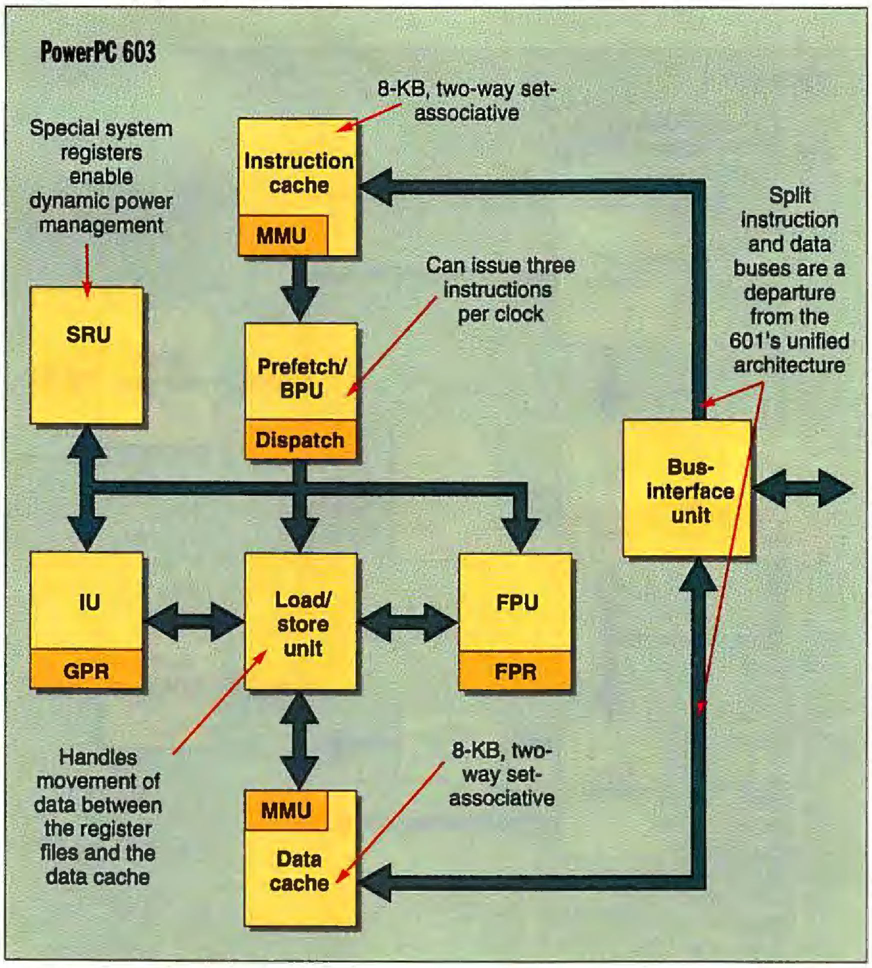
	NUMBER OF TRANSISTORS	MAXIMUM POWER DISSIPATION	PRICE (QUANTITY 1000)	SIZE IN MM²	SPECINT92	SPECFP92	OPERATING VOLTAGE
DECchip 21066	1.75 million	20+ W (166 MHz)	$424	209	70[1] (166 MHz)	105[1] (166 MHz)	3.3 (5-V peripherals)
PowerPC 603	1.6 million	3 W (80 MHz)	N/A	85	75[1] (80 MHz)	85[1] (80 MHz)	3.3 (5-V peripherals)
MicroSparc II	2.3 million	5 W (85 MHz)	$500	233	57.2 (85 MHz)	49.5 (85 MHz)	3.3 (5-V peripherals)
Mips/NEC R4200	1.3 million	2 W (40/80 MHz)	$75 (8000 yen)	81	55[1] (40/80 MHz)	30[1] (40/80 MHz)	3.3

[1]Based on simulations N/A = not available.

clock multiplier circuit. The PLL allows the processor to run at frequencies higher than the system clock, using a multiplier of 1×, 2×, 3×, and 4×. The PLL also enables the 603 to operate properly when slower system clock speeds (e.g., 33 and 50 MHz) are used to reduce the processor's power consumption.

Because the 603 uses static logic, the contents of the registers and caches are preserved when the processor kicks into low-power modes. The 603 provides three software-controllable power-saving modes: doze, nap, and sleep. The *doze* mode switches off most of the processor, except for the external bus-snooping logic. The bus interface processes external snoops and maintains coherency of the internal caches. The time-base register continues to operate. The PLL is also powered so that it remains locked to the system clock and can bring the processor into the full-powered mode in only a few clock cycles.

The *nap* mode disables the bus snooping, so cache coherency is not maintained. The PLL and time-base register are still active. Return to a full-power active state takes several clock cycles. In the *sleep* mode, the time-based register is switched off, leaving no internal units operating. External logic can disable the PLL for further power savings. This mode consumes minimum power, but it takes a number of clock cycles for the PLL to resynchronize before the processor can be placed into full power mode.



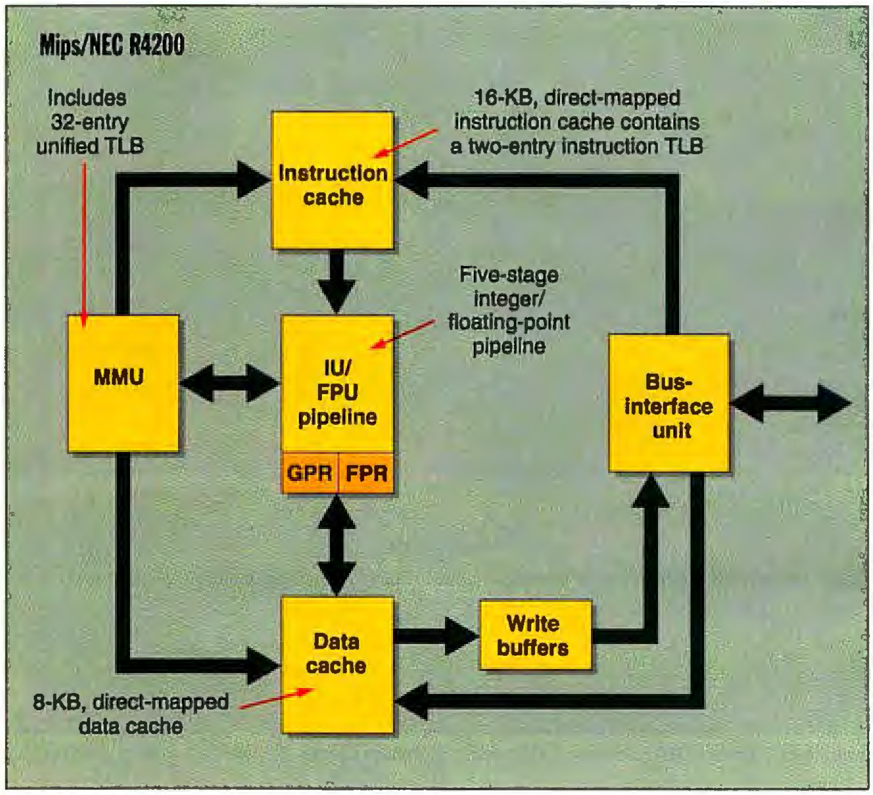
The PowerPC 603 *introduces a Harvard architecture and dynamic power management to the PowerPC line. Expected to dissipate 2 to 3 W at 80 MHz, it is ideal for notebooks and energy-efficient desktop systems.*

The 603 also uses dynamic power management techniques to reduce power consumption. Dynamic power management works by switching off the clock to certain processor subsystems when they are idle. The dispatch logic monitors the instruction stream, and if a certain subsystem—say the FPU—is idle and no floating-point instructions are forthcoming, the dispatch logic has the FPU clock disabled. Conversely, if the dispatch logic detects an incoming floating-point instruction, it can enable the FPU clock before issuing the instruction to it. This also explains the two additional execution units: Both the LSU and SRU can be disabled as necessary to save power.

Either cache can be switched off if it is inactive. For example, the 603 might be constantly fetching instructions but no data, so the data cache would be powered down. The dual-cache design also requires smaller on-chip buffers and eliminates the arbitration logic required for the 601's unified cache.

Also, the cache protocol has been reduced from four states (i.e., modified, exclusive, shared, and invalid) to three states (i.e., modified, exclusive, and invalid). The cache protocol is compatible with the four-state protocol. It was anticipated that the 603 would be used for stand-alone designs, so the sharing state was removed. These changes to the overall cache design use fewer transistors, which also translates into power savings.

Preliminary SPECmarks (obtained from simulations) indicate that a 66-MHz 603



The R4200 *integrates a complete RISC pipeline and 24-KB cache on a die 82 mm². Its low power consumption and high performance make it ideal for notebook systems.*

should post 60 SPECint92 and 70 SPECfp92. That compares favorably to a 66-MHz 601's performance of 60.6 SPECint92 and 72.2 SPECfp92, as obtained on the RS/6000 Model 250. The 603's comparable RISC performance, combined with its modest power consumption, makes it ideally suited to become the heart of future notebook computers.

The 603 will be manufactured at IBM's microelectronics facility in Burlington, Vermont, and Motorola's MOS-11 facility in Austin, Texas. Pricing was not available at this writing.

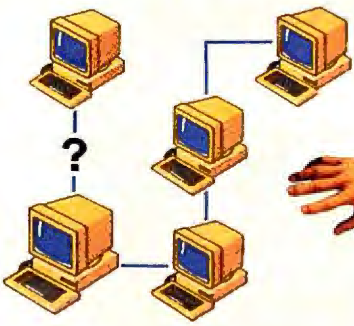
SGI Gets Small

Like DEC, Silicon Graphics is trying to ride into the desktop market on the back of Windows NT and is aiming to reduce system costs so that systems using the 64-bit Mips III architecture can offer a significant price/performance advantage over industry-standard 80x86 systems. Unlike DEC, however, the latest Mips design does not aim to integrate a lot of system logic on the microprocessor; instead, it goes for straightforward price reduction while maintaining RISC performance levels.

The R4200 is the result; a small (just 81 mm²), powerful (estimated 55 SPECint92), and inexpensive processor that can offer a significant price/performance advantage over any 80x86 chip. NEC, which has a one-year exclusive license to produce the chip, estimates that the R4200 will sell for 8000 yen—well under $100 at current exchange rates.

Unlike most RISC processors, the R4200 is neither superscalar nor superpipelined. It uses a fairly standard five-stage pipeline as opposed to the eight-stage superpipeline used in the other members of the R4x00 family. In addition, it combines its integer and floating-point pipeline into a single unit, creating a pipeline that can perform both types of operations.

Combining the two units into one degrades performance—floating-point performance is estimated at 30 SPECfp92—but saves a huge number of transistors. Another savings comes from reducing the number of TLB (translation look-aside buffer) entries in the MMU from 48 to 32. This might not seem like much compared to combining the fixed- and floating-point pathways, but considering that the TLB is fully associative, it is significant. Like other R4x00 processors, the R4200 retains a separate two-entry instruction TLB so that most simultaneous



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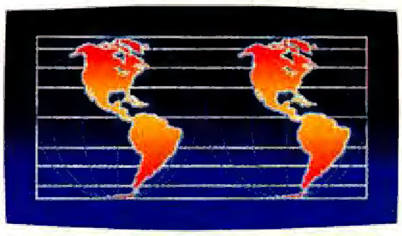

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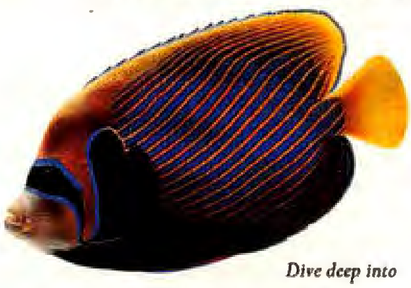

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data and instruction accesses don't result in one access being blocked while the other makes use of the MMU.

Another factor in reducing the size—and thus the cost—of the R4200 is the manufacturing process used to make it. NEC uses a 0.6-micron, three-layer-metal CMOS technology to produce the R4200. The chip operates at 3.3 V, and, unlike the 21066, requires 3.3-V peripherals. In addition, it incorporates a number of power management techniques. It can power down unused functional blocks and prevent switching in unused execution units. The chip isn't a static design, however, so you must save the state of the processor before powering down completely. NEC expects the chip to draw about 1.5 W, making it ideal for notebook and portable applications.

The R4200 stacks up quite well against both the Pentium and the high-end 486s. It provides 80 percent of the Pentium's integer performance at about 10 percent of the price. It betters the integer performance of the 486DX2, at 20 percent to 25 percent of the price. As an economical platform for NT, the R4200 will be hard to beat.

Coming of Age

The chips previously described make one thing perfectly clear: RISC is no longer a fringe technology. All the major RISC vendors offer a range of solutions with different features, performance levels, and prices. True, some architectures have only a couple of representatives, but in these cases—Alpha and PowerPC especially—the vendors are committed to providing an ever-growing choice of CPUs.

Vendors are also offering embedded solutions based on desktop CPUs. IBM has announced a family of embedded processors based on the PowerPC—the PowerPC 400 series—and Motorola is expected to do the same shortly. DEC sells an embedded version of the 21066 called the 21068. Embedded processor sales help ameliorate the design costs of desktop CPUs, letting companies like DEC and IBM compete more effectively with Intel. These developments are necessary if RISC is to garner a significant share of the desktop computing market. ■

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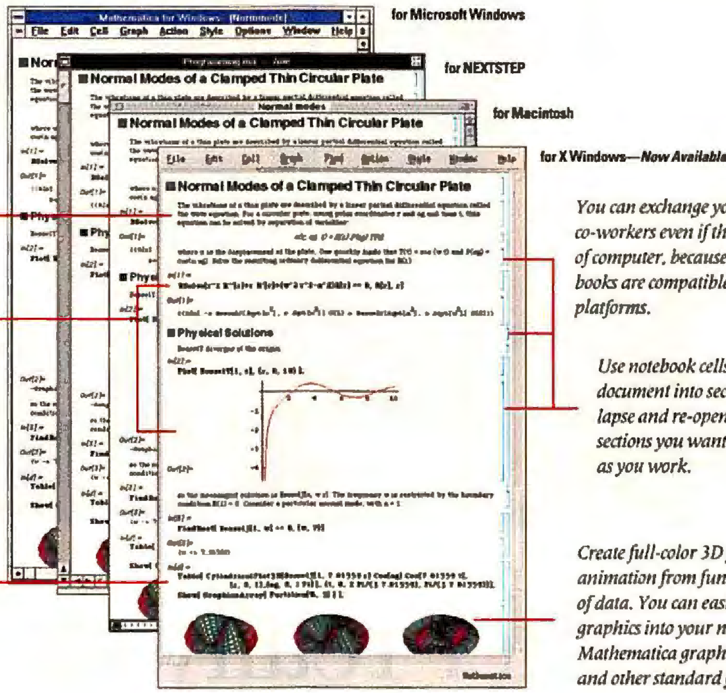

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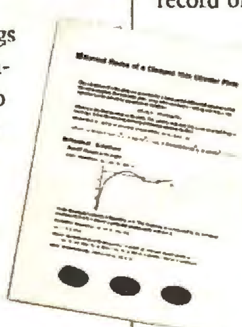

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INTEL/VLSI JOIN THE PDA FRAY

A new PDA chip set from Intel and VLSI brings the 80x86 architecture to PDAs

PAUL STATT

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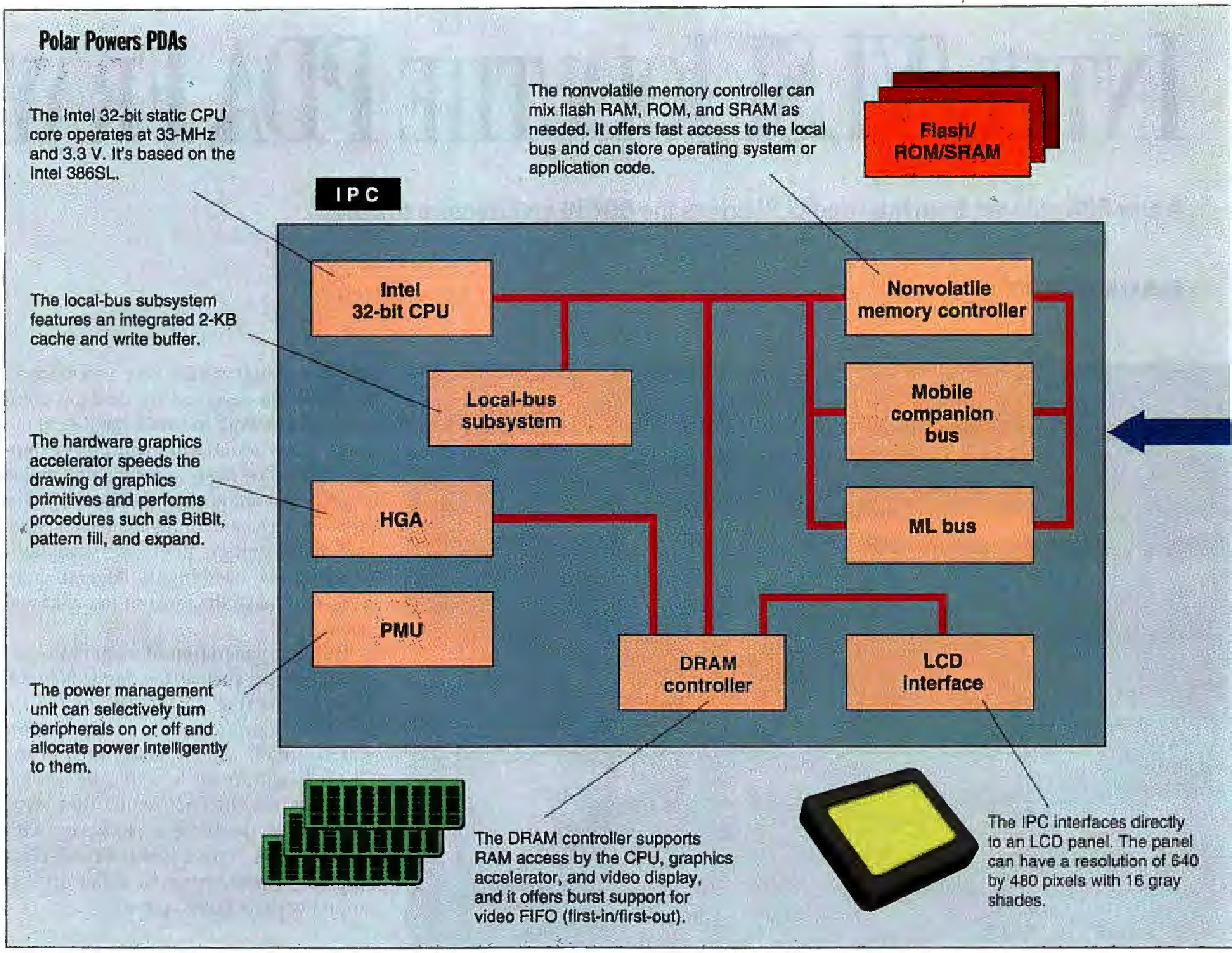
No matter which way you slice it, CPUs designed for desktop computers don't work in small, hand-held devices. They are too big and power hungry, require too many support chips, and in some cases, are not powerful enough for tasks such as handwriting and, eventually, speech recognition. PDAs (personal digital assistants) need highly integrated designs that make the most of the chip real estate.

The first generation of such chips exists in devices such as the Apple Newton MessagePad (the ARM610) and the Eo Personal Communicator (the Hobbit 92010). Intel, which makes most of the CPUs found in the world's desktops, stayed on the sidelines as the first wave of PDAs hit the market. However, with partner VLSI, long a maker of AT-class chip sets, Intel hopes to make up lost ground with its Polar chip set.

Computer on a Chip

Microprocessors are the heart of every personal computer, but only the heart. A PC—be it a notebook, desktop machine, or network server—requires numerous other chips to handle I/O, access SRAM (static RAM), DRAM, and VRAM (video RAM), and provide the glue logic that connects these subsystems to the CPU. In addition to the CPU, a typical desktop 486 system includes an AT-class chip set that controls memory access and interfaces with an ISA expansion bus; a secondary cache controller to buffer access to main memory; and a video controller, perhaps on a separate local bus.

The Polar chip set from VLSI and Intel provides these or comparable functions on two chips. To build a working machine, you need little more than a power supply and some DRAM. The Polar chip set is the basis of what Intel and VLSI call a mobile companion computer. *Mobile companion* is the Intel/VLSI name for a PDA. It reflects the company's efforts to enable



The Polar chip set *is a highly integrated solution that offers just about all the functionality you need in a PDA system.*

portable devices that are extensions of your desktop environment. You can expect machines based on the Polar architecture to be called mobile companion computers.

The IPC

At the core of the Polar chip set is the Integrated Processor Controller, or IPC. Designated VLSI part number VI86C300, it is a 32-bit processor architecture with support logic packaged in a 176-pin TQFP (thin quad flat package). Among the support functions it integrates are memory management, video control, and power management. The processor core of the new chip is a fully static Intel 32-bit CPU based on the Intel 386.

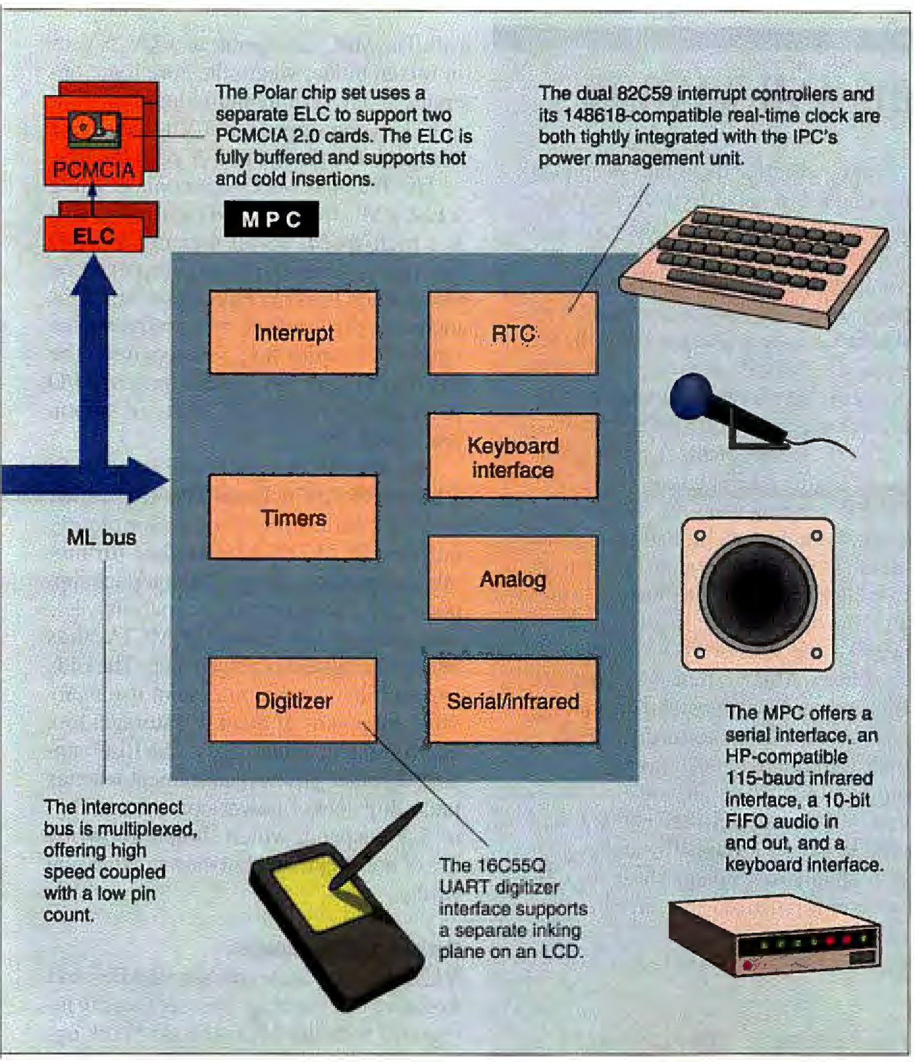
One of the key differences between the IPC and the 386 is that the former includes a cache controller with an integrated 2-KB cache and a tag RAM. This cache is unified, holding both instructions and data, and write-through. While the cache is too small to put the performance of the IPC on a par with 386 desktop systems that use external caches, it does provide a performance boost of cacheless 386 systems and helps reduce contention for main memory between the processor and the graphics subsystem. The IPC reduces this contention further by using a four-entry write buffer between the cache and DRAM.

One thing to note about the IPC is that DOS-based 386 programs cannot run on the new chip. Intel states, however, that the IPC's design should make it relatively easy for programmers familiar with the 80x86 architecture to write software for mobile companion computers.

In addition to the CPU core, the IPC handles both volatile and nonvolatile memory, the latter without discrimination. There are three types of nonvolatile memory: (1) flash memory, which can be likened to a RAM disk that stays on when the machine is turned off, (2) ROM, and (3) SRAM. All three types can be used interchangeably; an application never needs to know where it gets its bits from.

The large array, nonvolatile-memory interface is tuned for high-performance XIP (execute-in-place) code, as well as for data storage. This means that you can turn off a PDA using the Polar chip set at any time and return to the same screen when you switch it back on. Separate programmability of each of four banks allows mixing of flash, ROM, and SRAM device types. Additional signals are provided for programming control and power management of advanced flash-memory devices that do not require power to maintain data in memory.

The page-mode DRAM controller supports different chip configurations—256 KB by 16 bits, 512 KB by 8 bits, 1 MB



by 4 bits, 4 MB by 4 bits, 1 MB by 16 bits, and 2 MB by 8 bits—and both symmetric and asymmetrically addressed DRAMs. Because the DRAM on a mobile companion computer also doubles as storage for the video display, the IPC contains arbitration logic to handle contention between regular data access and video access. The IPC supports a 64-MB total memory space, which can be divided between DRAM, nonvolatile memory, and PCMCIA peripherals. DRAM is limited to 16 MB of RAM, while nonvolatile memory and PCMCIA peripherals can take up the full 64 MB of memory space.

Video and Power Issues

To handle video output, the IPC integrates a 640- by 480-pixel LCD controller and an HGA (hardware graphics accelerator). The controller and accelerator work with the flat frame-buffer graphics subsystem to provide high-end performance for LCD-based systems. The LCD graphics are 4-bit gray scale—not black and white—for 16 levels of gray and a corresponding crisp appearance. The LCD controller also connects to the video digitizer found on the multiple peripheral controller, or MPC (the second chip of the Polar set), allowing it to display an inking plane above the output display planes. The inking plane displays strokes entered using a pen-input device.

While many PDAs use simple LCD video, the IPC goes one step further with its graphics acceleration hardware. By speeding the drawing of common graphics primitives into the frame buffer, the acceleration hardware gives mobile companions a crisp, quick video interface. The built-in BitBlt lets the IPC move rectangular arrays of bits quickly in the frame buffer. This facilitates opening, closing, and moving menus and windows in a GUI environment.

The IPC is designed with low-power operation in mind. It is fabricated with a 0.8-micron, three-layer-metal CMOS process and supports 3.3- and 5-V operation. The IPC uses a fully static core that can preserve the state of the CPU even when the system clock is shut down. The IPC can generate 20-, 25-, or 33-MHz system clocks.

The IPC also contains a power management controller that is enabled by a system management interrupt and accessible via software. In addition to the simple types of on/off power management provided by hardware-based solutions used in PCs, the IPC power management system can be controlled by the operating system, which can usually make better judgments about which subsystems should remain active and which can be powered down. The power management system can shut down individual subsystems on the chip. Power dissipation is estimated at just over half a watt when operating at 3.3 V.

The MPC

As previously mentioned, in addition to the IPC, the Polar chip set contains the MPC (VLSI part number VI86C100), which is designed for standard I/O but incorporates several optimizations to better enable telecommunications. The MPC is the peripheral controller complement of the IPC. Packaged as a 100-pin TQFP, the MPC includes a serial-communications port for networking or printing, an infrared I/O port for a keyboard or remote access, and audio I/O for voice messaging, including voice storage and message forwarding. The MPC also uses analog I/O for system monitoring and control. A keyboard interface is optional, and a high-performance digitizer interface is standard.

The UART (universal asynchronous receiver/transmitter) part of the MPC is compatible with the VL16C550 standard and with its infrared I/O option, offers programmable I/O address and programmable interrupt levels. The UART may be configured to operate through a normal serial connector or through a dedicated I/O pin that connects directly to an infrared LED. This HPSIR (Hewlett-Packard Serial Infrared) interface is compatible with those found on the HP 95LX, 100LX, and OmniBook Super Portable Computers.

The MPC's audio features let you store, forward, and play back recorded sounds. The chip itself has the power to work like a telephone, as well as like a fax machine or modem (with the appropriate PCMCIA cards). The ADC (A/D converter) allows for battery monitoring so that you won't waste your last amp recording a phone

Intel/VLSI Join the PDA Fray

call. The MPC can operate at 3.3 V, 5 V, or in mixed mode, where the core logic operates at 3.3 V while individual functional blocks can operate at 5 V to provide a compatible interface to 5-V peripherals.

The IPC and MPC interconnect using VLSI's ML (multiplexed local) bus. This is a high-speed, 16-bit memory and I/O bus that is time-division multiplexed on the standard Intel microprocessor bus. This increases performance while reducing the number of connecting pins required. The ML bus also offers general-purpose I/O ports that allow a wide variety of system configurations.

The first ML bus peripheral is the VLSI VL82C146 ExCA Local-Bus Controller, or ELC, which provides a completely buffered PCMCIA 2.0 interface for mobile companion systems. The interface supports full "hot insertion" capability, letting you insert or remove PCMCIA cards while your system is powered up. The ELC lets mobile companion system use many different makes of memory, storage, I/O, and communications cards. The ELC supports advance power management features including socket power control and 3.3- to 5-V suspend, which should allow the use of both high- and low-power expansion cards.

Outlook and Speculation

VLSI and Intel are working with Microsoft to ensure that the Polar chip set is easily integrated with the Microsoft At Work operating system for hand-held devices. Microsoft At Work is a DOS-less variant of Windows designed specifically for PDA-type systems. The fact that it is a Windows variant will make it easier for developers familiar with the desktop version of Windows to produce software for mobile companion systems. One of the features of At Work that will directly support such systems is power management software that interfaces with the IPC's power management controller.

Abandoning DOS and DOS compatibility is a big step for Intel and VLSI to take with the Polar chip set. Both companies believe, however, that more important than DOS compatibility is data compatibility. No one is going to want to run a spreadsheet on a PDA, although you may want to massage data from a spreadsheet.

The Polar chip set is the first in a series of offerings from VLSI/Intel. In the works is a follow-on chip set based on an Intel 486 core. Such an offering may be a competitive necessity because other compa-

THE AM386SC DOES DOS AND WINDOWS

To produce a device to power a PDA (personal digital assistant), Advanced Micro Devices has taken what might seem an obvious approach—integrating all the features of a PC on a single chip. The Am386SC microprocessor combines a DOS/Windows-compatible 386 microprocessor core with AT-system architecture logic and a power management unit.

Unlike the Polar chip set, hand-held computers that use this chip run both Windows and DOS. An Am386SC-based PDA will be a tiny PC in size and price. The Am386SC is inexpensive—$50 each in lots of 10,000—and relatively small—a 208-pin TQFP (thin quad flat package).

And it's the only logic chip a computer requires; add some DRAM, flash ROM, and perhaps some SRAM (static RAM), and you have a computer system. In a PC based on the Am386SC, you *don't* need a separate PCMCIA 2.0 chip, a keyboard interface, a serial- or parallel-port interface, a graphics chip, timing, or power management chips. And, most important, you don't require a 32-bit 80x86 microprocessor. All those features are built into the AMD chip.

The downside of this totally integrated solution is that not every PDA manufacturer will want every part. It's easy to imagine the desire for a separate chip for, say, pen input or voice messaging, so AMD promises to build custom designs for its volume customers. Every design will start with the 80x86 CPU at its core; AMD will be able to integrate whatever the PDA maker needs into an Am386SC.

The key feature of this chip is its greatest strength and weakness—it's a PC. The PDA market today has no standards at all; therefore, it's probably not a bad idea to build a PDA around the existing PC standard. If the PDA market grows up to be a market for smaller, less expensive versions of existing personal computers, AMD's strategy will pay off. However, if consumers start demanding new standard features from their PDAs—such as telecommunications power, pen input, handwriting, or voice recognition—PDAs based on the Am386SC will need to hang a lot of hardware on their slots simply to keep up. Those impediments may prove too great, if, and when, a PDA standard emerges.

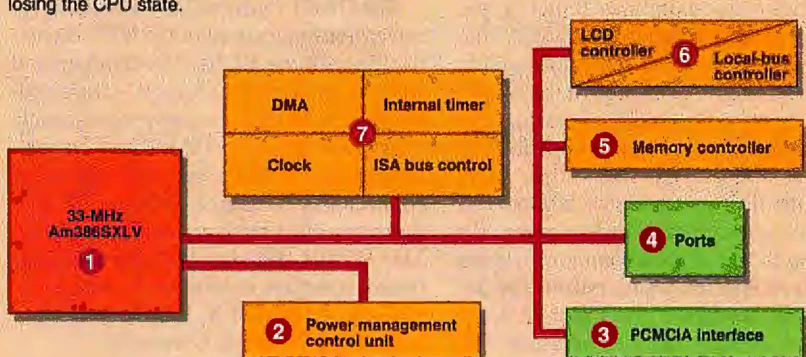
AT on a Chip

1 The Am386SXLV core includes a system management mode that can slow the processor down to 0 MHz without losing the CPU state.

2 The power management control unit monitors all system activity and determines which of five operating modes will best conserve power.

3 The Am386SC supports two PCMCIA 2.0–compatible cards, but each requires an external 16-KB buffer.

4 Parallel and serial ports are standard; they require an external data latch and a buffer, respectively.



5 The memory controller supports a high-speed 16-bit data path to DRAM or SRAM and to local-bus devices.

6 The internal LCD video controller is fully 6845-compatible and supports up to 640- by 400-pixel resolution in a single or split screen.

7 Other interfaces include two interrupt controllers, two DMA controllers, an internal timer/counter, a real-time clock, and an ISA bus controller.

The Am386SC is *a marvel of integration.*

The AT&T Hobbit Enters Its Second Generation

The AT&T Hobbit chip sets betray their corporate heritage. These are chips designed first and foremost for telecommunications applications. AT&T Microelectronics first offered a set of chips for PDAs (personal digital assistants) in 1992. The 92K Hobbit family, the chips that are used in the Eo Personal Communicator, has five parts: a CPU, a system controller, a bus controller, a video-display controller, and a peripheral-bus controller.

The price seemed high at $99 for the chip set, but it was complete. Late last year, AT&T introduced two new chip sets designed to broaden the line, with trade-offs in performance, system size, cost, battery life, and feature sets.

The ATT92020S processor provides higher performance—it uses a 6-KB prefetch buffer as opposed to the 3-KB buffer on the 92010—and requires less power than the original 92010 CPU. It also works with all the existing 92010 support chips except for the ISA controller. ISA support doesn't figure very highly in the new Hobbit offerings.

On the other hand, the ATT92020M performs and uses power like the original ATT92010, but it works with a new pair of support chips, a system manager and a video controller, for more integrated performance with a lower chip count. The most highly integrated solution is the ATT92020MX, which needs only a single support chip—a system controller. Both the 92020M and the 92020MX use a multiplexed address and data bus to lower their pin count.

All the members of the Hobbit family operate at 3.3 V. The Hobbit architecture grew out of research by Bell Labs into processor architectures designed to run C programs as quickly as possible. Hobbit processors use high-speed context switching and interrupt response to support the unique needs of PDAs running multiple applications and telecommunications.

Hobbit chip sets are designed to support the advanced communications features that you'll probably come to expect of a PDA. For example, support for AT&T's reprogrammable multimedia DSPs (digital signal processors) is built in, as is support for AT&T's DSP-based 3.3-V V.32lite PCMCIA data pump which, in turn, can support a high-speed fax or modem, two-way paging, or cellular connections.

AT&T is betting that the PDA future will look more like a telephone with a computer in it, and less like a small computer that can also fax and talk. It's a compelling bet, if only because the public is accustomed to small portable telephones and big stationary computers.

AT&T 92K HOBBIT FAMILY PROCESSORS

With the three 92020 processors, AT&T offers a wide range of solutions to PDA OEMs.

	ATT92010 CHIP SET	ATT92020S CHIP SET	ATT92020M CHIP SET	ATT92020MX CHIP SET
Price (quantity 1000)	$99	$152	$111	$76
Architectural enhancements	None	Wait for interrupt, 6-KB prefetch buffer	Wait for interrupt, 6-KB prefetch buffer	Wait for interrupt
Performance	13.5 MIPS	16 VAX MIPS	13.5 VAX MIPS	11.5 VAX MIPS
Performance/power	54 VAX MIPS/watt	76 VAX MIPS/watt	54 VAX MIPS/watt	40 VAX MIPS/watt
Power dissipation	250 mW (typical)	210 mW (typical)	250 mW (typical)	290 mW (typical)
Support controllers	System: 92011 Display: 92014 PCMCIA: 92012 Peripheral: 92013	System: 92011 Display: 92014 PCMCIA: 92012	System: 92021M Display: 92024M	System: 92021MX
Display type	LCD/CRT (21014)[1]	LCD/CRT (21014)[1]	LCD/CRT (92024M)[1]	LCD
Maximum resolution	1024 by 768 (92014)[1]	1024 by 768 (92014)[1]	1024 by 768 (92024M)[1]	640 by 480
Gray levels	8+1 (92014)[1]	8+1 (92014)[1]	16+1 (92024M)[1]	1+1
PCMCIA slots	4 (92012)[1]	4 (92012)[1]	2	1
P-ISA slots	8 (92013)[1]	0	0	0

[1] Support chip that supplies the indicated function

nies have already introduced second-generation versions of their PDA processor offerings.

Advanced RISC Machines, for example, recently introduced the ARM7DM, its second-generation processor for the Apple Newton. The ARM7DM fixes two shortcomings of the ARM610 used in the current Newton MessagePads; it operates at 3.3 V as opposed to 5 V, and it uses a fully static design. Both characteristics are essential in PDA-class processors. Also, AT&T has recently introduced new versions of its Hobbit chips (see the text box "The AT&T Hobbit Enters Its Second Generation").

Another company with a recent PDA chip is AMD, which has preserved DOS compatibility with its Am386SC (see the text box "The Am386SC Does DOS and Windows" on page 104). Whether DOS proves to be a plus or a minus on such systems remains to be seen.

Speculating about the future of these new, highly integrated chips and devices is an irresistible temptation. Recall that the original microprocessor—the Intel 4004—was not designed with personal computers in mind; nobody had ever heard of such things. The microprocessor, conceived as an inexpensive industrial controller, has managed to replace large expensive, centralized computers with something quite different. The small, fast, and inexpensive PDA chip sets may similarly evolve into something—or end up in a machine—unlike anything its creators ever imagined. ■

Paul Statt is a freelance technology writer who has been covering the computer industry for 10 years. You can reach him on the Internet at statt@aol.com or on BIX c/o "editors."

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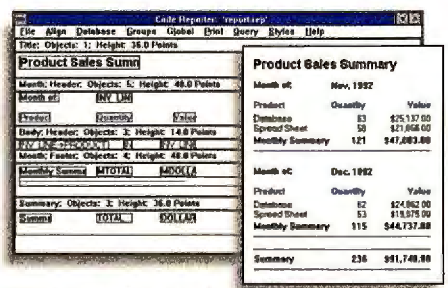

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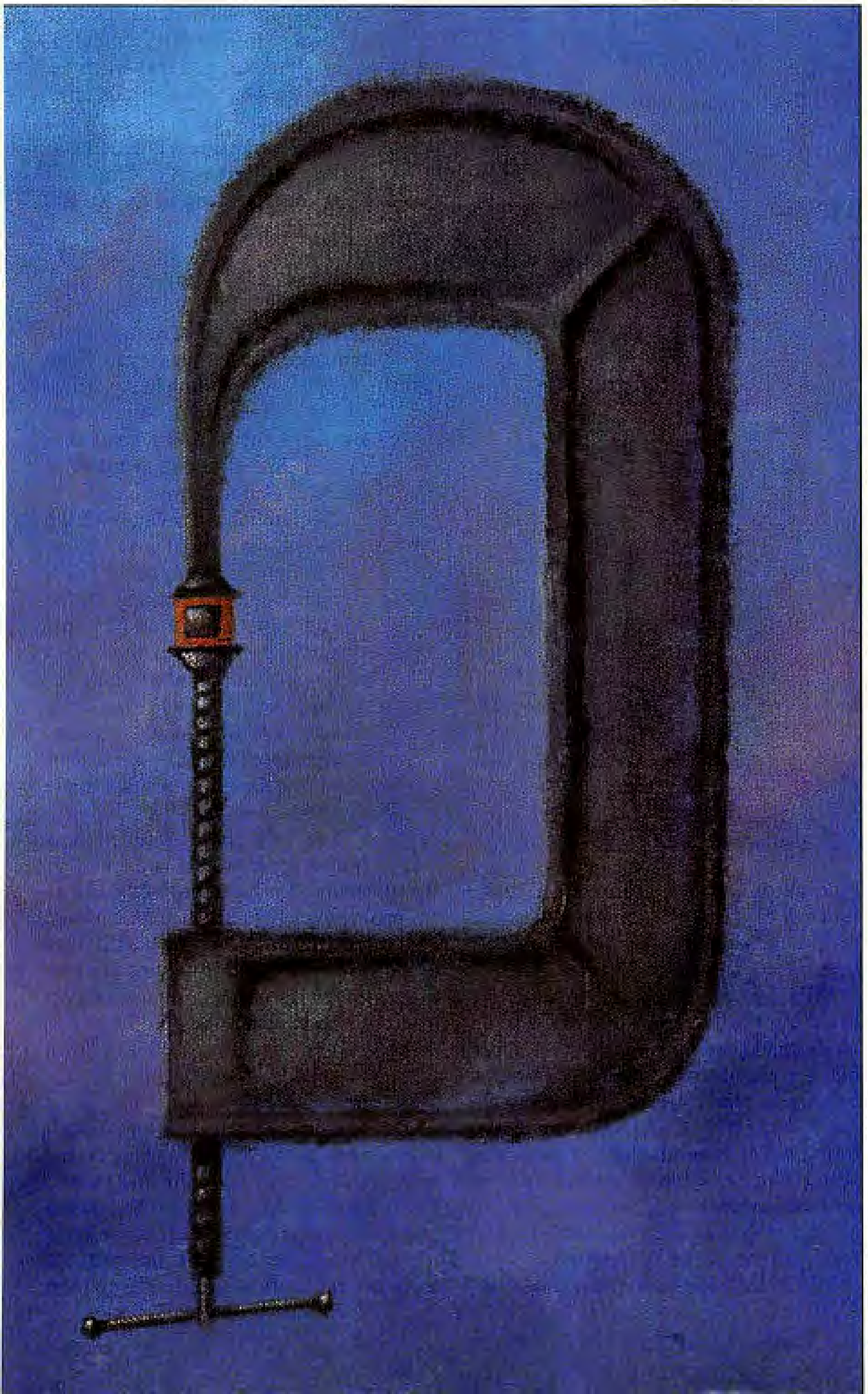
DIGITAL VIDEO GOES REAL-TIME

The VideoRISC Compression Architecture enables real-time MPEG 1 and 2 video encoding and decoding

PETER WAYNER



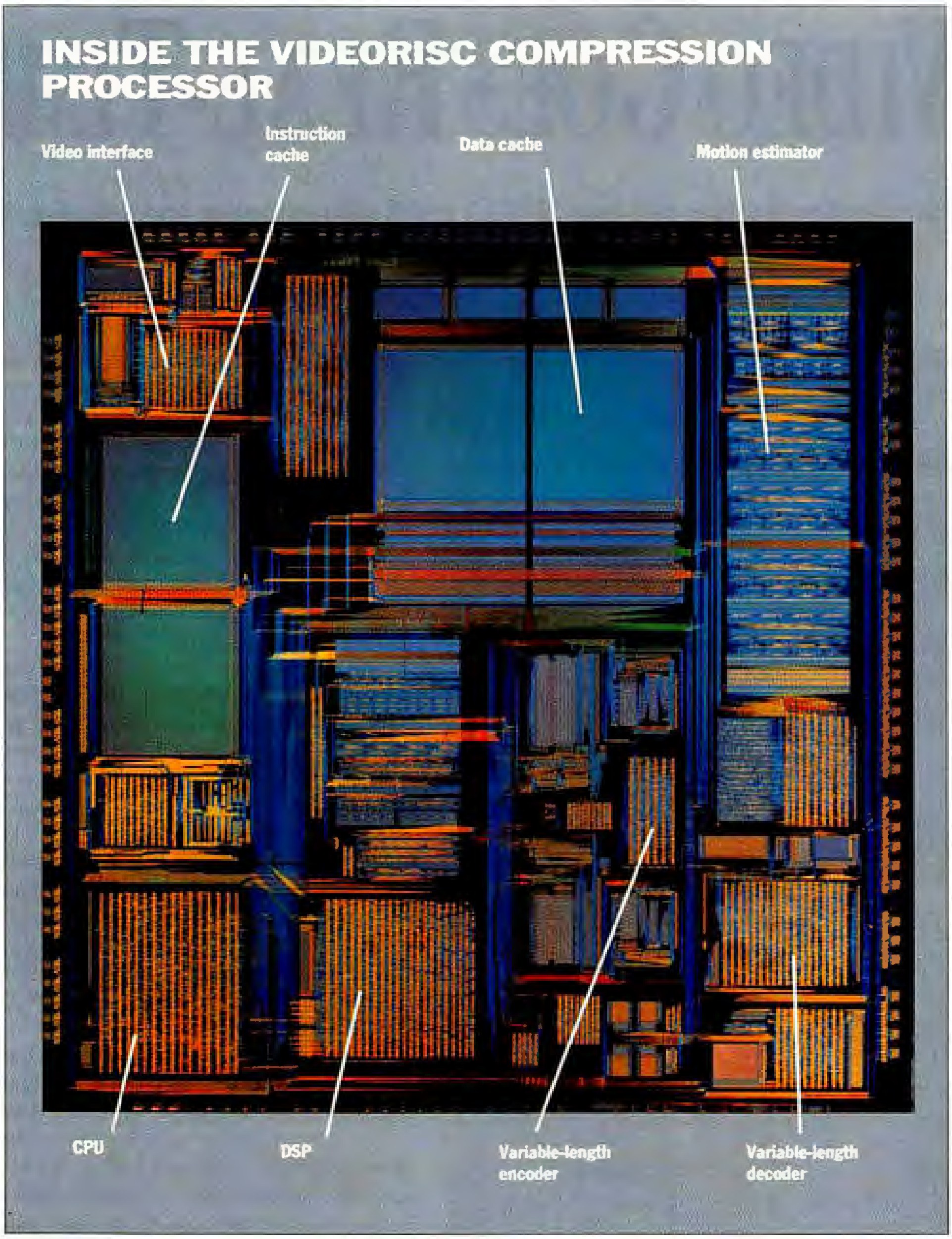
PAUL ZWOLAK © 1994

One of the most challenging feats for any desktop computer is the successful display of digital-video images from sources such as CD-ROM, the airwaves, or a LAN-based video conference. Full-motion video leaves no room for pauses or glaring errors. An operating system may take a few seconds to start up a program or write out a file to disk, but full-motion video needs to hit the screen 30 frames per second, every second.

The newest entry in the mad dash for digital video is a scheme by C-Cube Microsystems (Milpitas, CA) dubbed VideoRISC Compression Architecture. The heart of VideoRISC is the VideoRISC Compression Processor, or VCP. It can compress and decompress video signals fast enough for you to enjoy full-screen, real-time video on your computer. Before, you had to rely on expensive, dedicated hardware for this level of video quality or sacrifice resolution, the number of colors, or the frame rate. Most likely, you'd compromise on all three.

The VCP will allow vendors to scale both the capability and the price of video hardware. For example, it will allow easier implementation of videoconferencing at the high end. At the low end, it will allow CD-ROM drives to display high-quality animations in real time, a feat that their limited bandwidth makes impossible while using uncompressed video. (At 640-by 480-pixel resolution and 24 bits per pixel, you require a bandwidth of over 27 MBps to handle real-time video. Double-speed CD-ROM players deliver 300 KBps.)

But effective video compression has many other applications as well. With VCP, cable companies can fit 50 times as many channels on their digital networks. Satellites can handle 50 times as many signals. The market for other machines, such as boxes that decompress video signals from your cable company, could be substantially larger. Given the potential size of these markets, it is quite possible that the



VCP could become more important than microprocessors such as the 486.

Starting with Standards

The most popular method for compressing video signals is MPEG, a derivation of the popular JPEG standard used to compress and decompress still images. MPEG 1 handles SIF (source input format) resolution signals of 360 by 240 pixels, while MPEG 2 handles broadcast-quality 720- by 480-pixel signals. When linked in parallel, VCPs can encode such signals in real time. It takes two VCPs to encode real-time MPEG 1, eight to encode MPEG 2.

MPEG compresses consecutive frames by making the first frame a reference frame. It then finds the difference between this frame and the rest of the frames and compresses this difference.

MPEG computes the difference by breaking the frame into 8- by 8-pixel blocks and searching for the best match for these pixels in the reference frame. It compresses the difference using a technique called DCT (Discrete Cosine Transform), which is similar to the one used in JPEG. Once computed, the coefficients are then Huffman-coded to produce the final signal that is often one-tenth to one-twentieth the size of the original.

MPEG includes several important functions that are difficult to implement on a general-purpose CPU. When each 8- by 8-pixel block is compared to the reference frame, the best match may not be in the corresponding location, because objects often move across the screen. To get high-compression ratios, MPEG needs to take advantage of this redundant data even though it has moved in relation to the reference frame. It uses a computationally intensive search procedure to find such redundancies. Unlike general-purpose CPUs, the VCP has a special functional unit devoted to this search. It also has a functional unit dedicated to the Huffman coding that forms the last step in the MPEG algorithm.

Chip Basics

At the core of the VCP is a RISC microprocessor that runs a small, embedded operating system. Even though you could run many different jobs on this processor (including most software for basic machines), the structure is tuned to the MPEG algorithms.

The internal architecture of the RISC core is similar in some respects to that of many of the DSPs (digital signal processors) on the market. DSPs are popular for sound processing—which is like video processing, an analog encoding/decoding chore—so the similarity should not be surprising. The Fourier transform that DSPs use to generate reverberation or other sonic novelties is similar to DCT.

The VCP chip can function as both a general CPU and a DSP at the same time. The backbone of the chip is the processing pipeline, which forks where the processing path splits into a RISC half and a DSP half. All instructions are preprocessed in a similar way in the first part of the pipeline. After the split, however, standard arithmetic instructions flow down one fork, while DSP-specific instructions flow down the other.

The four initial stages that process all instructions include Fetch 1, where the instruction is retrieved from the cache; Fetch/Jump, where the fetch is completed and a jump is executed if the instruction is a jump; Read/Decode, where the operands from the registers are retrieved and the instruction is decoded; and Execute, where instruction execution begins.

The simple arithmetic instructions (e.g., addition, subtraction, AND, OR, XOR, and arithmetic shifts) complete in the Execute stage and move to a Writeback stage. The more complicated DSP instructions move from the Execute stage to the DSP fork of the pipeline, which uses three stages to complete the instructions.

The branch of the pipeline used for the complicated instructions is where most of the VCP's power lies. The canonical DSP instruction, the MAC (multiply/accumulator) instruction, is where two numbers are multiplied together and added to an accumulator register. MAC operations are frequently used in signal processing, and DSP designers concentrate on making them as fast as possible. In many cases, the small, tight loops of DSP programs repeat MAC codes many times to find a large sum. The VCP is optimized for these computations.

In addition to optimizing a MAC instruction, the VideoRISC includes many functions not found in general-purpose DSP chips, which are required by the MPEG algorithms. For example, one command computes the spatial frequency of 8 bytes by finding the sum of the squares of the differences between pairs of the bytes. This is an integral part of the DCT. A normal processor would be slowed down because splitting the two 32-bit quantities that the memory systems delivers would probably take the same amount of time as the actual computation.

Another set of instructions averages two different 32-bit quantities in a variety of ways. One instruction will find the average of two 32-bit numbers; another will split the 32-bit words into half-words and find the average of four 16-bit numbers; and a third will average the 8 bytes. All these extra instructions prove to be very useful in computing the DCT.

Although the VCP has many complex computational instructions, it still qualifies as a RISC core because the extra instructions can only access the registers. They can't load information directly from the memory for their operation. This means that a compiler (or the machine-language programmer) can still rearrange the loads and the computations so that there are a minimum of conflicts.

The Motion Estimator

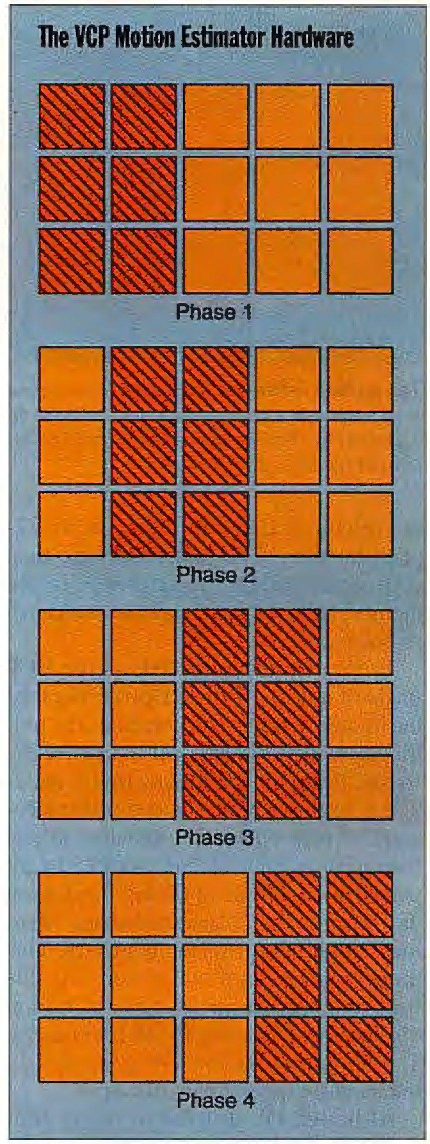
Estimating motion, or changes, from frame to frame is one of the most common bottlenecks in the MPEG compression routines. The algorithm looks for sections of the screen that move from one position to another between frames. This small amount of motion is present whenever a camera pans across a scene or when a person or object moves across the background.

The motion estimator is essentially another processor that runs on its own. Its basic function is to take a rectangle of pixels in one frame of the video and compare it to a reference frame to find the change in horizontal and vertical position that will make the best match. The quality of the match is judged by positioning the rectangle over each possible displacement in the reference frame and summing the differences between the pixels that overlap. If an exact match is found, there will be no difference between the source pixels and the ones in the reference frame, and the sum will be zero.

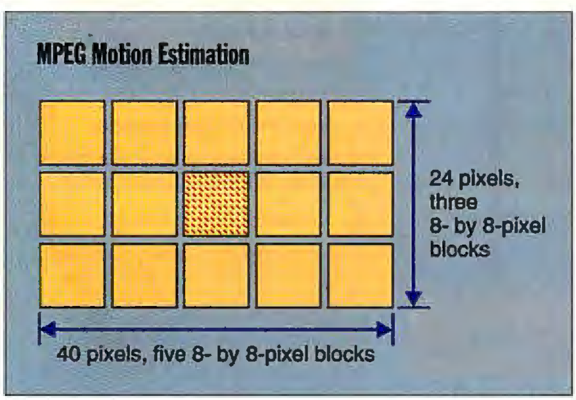
The programmer can set the range of this search procedure to a flexible area of the reference frame. The chip can also calculate the best displacement in half-pixel increments, because it has the ability to interpolate between neighboring frames.

Once the motion estimator receives the coordinates of the two frames and their location in memory, it finds the best displacement estimation. When done, it will raise an interrupt, and the main CPU will be able to get the right solution from the register. The half-pixel interpolation is done in a special part of the motion estimator, not with the averaging functions in the main CPU.

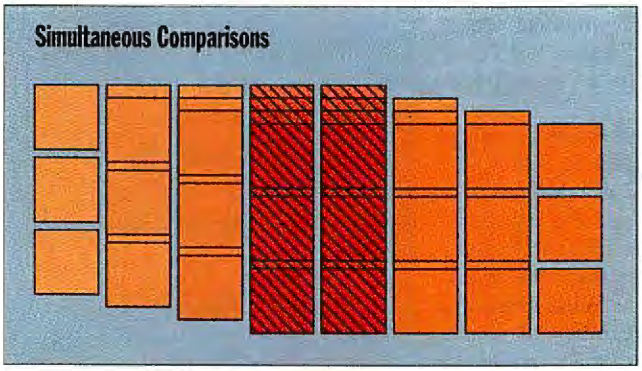
To overcome performance bottlenecks involved in accessing main memory, the motion estimator has its own memory that holds a 16- by 32-pixel subset of the reference frame and a 32- by 8-pixel subset of the frame being compared. The MPEG algorithm itself compares 8- by 8-pixel blocks of data to all possible displacements in a 40- by 24-pixel block of the reference frame. To implement this function, the VCP performs a number of comparisons concurrently. It loads four blocks of the frame being processed into the 32- by 8-pixel memory and eight blocks of



The VCP doesn't store *the entire 40- by 24-pixel block internally because such a large block would slow processing throughput; thus, the hardware compares the blocks in four phases.*



The MPEG algorithm *searches a 40- by 24-pixel block surrounding a single 8- by 8-pixel block to find the best alignment between the reference frame and the current one.*



The motion estimator hardware *lets the same 16- by 24-pixel range be used for phases 1, 2, 3, and 4 of four different 8- by 8-pixel blocks concurrently. This limits the number of times that a piece of an image must be loaded into the motion estimator.*

the reference frame into the 16- by 32-pixel memory. The four blocks are then compared against the reference frame memory, and the best result is stored in a register.

The search then proceeds as the VCP loads in a new 16- by 32-pixel block of the reference frame and compares the four blocks to this block from the reference frame. If any of the blocks find a better match in this region, the better displacement vectors replace the ones currently in the registers. Half of this block (8 by 32 pixels) is a duplicate of the last block from the reference frame, because the best alignment might lie across the boundary. This process is repeated twice more. At this time, the registers hold the best motion displacement estimate for all four blocks. The motion estimator now generates an interrupt for the main processor.

Although the process of doing four searches simultaneously might seem a bit strange, the design optimizes the memory-access strategy. Loading the reference block into on-chip memory makes access fast. This is important, because many parts of the reference block will be compared to all 64 pixels in each 8- by 8-pixel block. Loading four 8- by 8-pixel blocks at once makes sense, because many of these pixels will also be compared against all 64 pixels in each of the four blocks.

How important is the motion estimator? Steve Purcell, C-Cube Fellow and the chief architect of the chip, says that it would take about 2000 MIPS of processing power to duplicate the work done by the motion estimator, roughly the cumulative might of 18 Intel Pentium processors. This is because the chip is able to chain together the work of 32 logical units that are doing part of each comparison in parallel. The computational work is so regular that it is easy to do in parallel.

After motion estimation is complete, the VCP uses special functional units for processing the last layer of encoding. In this layer, the 64 coefficients computed for each frame of the DCT must be compressed one last time by using a variable-length encoding scheme. This method gives common values short vectors and rare values the longer ones. The net effect is that the entire transmission shrinks in size.

The Final Results

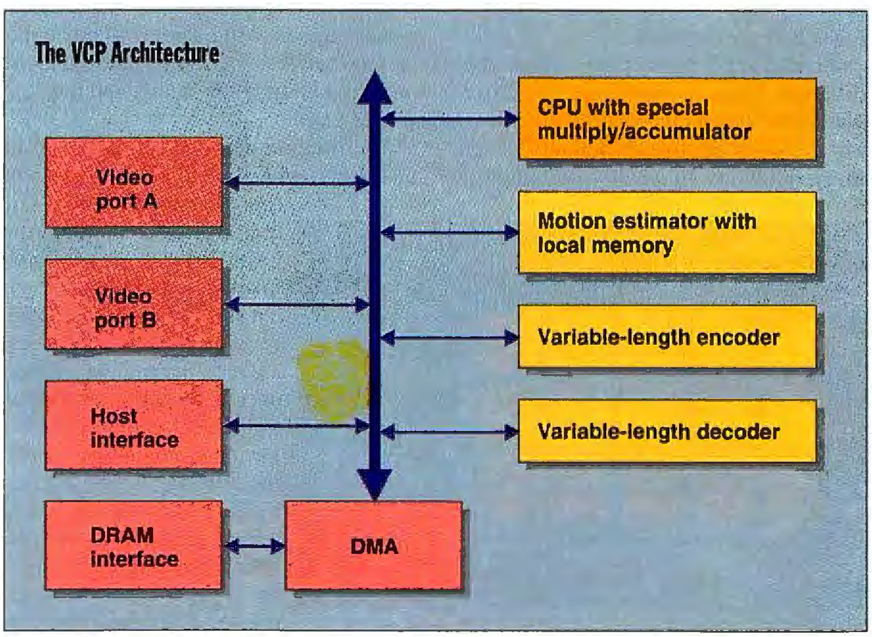
The VCP has two functional units for handling this process, one for compression and the other for decompression. Both act as smart buffers that hold all the incoming and outcoming data until it is needed and then transform it while it is waiting. The incoming buffer, for instance, waits until it has the coefficients for an entire frame before passing them on to the main CPU, which assembles the digitized image.

The main CPU could compute this information. Most of the standard compression programs for PCs will use some form of Huffman encoding from time to time, but it is inefficient to do this 1 bit at a time. Most machines are not successful at writing variable word lengths because they are optimized to load values aligned on word boundaries in standard, 16- or 32-bit sizes. As before, the standard processors are optimized for standard word sizes—not variable bits—and these differences are significant enough to merit the additional functional units.

The Memory Hierarchy

Most processing chips focus their attention on one stream of instructions that must be done in sequential order. In contrast, the work going on in the center of the VCP is more like a three-ring circus: Different functional units on the chip need to access both the main DRAM holding the images and the video I/O streams. The memory hierarchy is tuned to make it easier for the chip to bring information on and off the chip successfully.

Like most general-purpose CPUs, the VCP uses caching to speed up memory access. It uses an instruction cache and a data cache to handle instruction and data flow to the CPU pipeline. The data flowing in and out of the variable-size compressor and decompressor bypasses this cache, because it is unlikely that any of this information will be used again. Putting the cache between these units and



Although the CPU controls the chip, *it is the motion estimator, the memory subsystem, and the variable-length encoders that provide most of the chip's computational power.*

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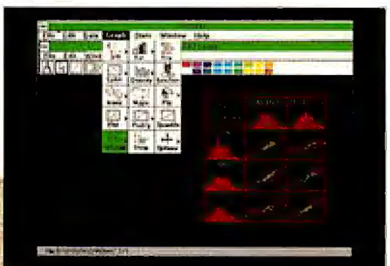

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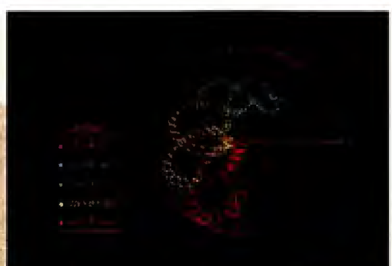

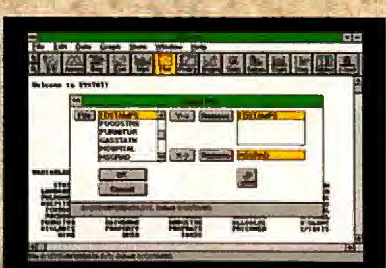

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Splitting off this data stream also allows the cache to be much more efficient. The VCP cache achieves hit rates of nearly 100 percent, because the programmer can anticipate the needs of the program perfectly. In many cases, the programmer can request data almost 100 cycles before it is needed to give the memory system ample time to fulfill the request.

The memory-access circuitry is also flexible enough to access images stored in different formats. For instance, it is common to store a bit map in row-major order, where each 32-bit word contains 4 bytes that are next to each other on the same row. The VCP, however, often converts bit maps into a format that stores 4 bytes from a 2- by 2-byte grid into one 32-bit word. Some of the special CPU instructions for computing statistics such as spatial frequency use this format. The memory circuitry is designed to read and write blocks of data in either format, so it is possible to import data in row-major order, operate on it in 2- by 2-byte block format, and then rewrite it out in row-major order without doing complicated rewriting. The CPU doesn't need to worry about this, because the memory hardware automatically rearranges the bytes.

Toward Tomorrow

In recent years, the relentless speed improvements of general-purpose RISC chips have made many special-purpose hardware implementations obsolete. The high cost of developing hardware with only a limited market could rarely compete with the ease of using RISC chips developed for larger markets. Video compression and decompression, though, require so many complicated instructions that it is often impossible to do the job in real time without a $100,000 machine.

The VCP represents an excellent fusion of specialized hardware and the ability to perform general mathematical functions. The designers deliberately left extra programmability in each of the functional units to match different MPEG implementations. Because MPEG is not completely specified—it is a combination of a set of guidelines and a final format—it is entirely possible that the MPEG compressors from different companies will generate output with different qualities. Everyone is free to implement the encoding algorithms differently. For instance, the VCP lets you limit the motion estimator to 8- by 8-pixel blocks, because many MPEG implementations work at this level.

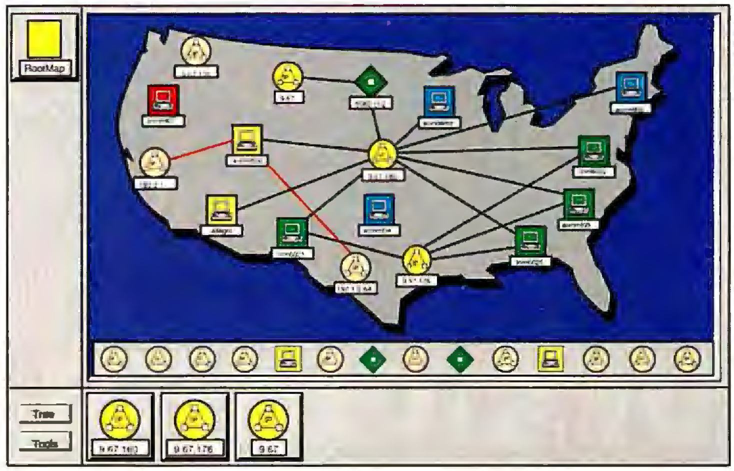
This flexibility is important. For example, it lets some companies use a less complicated compression algorithm that is easier for a general-purpose processor to decompress. The algorithm would still need the power of the VCP and its multiple functional units for compression, but it wouldn't need the VCP for decompression. This lets companies offer video systems at different capabilities and price points. That, in turn, hastens the day when video will become a common data format on your system. ■

Peter Wayner is a BYTE consulting editor. You can reach him on the Internet at pcw@access.digex.com or on BIX as "pwayner."

SPECIAL BYTE REPORT

ADVANCED OPERATING SYSTEMS

A look inside the next generation of computing environments, including IBM's Workplace OS, Microsoft's NT, and software from Novell/USL, Sun, Next, and Taligent



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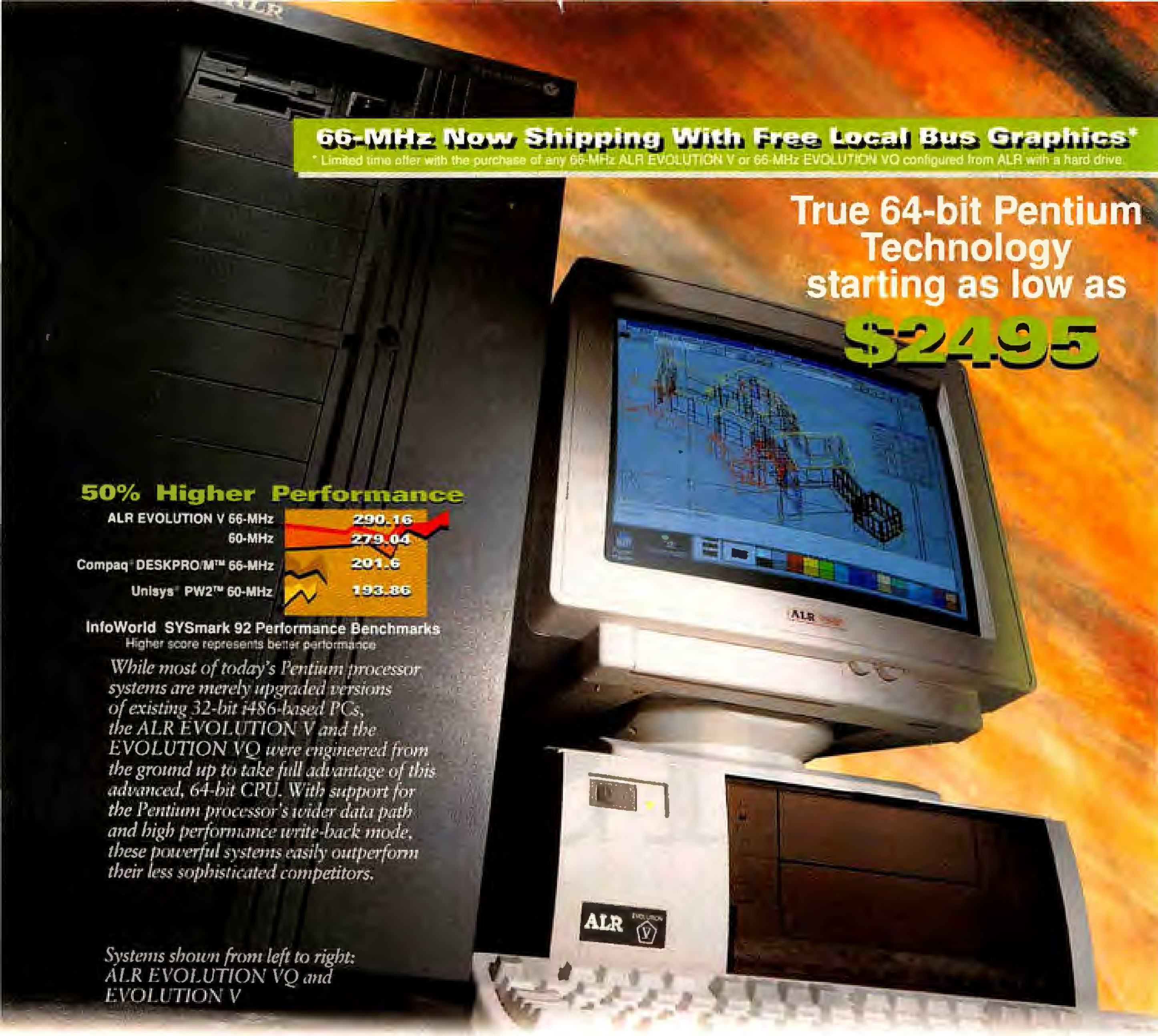

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The Great OS Debate

Since the dawn of microcomputing, users and developers have jousted with one another to defend the honor of their chosen operating systems. The battle still rages; the dust hasn't even begun to settle. New contenders will exploit mainstream RISC workstations built around MIPS, Alpha, and PowerPC processors even as they ride the Intel performance escalator. But the grounds of the operating-system debate are subtly shifting. Microsoft, IBM, USL (Unix Systems Laboratories), Sun Microsystems, and others are rapidly converging on a set of common design themes—microkernels, objects, and personalities. The battle is no longer about whether to layer object-oriented services and emulation subsystems (i.e., personalities) on a small kernel. Everyone's doing that. The question isn't *whether* to build an operating system in this style but *how* to do the job right. **— Jon Udell, Senior Technical Editor**

MICROKERNELS

In Windows NT, layered subsystems communicate by passing messages through a microkernel. But NT doesn't follow the pure microkernel doctrine, which holds that all nonessential services should run in the processor's nonprivileged (user) mode. IBM, USL, and others say that NT's executive, a layer above the NT microkernel that runs security, I/O, and other services in privileged (kernel) mode, compromises NT's claim to be a microkernel-based system. Microsoft, however, notes that NT's privileged-mode executive subsystems communicate with each other and with the kernel by passing messages, just as its user-mode emulation subsystems do.

IBM's Mach-based Workplace OS, meanwhile, will adhere to the pure microkernel doctrine, relegating the pager, the scheduler, the security system, the file systems, and even major parts of its device drivers to user mode. With this approach, says IBM, its microkernel will be especially valuable as a base that OEMs can customize for specific purposes. USL, however, says that its Chorus microkernel, which can run services in kernel mode or user mode, gives the best of both worlds. It can locate services in kernel mode for performance or in user mode for flexibility.

In "Small Kernels Hit It Big," Peter D. Varhol explores these and other issues across a range of microkernel-based systems. And in "The Chorus Microkernel," Dick Pountain takes a close look at the advanced technology chosen by USL as the foundation for future Unixes.

OBJECTS

As applications supporting Microsoft's OLE 2.0 begin to roll out, mainstream users are getting a glimpse of an object-oriented, document-centered style of computing in which applications function as components. Apple, IBM, and partners are countering with OpenDoc, a portable compound-document standard that will bring OLE-like benefits to a broader range of platforms than are supported by OLE. Apple says that OpenDoc's object technology, which relies on IBM's groundbreaking System Object Model, or SOM, offers developers and users the full power of object-oriented programming—including inheritance—while remaining language-neutral. Microsoft says that OLE 2.0's Compound Object Model, which is closely aligned with C++ yet does not support inheritance, will nevertheless yield better results by requiring developers to articulate interfaces precisely and consistently.

On the horizon looms Taligent, an objects-from-the-ground-up system that IBM and Apple say will redefine computing. Meanwhile NextStep, available now on Intel and Motorola platforms, delivers the distributed-object technology that the others are all still talking about. In "Objects on the March," Peter Wayner explores some of the key issues in object and distributed-object computing.

PERSONALITIES

But will it run 1-2-3? For the new breed of operating systems, the answer is almost certainly yes, even on non-Intel hardware, thanks to a hybrid emulation strategy that offsets the inherent inefficiency of pure processor emulation by implementing GUI libraries in native RISC code. Applications lean heavily on GUI libraries nowadays; Windows and Mac libraries are appearing as "personalities" on a variety of new operating systems.

In "Personality Plus," Frank Hayes investigates how Microsoft's Windows NT and IBM's Workplace OS implement personalities. Frank also explores popular third-party solutions like Sun's Wabi (Windows Application Binary Interface), Insignia Solutions' SoftWindows, as well as Quorum Software Systems' Equal.

Small Kernels Hit It Big

PETER D. VARHOL

STEVE LYONS © 1994

A microkernel is a tiny operating-system core that provides the foundation for modular, portable extensions. Every next-generation operating system will have one. However, there's plenty of disagreement about how to organize operating-system services relative to the microkernel. Questions include how to design device drivers to get the best performance while abstracting their functions from the hardware, whether to run nonkernel operations in kernel or user space, and whether to keep existing subsystem code (e.g., a legacy version of Unix) or to throw everything away and start from scratch. IBM, Microsoft, and Novell's Unix Systems Laboratories answer these questions differently; each company has strong opinions about how and why its approach will work best.

It was the Next computer's use of Mach that introduced many of us to the notion of a microkernel. In theory, its small privileged core, surrounded by user-mode services, would deliver unprecedented modularity and flexibility. In practice, that benefit was somewhat obscured by the monolithic BSD 4.3 operating-system server that Next wrapped around Mach. However, Mach did enable Next to supply message-passing and object-oriented services that manifest themselves to the end user as an elegant user interface with graphical support for network setup, system administration, and software development.

Then came Microsoft's Windows NT, which touted not only modularity but also portability as a key benefit of the microkernel approach. NT was built to run on Intel-, Mips-, and Alpha-based systems (and others to follow) configured with one or more processors. Because NT would have to run programs originally written for DOS, Windows, OS/2, and Posix-compliant systems, Microsoft exploited the modularity inherent in the microkernel approach by structuring NT so that it did not architecturally resemble any existing operating system. Instead, NT would support each layered operating system as a separate module or subsystem.

More recently microkernel architectures have been announced by Novell/USL, the Open Software Foundation, IBM, Apple, and others. One prime NT competitor in the microkernel arena is Carnegie Mellon University's Mach 3.0, which both IBM and OSF have undertaken to commercialize. (Next still uses Mach 2.5 as the basis of NextStep, but it is looking closely at Mach 3.0.) Another is Chorus 3.0 from Chorus Systems, which USL has chosen as the foundation of its Unix offering (see "The Chorus Microkernel" on page 131). Sun's SpringOS, an object-oriented successor to Solaris, will use a microkernel, and the Taligent Operating Environment will rely on the same microkernel that IBM is developing for its Workplace OS. Clearly, there's a trend away from monolithic systems and toward the small-kernel approach. That's no surprise to QNX Software Systems and Unisys, two companies that have for years offered successful microkernel-based operating systems. QNX Software's QNX serves the real-time market, and Unisys' CTOS is strong in branch banking. Both systems exploit the modularity enabled by a microkernel foundation with excellent results.

Suddenly microkernels are the central design element of new operating systems. But Microsoft, IBM, USL, and others differ on how best to implement one.

Fueling the current microkernel frenzy is the recent fragmentation of the operating-system market. With no one vendor a clear winner in the operating-system sweepstakes, each needs to be able to support the others' applications. AT&T tried this tack a few years ago with Unix System V release 4.0, by including support for the Berkeley and Xenix extensions. But while SVR4 has done well enough, it hasn't been the grand unification of Unix for which AT&T (now Novell's USL) had hoped. On the other hand, Microsoft's NT seems to have succeeded—at least in this respect—by being the first to unify multiple subsystems capable of running Win32, Win16, DOS, OS/2, and Posix applications. IBM is responding with a portable successor to OS/2, the Workplace OS. Its truly modular operating-system architecture, with plug-and-play components and multiple operating-system personalities, may advance expectations still further.

Defining the Microkernel

A microkernel implements essential core operating-system functions. It's a foundation for less-essential system services and applications. Exactly which system services are nonessential and capable of being relegated to the periphery is a matter of debate among competing microkernel implementers. In general, services that were traditionally integral parts of an operating system—file systems, windowing systems, and security services—are becoming peripheral modules that interact with the kernel and each other.

When I first learned about operating systems, the layered approach used by Unix and its variants was the state of the art in operating-system design. Groups of operating-system functions—the file system, IPC (interprocess communications), and I/O and device management—were divided into layers. Each layer could communicate only with the one directly above or below it. Applications and the operating system itself communicated requests and responses up and down the ladder.

While this structured approach often worked well in practice, today it's increasingly thought of as monolithic because the entire operating system is bound together in the hierarchy of layers. You can't easily rip out one layer and swap in another because the interfaces between layers are many and diffuse. Adding features, or changing existing features, requires an intimate knowledge of the operating system, a lot of time, some luck, and the willingness to accept bugs as a result. As it became clear that operating systems had to last a long time and be able to incorporate new features, the monolithic approach began to show cracks. The initial problems vendors encountered when SVR4 shipped in 1990 illustrate this point.

The microkernel approach replaces the vertical stratification of operating-system functions with a horizontal one. Components above the microkernel communicate directly with one another, although using messages that pass through the microkernel itself. The microkernel plays traffic cop. It validates messages, passes them between components, and grants access to hardware.

This arrangement makes microkernels well suited to distributed computing. When a microkernel receives a message from a process, it may handle it directly or pass the message to another process. Because the microkernel needn't know whether the message comes from a local or remote process, the message-passing scheme offers an elegant foundation for RPCs (remote procedure calls). This flexibility comes at a price, however. Message passing isn't nearly as fast as ordinary function calls, and its optimization is critical to the success of a microkernel-based operating system. For example, NT can, in some cases, replace message ports with higher-bandwidth shared-memory communications channels. While costly in terms of nonswappable kernel memory, this alternative can help make the message-passing model practical.

Portability, Extensibility, and Reliability

With all the processor-specific code isolated into the microkernel, changes needed to run on a new processor are fewer and group logically together. Since the processor market seems more likely to fragment with competing designs than to converge on a single architecture, running an operating system on more than one processor may be the only way to leverage buyers' investment in hardware. Intel is still on top of the microprocessor hill, but IBM/Motorola/Apple, DEC, Mips, and Sparc International, among others, are making determined runs at its dominant position.

Extensibility is also a major goal of modern operating systems. While hardware can become obsolete in a few years, the useful life of most operating systems may be measured in decades. Whether the operating system is small like DOS or large like Unix, it will inevitably need to acquire features not in its design. For example, DOS now supports a disk-based file system, large hard disks, memory management, and—most radically—Windows. Few, if any, of these extensions were envisioned when DOS 1.0 shipped.

Operating-system designers have learned their lesson and now build operating systems that make adding extensions manageable. There's no alternative. With increasingly complex monolithic systems, it becomes difficult, if not impossible, to ensure reliability. The microkernel's limited set of well-defined interfaces enables orderly growth and evolution.

There's also a need to subtract features. More users would flock to Unix or NT if these operating systems didn't require 16 MB of memory and 70 MB or more of hard disk space. *Microkernel* does not necessarily mean *small system.* Layered services, such as file and windowing systems, will add bulk. Of course, not everyone needs C2 security or wants to do distributed computing. If important but market-specific features could be made optional, the base product would appeal to a wider variety of users. Martin McElroy, brand manager for Workplace OS at IBM's Personal Systems Products division, says that IBM's Mach implementation will eventually run the gamut from "palmtops to teraFLOPS." The services riding on the microkernel can be customized to meet the needs of the platform and the market.

The microkernel approach can also help improve the overall quality of the computing environment. Systems like Unix, OSF/1, and NT require hundreds of thousands of lines of code and take years to mature. Programmers who write applications for these systems don't have time to worry about undocumented APIs; they've got their hands full just learning about the hundreds of APIs that are documented. The learning curve for new operating-system calls is becoming so steep that no developer can reasonably expect to know and use them all.

The result is that no one can guarantee the correctness of code making use of several system-service APIs, and no one can guarantee even the correctness of the operating system itself. A small microkernel that offers a compact set of APIs (the OSF microkernel will have about 200, and the tiny QNX microkernel has just 14) improves the chances of producing quality code. This compact API is visible to the systems programmer only; the applications programmer must still wrestle with hundreds of calls. But it certainly enhances the value of microkernels such as IBM's, which the company plans to license to OEMs for customized development.

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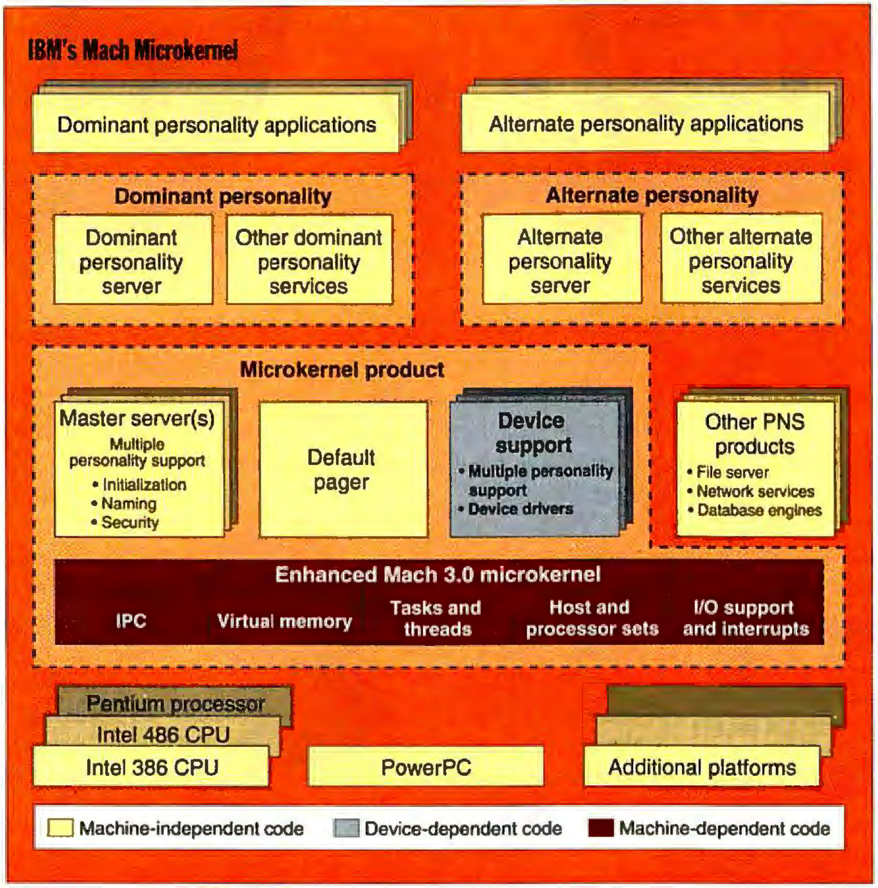

IBM uses the Mach microkernel *as the foundation for personality neutral services and multiple operating-system personalities.*

labor between the microkernel and its surrounding modules is a matter of debate. The general idea is to include only those features that absolutely need to run in supervisor mode and in privileged space. That typically means processor-dependent code (including support for multiple CPUs), some process management functions, interrupt management, and message-passing support.

Many microkernel designers include process scheduling, but IBM's implementation of Mach locates scheduling policy outside the microkernel, using the kernel only for process dispatch. IBM's approach separates policy from implementation, but it requires close collaboration between the external scheduler and the kernel-resident dispatcher.

Device drivers may be in-kernel, out-of-kernel, or somewhere in between. Some implementations (e.g., OSF's) locate device drivers in the microkernel. IBM and Chorus locate the device drivers outside of the microkernel but require that some driver code run in kernel space so that interrupts can be disabled and set. In NT, device drivers and other I/O functions run in kernel space but work with the kernel only to trap and pass interrupts.

IBM's Paul Giangarra, system architect for the Workplace OS, says that separating device drivers from the kernel enables dynamic configuration. But other operating systems (e.g., NetWare and OSF) achieve this effect without abstracting the devices from the kernel. While NT doesn't permit dynamic configuration of device drivers, Lou Perazzoli, project leader for NT development, notes that its layered driver model was designed to support on-the-fly binding and unbinding of drivers. But the necessary support for this feature didn't materialize in the first release of NT.

Dynamic configuration notwithstanding, there are other reasons to treat device drivers as user-mode processes. For example, a database might include its own device driver optimized for a particular style of disk access, but it can't do this if drivers reside within the kernel. This approach also yields portability since device-driver functions can, in many cases, be abstracted away from the hardware.

Mach and the Workplace OS

IBM's forthcoming Workplace OS uses a Mach 3.0 microkernel that IBM has extended (in cooperation with the OSF Research Institute) to support parallel-processing and real-time operations. This implementation counts five sets of features in its core design: IPC, virtual memory support, processes and threads, host and processor sets, and I/O and interrupt support. Giangarra refers to the Workplace OS microkernel as its *hardware abstraction layer* (not to be confused with NT's HAL, which is just the lowest slice of the NT microkernel). The file system, the scheduler, and network and security services appear in a layer above the microkernel. These are examples of what IBM calls *personality neutral services*, or PNSes, because they're available to any of the individual operating-system personalities layered above them.

A key distinction between the IBM PNS layer and NT's own service managers is that IBM's PNS layer runs in user space, while the bulk of NT's services run in kernel space. IBM's approach aims to let OEMs add or replace system services freely; NT's system services are intended to remain in place.

Perhaps the best way to describe the relationship of the kernel to the nonkernel processes is that the kernel understands how the hardware works and makes the hardware operation transparent to the processes that set and enforce operating-system policy. In IBM's case, process and thread management is a kernel function. However, only the process dispatcher actually resides in the kernel. The scheduler, which sets policy by checking priorities and ordering thread dispatching, is an out-of-kernel function.

This is an important distinction. Dispatching a thread to run requires hardware access, so it is logically a kernel function. But which thread is dispatched, Giangarra says, is irrelevant to the kernel. So the out-of-kernel scheduler makes decisions about thread priority and queuing discipline.

The other microkernel implementations don't relegate the scheduler to the periphery. Why would you want them to? In IBM's case, the company plans to license its microkernel to other vendors, who might need to swap the default scheduler for one that supports real-time scheduling or some specialized scheduling policy. NT, which embodies the notion of real-time priorities in its kernel-resident scheduler, does not currently expose these to the programmer. You cannot modify or

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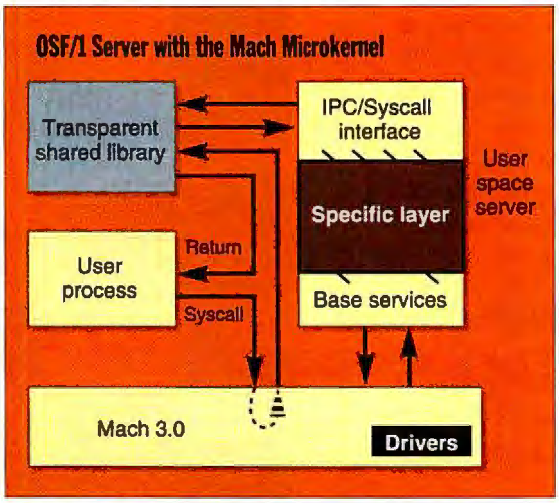
replace the NT scheduler.

Memory management, like scheduling, is divided between the microkernel and a PNS. The kernel itself controls the paging hardware. The pager, operating outside the kernel, determines the page replacement strategy (i.e., it decides which pages to purge from memory to accommodate a page fetched from disk in response to a page fault). Like the scheduler, the pager is a replaceable component. IBM is providing a default pager to boot Workplace OS, but the primary paging mechanism will be integrated with the file system. The Workplace OS file system (like NT's) unifies memory-mapped file I/O, caching, and virtual memory policies.



OSF/1 1.3 runs the OSF/1 *server as a monolithic component on top of the Mach microkernel.*

PNSes can include not only low-level file system and device-driver services but also higher-level networking and even database services. Giangarra believes that locating such application-oriented services close to the microkernel will improve their efficiency by reducing the number of function calls and enabling the service to integrate its own device drivers.

Mach and OSF/1

The OSF, whose OSF/1 1.3 will also incorporate Mach microkernel technology, includes virtually the same microkernel features as does IBM. The code for this version of OSF/1 was frozen in December 1993 and is due to be distributed to OSF licensees in the second quarter of 1994. IBM is a member of the OSF, and the two organizations have been exchanging microkernel technologies. However, OSF's approach differs from IBM's in important ways. OSF/1 was reworked to be able to call Mach for basic system services. Then the entire OSF/1 server system was placed on top of Mach and run in user space. What IBM divides into separate PNSes and layered personalities, OSF lumps into a single structure.

Why the monolithic Unix server riding on top of the microkernel? OSF/1 is mature and proven code, and the OSF says it wasn't feasible to start from scratch. The amount of code reuse between OSF/1 1.3 and the previous version of OSF/1 is over 90 percent. On the other hand, the OSF is also rewriting parts of the Mach kernel in C++, to be able to provide better support for object management.

The net result is that OSF/1 1.3 is less modular than Workplace OS. But by reusing a substantial part of OSF/1, the OSF can ship a more or less complete microkernel-based operating system to its members ahead of the expected debut of the Workplace OS in late 1994. Note that it is precisely this configuration—the OSF/1 server running on Mach—that IBM currently demonstrates as the Unix personality of its Workplace OS.

The OSF's goal is to let the Mach-plus-OSF/1-server combination run efficiently on massively parallel hardware systems. One of the active areas of study in the OSF Research Institute is to configure systems with dozens or hundreds of processors and to observe distributed operating-system behavior as the number of processors grows. The Mach microkernel will run on all processors, but the server—which provides file system, process management, and networking services—need run only on some.

According to Ira Goldstein, vice president of research and advanced development at the OSF Research Institute, future Mach-based versions of OSF/1 will be able to run the OSF/1 server system either in user space or kernel space, depending on the system administrator's choice when configuring the system. Running the OSF/1 server in kernel space will improve performance, because procedure calls will replace message passing, and all server code will remain in memory. Running the server in user space makes it swappable, potentially freeing memory for user programs. Note that USL is planning the same sort of flexibility for its Chorus-based offering. Arthur Sabsevitz, chief scientist at USL, expects the same advantages that NetWare 4.0 developers currently enjoy. Services will be developed and tested in user space. Once debugged and deemed trustworthy, they can move to kernel space for best performance.

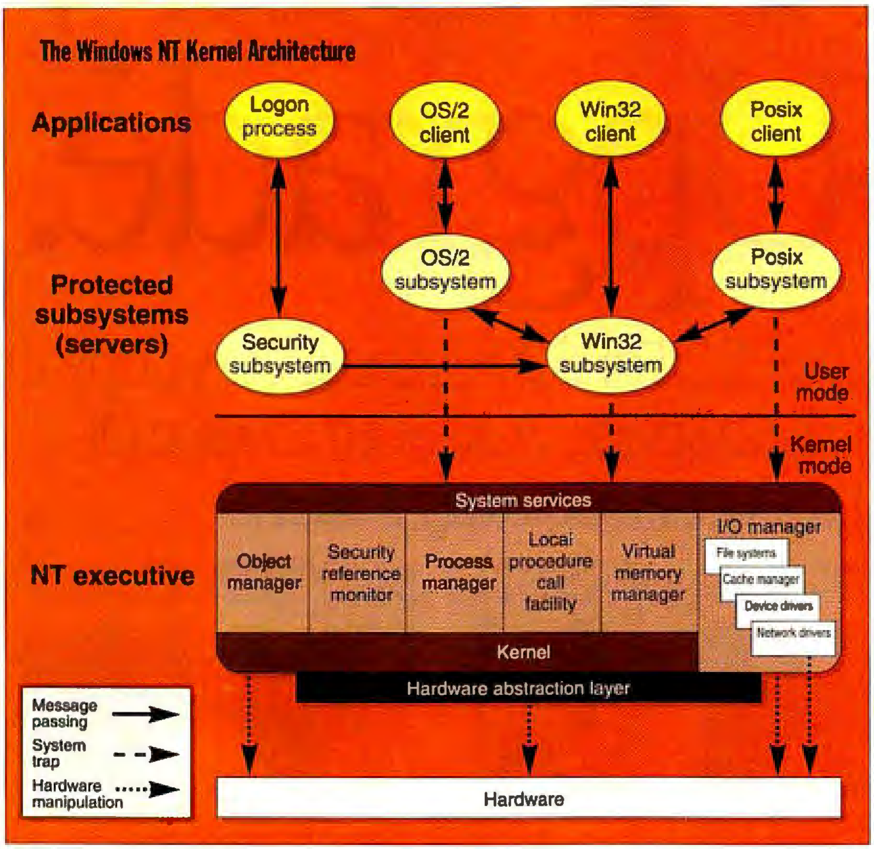
The OSF is still investigating the issue of where to locate device-driver support. Currently, drivers reside within the Mach microkernel. Goldstein says this approach should not preclude dynamic configuration of drivers. Since the OSF is working closely with IBM on microkernel issues, it will look at the IBM approach to device drivers when it receives the technology.

Is NT Really a Microkernel OS?

NT's microkernel serves primarily to support a specific set of user environments on top of a portable base. Its concentration of machine-specific code in the microkernel makes NT relatively easy to port across diverse processors. NT is also extensible, but not in the same way IBM's Workplace OS will be. Whereas IBM wants to license its microkernel separately, it is unlikely that Microsoft will attempt to unbundle NT's microkernel. This is one reason why many observers now conclude that NT is not, in fact, a true microkernel in the same sense that Mach and Chorus are. These critics also note that NT does not rigorously exclude layered services from kernel space (although OSF/1 and Chorus/MiX aren't religious on this point either) and that NT's device drivers cooperate minimally with the kernel, preferring to interact directly with the underlying HAL.

Workplace OS applications talk to user-mode "environment subsystems" that are analogous to the Workplace OS's personalities. Supporting these subsystems are the services provided by the NT executive, which runs in kernel space and does not swap to disk. Executive components include the object manager, the security monitor, the process manager, and the virtual memory manager. The executive, in turn, relies on lower-level services that the NT kernel (or microkernel, if you will) provides. Its services include scheduling threads (the basic level of execution), handling interrupts and exceptions, synchronizing multiple processors, and recovering from system crashes. The kernel runs in privileged mode and is never paged out of memory. It can only be preempted to handle interrupts. The kernel rides on the HAL, which concentrates most hardware-specific code into a single location.

Lou Perazzoli says that NT's design was



Microsoft's Windows NT *separates the device driver from the kernel and runs its operating-system service managers in kernel space.*

driven by strong biases toward performance and networkability, as well as by the requirement to support a specific set of layered personalities. The resulting separation of function between kernel and nonkernel modules reflects these goals. For example, data transfers to the file system and across the network run faster in kernel space, so NT provides in-kernel buffering for the small (16 to 32 KB) reads and writes that typify client/server and distributed applications. Locating these I/O functions in the kernel may violate the academic purity of the NT microkernel, says Perazzoli, but it supports NT's design goals.

Decisions regarding mechanism and policy were motivated by similarly pragmatic concerns. For example, Win32 support did not require a traditional process hierarchy, but other environment subsystems (e.g., OS/2 and Posix) did. The NT executive provides a set of process management services sufficient for the current set of NT personalities, and potentially for others that are similar but not yet supported (e.g., VMS). Radically different alternatives that would require modifying the executive are, however, beyond the scope of NT users.

Because executive components such as the process manager and the virtual memory manager run in kernel space (although they're not technically part of the kernel), some critics say NT is more monolithic than Microsoft likes to admit. However, while these executive-level resource managers do reside in kernel space, they nonetheless function as peers and communicate by passing messages just as the user-level subsystems do.

The NT model is object-based, even though not completely object-oriented. System resources such as processes, threads, and files are allocated and managed as objects; each object type exposes a set of attributes and methods. User-visible resources including windows, menus, and files are also built on object foundation. Because of their status as objects, these resources can be named, protected, and shared. NT distinguishes between kernel- and executive-level objects. Kernel objects have threads, events, interrupts, and queues. Executive objects, which executive resource managers create and manipulate, package the more basic kernel objects—adding, for example, names and security descriptors—and, in turn, pass them to user-mode subsystems.

Interrupts and Device Drivers in NT

Like other microkernels, the NT kernel also handles interrupts and context switching. An interrupt is handled within the kernel and then dispatched to an ISR (interrupt service routine). The kernel uses an interrupt object to associate an interrupt level with an ISR; this arrangement conceptually separates the device drivers from the interrupt hardware. It also leads to a distinction between NT and most other microkernels in terms of the I/O subsystem. In Mach and in Chorus, device drivers reside above the kernel and access the hardware entirely through its services. In NT, the I/O manager, which includes file systems, device drivers, and networking support, generally bypasses the kernel and works directly with the HAL underneath the kernel. Kernel support is still required for interrupt processing, but in other respects, drivers work autonomously.

Perazzoli says there are good reasons to design the device-driver interface this way. For example, IBM found that it could not accomplish all device-driver functions out-of-kernel and had to find a way to let parts of drivers run in kernel space. NT establishes an object-based link to device drivers for interrupt handling and dispatch and then lets the drivers work directly with their associated devices through the HAL.

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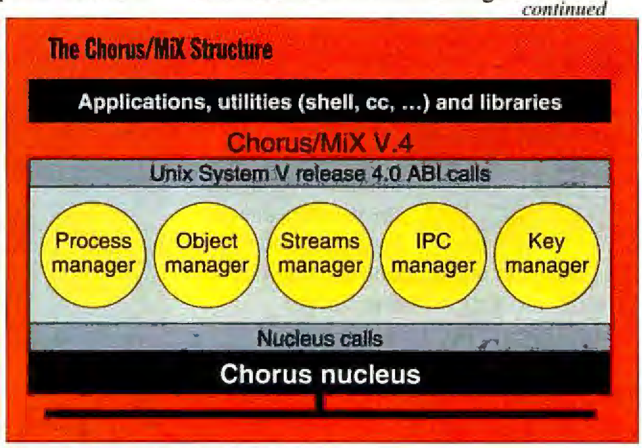

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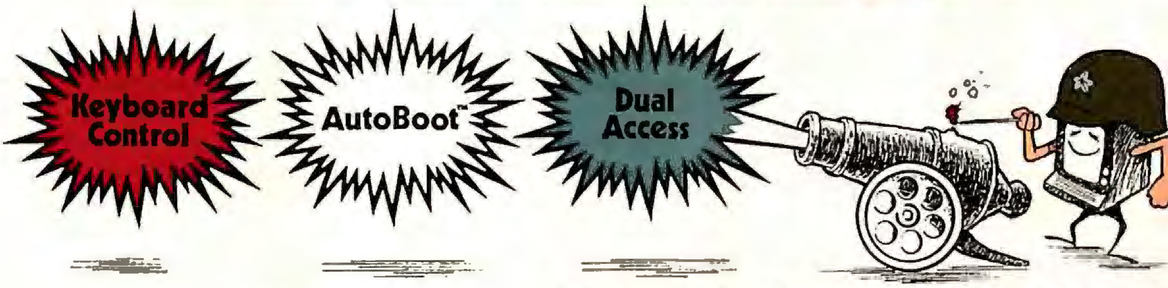

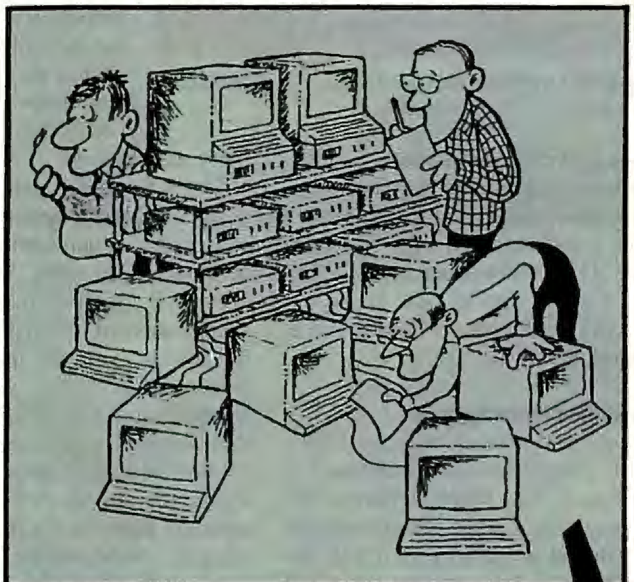

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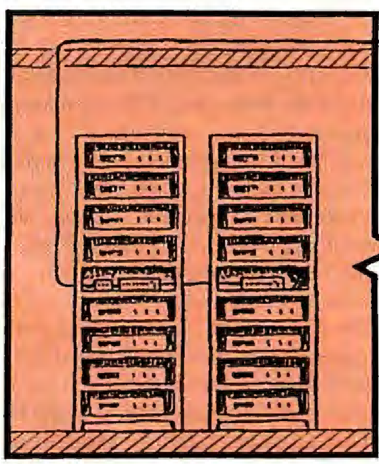

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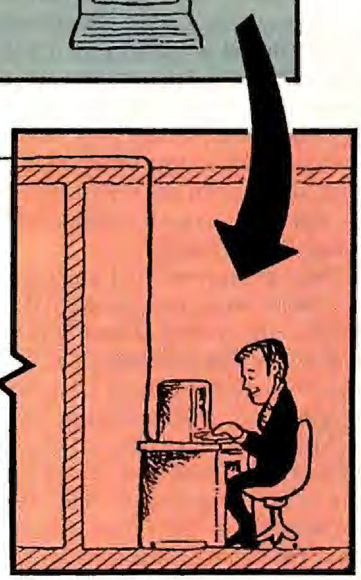

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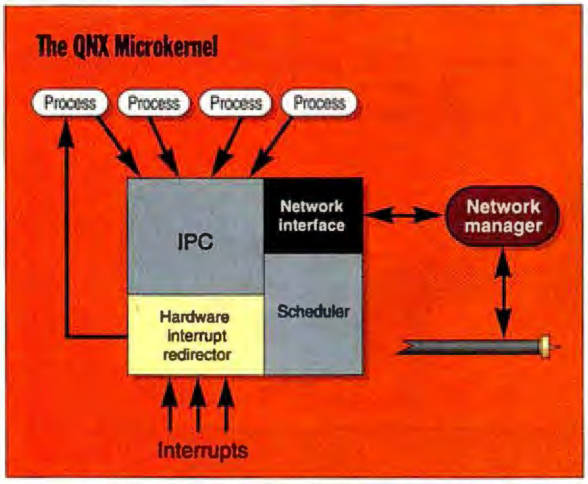

The small QNX microkernel *is designed to be able to easily add service modules for specific uses.*

Nothing prevents applications vendors from writing specialized device drivers, Perazzoli notes, but these must be distinct from the application and must cooperate with the NT I/O subsystem. Is that a limitation? Perhaps not, in view of the impressive I/O performance NT has shown in benchmark tests.

AT&T and the Chorus Nucleus

The Chorus microkernel resembles IBM's and OSF's implementations of Mach in many respects. Like Mach, it takes a minimalist approach. Chorus includes support for distributed processors, multiple distributed operating-system servers (much like the Mach-OSF/1 combination), memory management, and interrupt handling. It can also communicate transparently with other instances of the Chorus microkernel, making it a good foundation for highly distributed systems.

There are several implementations of the Chorus nucleus microkernel. Chorus/MiX, the version of the Chorus operating system with Unix interfaces, includes separate versions for SVR3.2 and SVR4 compatibility. USL will offer the Chorus/MiX V.4 as a microkernel implementation of SVR4. USL and Chorus Systems plan to work together to develop Chorus/MiX V.4 as the future direction of Unix. The figure "The Chorus/MiX Structure" on page 126 shows how Chorus/MiX V.4 is configured on top of the nucleus microkernel. Chorus also supports an SCO-compatible implementation of Chorus/MiX for use specifically on PCs.

The Chorus nucleus does not include device drivers in the kernel. As with IBM's approach, device drivers work through the kernel to access hardware. According to Michel Gien, general manager and director of R&D for Chorus, this enables a higher-level component called the device manager to keep track of drivers dispersed throughout distributed systems.

On the Drawing Board

Sun, Apple, and Taligent are also moving toward a microkernel-based operating-system architecture for their respective platforms. None of these companies was willing to discuss its plans in any great detail, but all acknowledge that microkernel technology is a crucial ingredient of operating-system design.

Sun's SpringOS, which is still in the design and implementation phase, is incorporating a microkernel and making use of object extensions. While details are sketchy, it appears that SpringOS will use a large amount of existing Solaris code, much in the same way that OSF/1 uses the existing OSF/1 server. Sun has not yet announced support for any of the independent microkernels, and it may be developing its own. Still less is known of Apple's and Taligent's efforts. Although Apple will have the rights to use the Taligent Operating Environment, the company is also rumored to be developing a microkernel for the Mac System 7.

Microkernels Here and Now

QNX and CTOS are two mature microkernel operating systems that have been shipping for years. The 8-KB QNX microkernel handles only process scheduling and dispatch, IPC, interrupt handling, and low-level network services. It exports just 14 kernel calls. The compact kernel can fit entirely in the internal cache of some processors, such as the Intel 486.

A minimal QNX system can be built by adding a process manager, which creates and manages processes and process memory. To make a QNX system usable outside of an embedded or diskless system, add a file system and device manager. These managers run outside of kernel space, so the kernel remains small. QNX Software claims that this message-passing system has performance at least comparable to that of other traditional operating systems.

CTOS, introduced in 1980, was written for Convergent Technologies workstations, a family of Intel-based machines built to run in "cluster networks" linked by ordinary telephone wire. Now sold by Unisys, these CTOS-based machines were demonstrating the benefits of message-based distributed computing long before the term became fashionable. The tiny 4-KB CTOS microkernel concerns itself only with process scheduling and dispatch and message-based IPC. All other system services communicate with the microkernel and with each other through well-defined message interfaces.

Networking is integral to CTOS workstations and effectively transparent to applications, which do not need to know whether a request for service will be handled locally or remotely. The same message-based IPC transmits the request in either case. Building modular system services to service such requests is straightforward. One practical result has been that CTOS applications running unattended in remote branch offices are easily controlled by central management tools.

The Microkernel Advantage

If you're charting the enterprise computing strategy for your organization, you've got to be excited about the trend toward microkernel-based operating systems. Increasingly, you will be able to match kernel-independent networking, security, database, and other services to your available hardware, and customize systems for individual user's needs.

Of course, end users don't care much about how operating systems work, they just want to run the applications that enable them to do their jobs. Will microkernels influence end-user computing? You bet. By abstracting application-level interfaces away from underlying operating systems, microkernels help ensure that an investment in applications will last for years to come, even as operating systems and processors come and go.

The full benefits of microkernels won't be apparent for years. It will take that long to field the operating systems and for useful add-on modules to appear. Some benefits (e.g., quality and robustness) may never be directly apparent to users. However, it's clear that microkernels are here to stay. ■

Peter D. Varhol is an assistant professor of Computer Science and Mathematics at Rivier College in New Hampshire. He can be reached on the Internet or BIX at pvarhol@bix.com.

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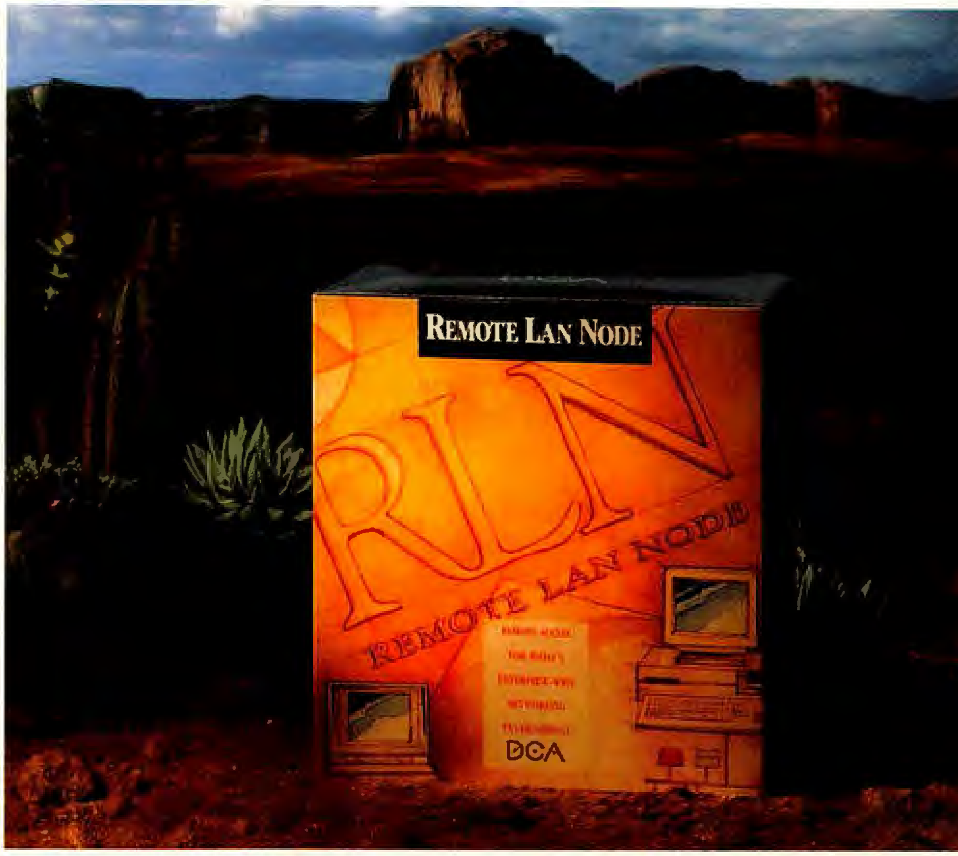

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The Chorus Microkernel

Amid all the hype about microkernel-based operating systems, don't overlook Chorus/MiX, a commercially proven Unix variant from France that offers a number of enhanced features

DICK POUNTAIN

Life has never been tougher for operating-system designers. Any operating system that aspires to cope with all the directions computing will take in the coming decade needs to fulfill a formidable wish list—multitasking, networking, fault tolerance, symmetric multiprocessing, and massive parallelism—while maintaining binary compatibility with industry-standard software across heterogeneous distributed platforms. Oh, and would it also support object orientation, please? As daunting as all this sounds, however, there's an existing, commercially proven operating system that supports all these features. It's made in France, and it's called Chorus/MiX.

Chorus/MiX is a microkernel-based, distributed Unix operating system that grew out of research into packet-switched networks in the late 1970s at INRIA (Institut National de Récherche en Informatique et Automatique), a government-funded laboratory in suburban Paris. In 13 years of development, Chorus has passed through four major versions and has absorbed key concepts from all the most important academic research projects in the distributed-systems field. Message passing was influenced by Stanford University's System V, threads and distributed virtual memory by Carnegie Mellon University's Mach, and network addressing by Amsterdam University's Amoeba.

In 1982, version 0 of Chorus established the basic principle of a small distributed kernel (called the *nucleus*) that directly supports IPC (interprocess communications). By 1986 the Chorus team had spun off from INRIA into a new company, Chorus Systèmes (now Chorus Systems), to exploit Chorus in the commercial arena. The current product, Chorus/MiX, is based on version 3 of the Chorus nucleus. It presents a standard, 100 percent binary-compatible Unix System V release 3.2 or SVR4 interface with added real-time and multithreading features.

Chorus has met with considerable success in its home country; communications giant Alcatel, France's equivalent to AT&T, has just adopted it as the standard operating system for all its future PBX equipment. More recently, Chorus has started to attract attention in the U.S., announcing deals with Unisys, Tandem, Cray Research, The Santa Cruz Operation, and Unix Systems Laboratories. It is available for a wide range of hardware, from the Intel 80x86 family to the Inmos Transputer, and Motorola has recently announced the development of a RISC chip in the PowerPC family that will have the Chorus nucleus "on-chip" for embedded applications.

Chorus Basics

Chorus systems are built on a tiny nucleus (typically only 50 to 60 KB in size) that handles scheduling, memory management, real-time events, and communications. Everything else in the operating system is a *server* that sits on top of the nucleus and communicates with it by passing messages. File managers, stream and socket managers, and even device drivers are all treated as servers; a group of such servers is called a *subsystem*. In the case of Chorus/MiX, the complete Unix V implementation is such a subsystem (see the figure "Chorus Nucleus with Layered Unix Services").

This extreme modularity confers many important advantages. For example, in the Unix subsystem, only those servers that are actually being used need to be loaded into memory. The ease of substituting one modular server for another simplifies the implementation of fault tolerance and redundant backup.

The system-level communications abilities allow easy distribution of the operating system by running a separate nucleus on each processor. Combining these abilities lets you build distributed fault-tolerant systems that can reconfigure themselves dynamically.

The ability to support conventional operating systems as subsystems means you could develop multiple "personalities"—say OS/2, Unix, and Windows—and have them interwork transparently via the common underlying commu-


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nications layer. IBM appears to be basing its future operating-system strategy on a similar idea, implementing it on the Mach 3.0 microkernel rather than on Chorus.

Perhaps more important than these advantages is the fact that the modular Chorus system can remain comprehensible and maintainable even as it grows very complex. You can write, test, and debug servers on a running system in piecemeal fashion. In contrast, monolithic operating systems that grow by adding on extra layers tend to reach a crucial complexity barrier beyond which they become very difficult to manage.

The Chorus Nucleus

The IPC manager in the Chorus nucleus (see the text box

"Inside the Nucleus" below) delivers messages between *actors* on the same *site*, but a network manager external to the nucleus is responsible for keeping track of *ports* throughout the system and for the dirty business of network communications. (For definitions of these terms, see the text box "A Chorus Lexicon" on page 136.)

At present, the network manager supports both OSI and Internet protocols. In addition, it acts as a communications server for those special actors that need to access network services directly; for all other actors, IPC is network transparent.

As well as being compact, the Chorus nucleus is also highly portable to different CPU architectures, because only the supervisor and part of the memory manager are hardware dependent. Indeed, this isolation of hardware dependencies is perhaps the strongest commercial rationale for adopting a microkernel approach. Similar reasoning lies behind the HAL (hardware abstraction layer) in Windows NT, which so far supports Intel, Mips, and DEC Alpha processors.

Messages and Efficiency

The choice of a message-passing rather than a shared-memory paradigm for IPC in Chorus is the key to its elegant ease of distribution, particularly in heterogeneous environments where shared memory can be a nightmare to implement. However, message passing has a reputation for being less efficient than shared memory, and since every server in a Chorus subsystem such as Unix ultimately relies on IPC to communicate with other servers, any message-passing overhead will have a serious impact on overall system performance.

Accordingly, Chorus's designers have made great efforts to optimize the IPC system. Chorus messages use a very simple format—just untyped strings of contiguous bytes—and the IPC manager implements no flow control or security checks. System builders add these facilities at the subsystem level using the raw services provided by the nucleus, so that their overhead is incurred only where necessary.

The RPC (remote procedure call) mode of communication employs optimizing algorithms (or *lightweight RPC*) that exploit any locality of client and server. For example, when both client and server threads are executing on the same site, the IPC manager instructs the memory manager to move the message data by simply remapping addresses, without any actual copying. When copying between sites does occur, a copy-on-write scheme ensures that data is transferred only as needed. Given a host processor that provides on-chip communications, such as the Inmos T9000 Transputer, the Chorus IPC service can be mapped directly onto the hardware. The French firm Archipel has done this for its Volvox range of massively parallel supercomputers.

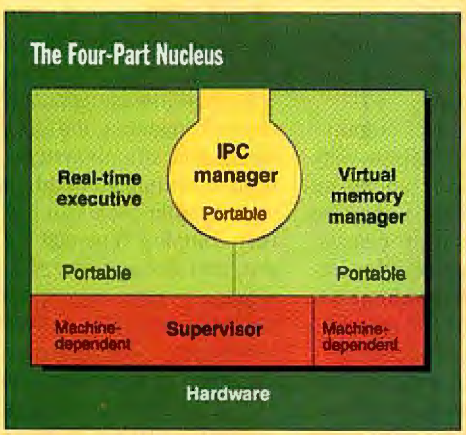
The nucleus's supervisor has also been subject to extensive optimization, both to improve performance and to achieve 100 percent binary compatibility for the Unix subsystem. Version 2 of Chorus employed a pure message-passing interface to Unix and required that all device drivers be part of the nucleus executing in privileged mode. All Chorus/Unix processes had to contain user-level *stubs* to convert system calls into messages; this altered the memory map and spoiled Unix binary compatibility.

Version 3 of Chorus, therefore, introduced a new class of entities, called *supervisor actors*, that execute in the supervisor's address space in privileged mode but are still

INSIDE THE NUCLEUS

The Chorus nucleus is divided into four functional parts:

The multitasking real-time executive allocates local processors and schedules threads using a priority-based preemptive scheme (or, optionally, by time slicing). The executive's programming interface provides primitives for thread creation and destruction, as well as synchronization via semaphores, spin locks, mutexes, or condition variables. Here, as elsewhere, the Chorus philosophy is to provide a variety of efficient but low-level mechanisms, leaving the choice of performance trade-offs to the (sub)system builder.



The real-time executive and the IPC manager are fully portable. The supervisor, like NT's HAL (hardware abstraction layer), is fully machine-dependent. The memory manager is partly portable, partly machine-dependent.

The memory manager supports distributed virtual memory. The basic unit of stored data is a *segment* that normally exists on some form of backing store. The virtual address space of an actor is divided into contiguous regions that map a portion of a segment into physical memory. System actors called *mappers* manage segments, maintaining the coherency of distributed shared memory when different threads access the same segment concurrently.

The supervisor dispatches interrupts, exceptions, and traps to dynamically defined device drivers and other real-time event handlers at run time. Its response time is fast enough for Chorus to be applied in real-time control systems.

The IPC (interprocess communications) manager delivers messages between ports throughout the system. Two communications modes are supported: a simple, nonblocking, asynchronous send/receive protocol in which messages are not acknowledged, and an RPC (remote procedure call) with full client-server semantics.

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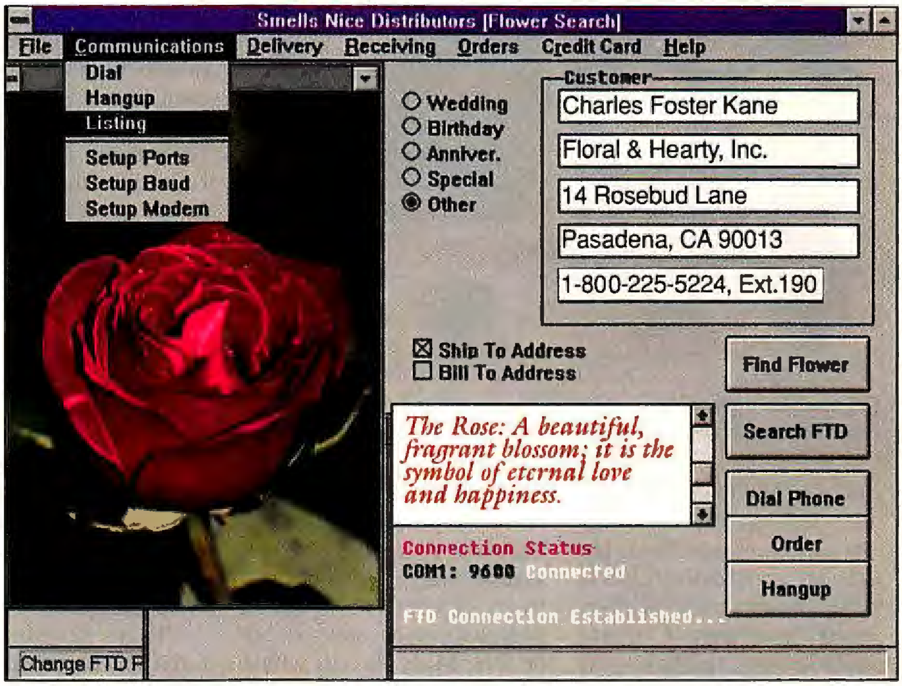

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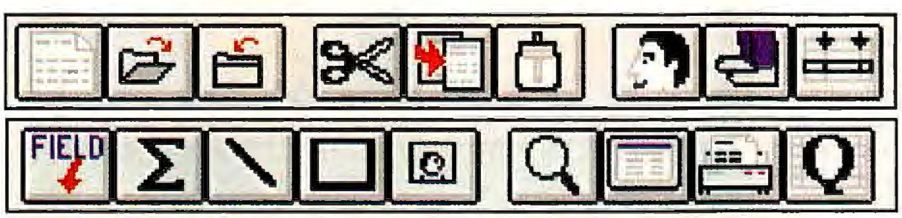

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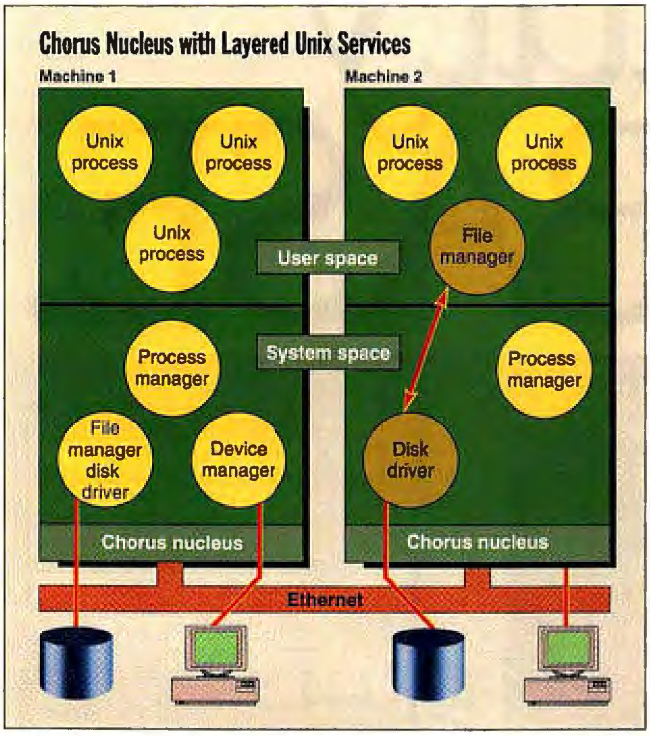


The modular approach *simplifies implementation of fault-tolerant systems that can reconfigure themselves dynamically. (Figure courtesy of Chorus Systèmes)*

compiled and loaded as separate modules. Supervisor actors, alone among Chorus objects, are granted direct access to the hardware event facilities, and they can install threads (called *connected handlers*) that are called directly by nucleus code, like parameterized subroutines, and then return control to the nucleus.

Connected handlers provide a conventional system-trap (rather than message-passing) interface to the nucleus, thus restoring Unix binary compatibility. Their judicious use greatly reduces interrupt response time and enables device drivers to be implemented entirely outside the nucleus. You don't need to modify the nucleus to accommodate new device types, and drivers can be dynamically loaded and destroyed with no loss of interrupt response. While Chorus adheres to its elegant theoretical principles for the most part, it is pragmatic enough to relax them when performance requires it.

Ports and Port Groups

A Chorus port represents both a resource (i.e., a queue of messages waiting to be consumed by one or more threads) and an address to which messages can be sent. Many threads within an actor can use the same port, so you can improve the performance on a multiprocessor machine, transparently to the existing clients, by adding more processors. Ports can also be dynamically migrated to a succession of different actors, which provides the basis for Chorus's run-time reconfiguration abilities.

Chorus can assemble a number of ports into a named port group, which introduces an extra level of indirection into communications. Messages sent to a port group are "multicast" to all its members; since the membership of the group can change over time, this provides a powerful mechanism for the dynamic binding of messages. Before examining groups further, I need to explain a little about naming objects in Chorus.

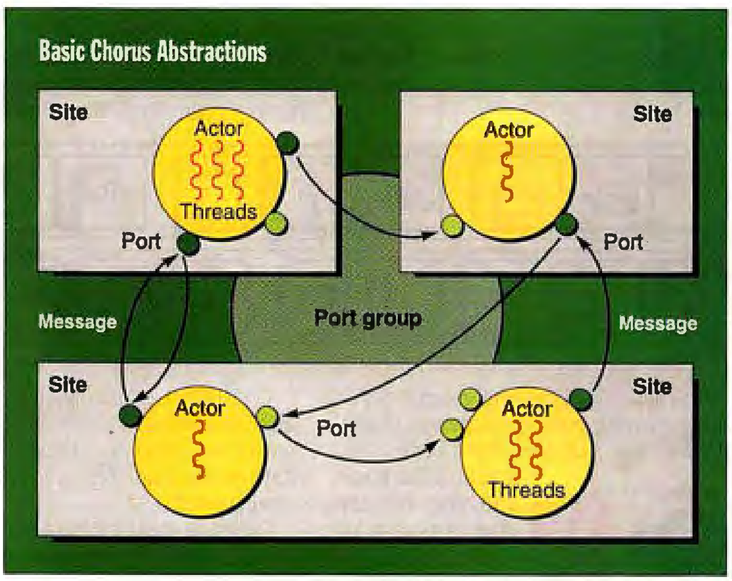
Chorus employs a single, global name space with names that are usable at any level, from nucleus to application. This contrasts with systems such as the DNS (Domain Name System) servers used under TCP/IP on the Internet, in which names are local to each site and a central name server routes messages. Chorus's name management is fully distributed, which removes a potential point of failure in the name server and makes it easier to achieve high-reliability systems.

Chorus generates names called UIs (unique identifiers) for all actors, virtual memory segments, and IPC addresses (i.e., ports and port groups), in such a way that the UIs are unique in both time and space; no two objects in a distributed Chorus system will ever use the same UI for as long as the life of the system.

UIs are 128-bit quantities formed by concatenating a site number, which records the birthplace of the object, with a "stamp" chosen from a very large, sparse random-number space. If you need to build a gateway from one distributed Chorus system to another, you can preface each system's UIs with an extra domain name identifying the system.

Chorus supplies the raw means for protecting names, although the actual protection policies must be implemented in subsystems. Objects created by external servers (e.g., segments) rather than by the nucleus are named by global *capabilities* constructed by combining the UI of a port of the server that manages the object with a 64-bit key that holds access control information. Protection in Chorus can be summed up by the following three rules:

1. Only possession of a port gives the right to receive on it. Ports cannot be shared between actors.
2. Only knowledge of the name of a port or port group gives the right to transmit to it. The knowledge of names is protected against forgery by the



Threads and messages *work much as you'd expect if you're familiar with Mach or Windows NT, and you won't go far wrong if you think of actors as the Mach or NT equivalents of processes. Port groups introduce a multicast capability that's a powerful mechanism for dynamic binding of messages.*

A Chorus Lexicon

Actor. The equivalent of a Unix process; it provides an execution context for one or more threads. An actor is the unit of distribution in Chorus, the smallest software entity that can be allocated to a site. It is not the smallest unit that can be allocated to an individual processor, however; Chorus can allocate the individual threads within an actor to different processors on a multiprocessor site, so that Chorus supports tightly coupled parallel computers as well as loosely coupled networked computers.

Ports. Queues attached to actors by which threads of one actor send messages to threads of another. Sending messages via ports rather than directly to the other thread decouples communication from execution, so communication in Chorus becomes transparent with respect to distribution; one thread need not know where another is executing in order to communicate with it. A thread can only ever belong to one actor, but a port can migrate from one actor to another, redirecting all messages to the new actor.

Site. The basic unit of computing hardware under Chorus, consisting of one or more processors and some memory and I/O devices. It might be a whole computer or just a board in a rack. Each site runs one nucleus.

Thread. The unit of execution in Chorus. It has the same meaning (i.e., a lightweight process) as it does in Windows NT and OS/2. Unlike a heavyweight Unix process, a thread does not need a private address space but only its own stack, and many threads can share the same address space. Under Chorus, that address space belongs to an actor.

sparse and random nature of name generation.
3. Only knowledge of the key of a port group gives the right to update it (i.e., to insert or remove ports).

The Chorus IPC system also supports authentication, issuing to every new actor and port a protection identifier that cannot be altered except by a special superuser. Every message is stamped with the identifiers of its sender actor and port. The receiver can read, but not modify, this stamp and apply its own authentication policies (e.g., traditional Unix file permissions).

The UI of a port group names all the ports in the group so that when a thread sends a message to that UI, the message will be received by every port in the group. A newly created port group is just an empty UI, into which ports can be inserted and removed dynamically. A port can belong to more than one group at the same time.

This group concept is very important to Chorus, because the group UI provides a single stable name for what might be a changing group of entities. In effect, a group UI names a system service rather than the actual servers that provide the service.

Groups permit a degree of immortality, because they persist even after the ports they contain have terminated. This property allows failed servers to be dynamically replaced (i.e., *hot reconfiguration*) without disrupting any transactions in progress.

Take, for example, a RAID-style file server built from a bank of drives. Each drive's server will have one or more ports by which actors elsewhere in the system can exchange data with it. If these ports are all inserted into a single group and remote threads send messages to the group rather than to the individual ports, you can replace a failed drive with a backup unit, and programs that are running will never notice any difference.

Objects Are COOL

With Unix pretty well tamed, Chorus Systems has turned its attention to object orientation. COOL (Chorus Object-Oriented Layer) is an ongoing research project, now into its second iteration, being carried out with INRIA and two European Esprit projects. COOL-2 defines three layers that sit on top of the Chorus nucleus.

COOL-base, the first layer, encapsulates the Chorus nucleus to present a new object-oriented microkernel with a system-call interface. COOL-base deals with abstractions called *clusters*, which are simply collections of virtual memory regions mapped into an address space. From a higher-level viewpoint, clusters are the places where objects exist. The COOL-base layer manages clusters, mapping them into multiple address spaces to produce distributed cluster spaces. Clusters are the units of persistence and are subject to garbage collection.

On top of COOL-base lies the GRT (generic run-time) layer, which provides support for finer-grained objects within clusters. In particular, the GRT provides for object execution, virtual object memory, a single-level persistent object store similar in concept to that used in Apple's Newton architecture, interobject communications based on nucleus RPC, and a protection subsystem to enforce protection of objects during application execution.

The final layer is the language-specific run-time layer, which maps the object model of particular programming languages, such as C++ or Smalltalk, onto the GRT's abstractions. This layer uses preprocessors to generate an upcall table for every type of object created at the GRT level, through which the GRT can call to obtain language-specific information about the semantics of certain operations. For example, it could find out how to convert in-memory object pointers to persistent pointers for storage, or how to handle method dispatch. This mechanism will enable COOL to support many different OOP (object-oriented programming) languages with reasonable efficiency.

The toughest outstanding problem in COOL right now is how to group objects that invoke one another into the same cluster, so as to maximize efficiency. Current versions do this statically, scanning the source code for object interactions, but the long-term plan is to investigate dynamic clustering based on the run-time execution patterns of objects.

When COOL makes it to product status, then Chorus, alone among current operating systems, will be able to claim that it can handle every item on that wish list at the beginning of this article. It's beginning to look as though Taligent (the IBM/Apple joint venture) and Microsoft may be busy reinventing wheels that they could have bought on a shopping trip to Paris. ■

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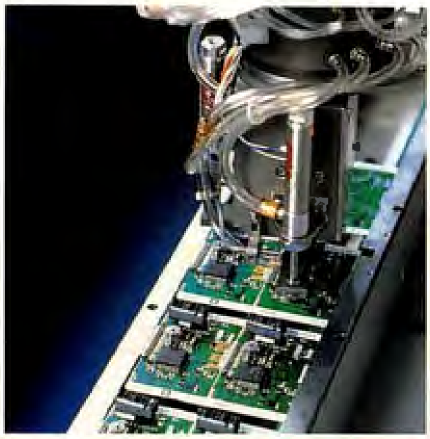




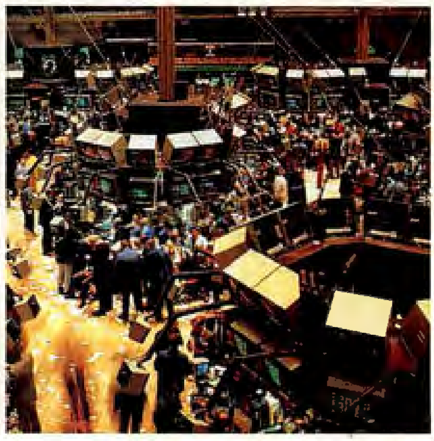


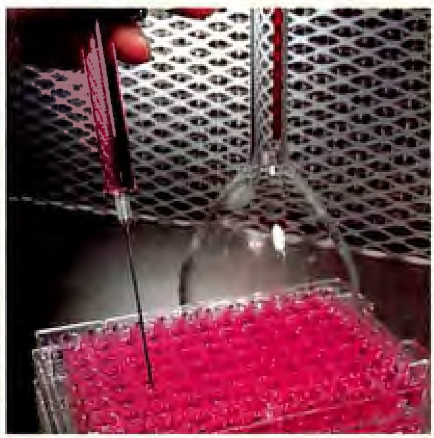

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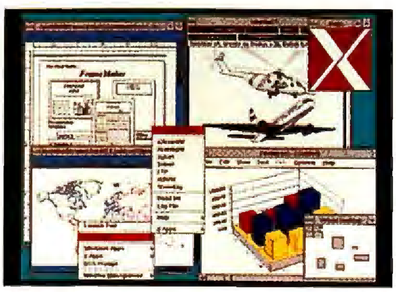

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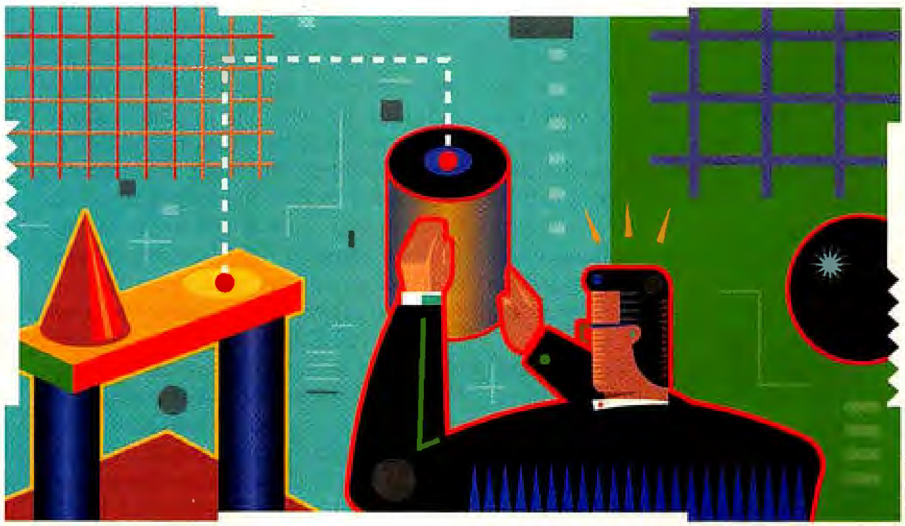
Objects on the March

PETER WAYNER



Microkernel technology lays a foundation for modular systems that can evolve in an orderly manner, but it doesn't guarantee results. For example, you could argue, with some justification, that MS-DOS already is a microkernel to which users add extensions such as networking and Windows. Of course, redefining DOS in this way doesn't sweep away the instabilities and conflicts that arise when you pile on arbitrary mixtures of TSR programs, device drivers, and memory managers. Similarly, Macintosh users find that INITs and other system extensions often lead to trouble.

Clearly what's needed is an object-oriented approach to the design of operating systems—one that lends discipline to the process of adding modular extensions to a small kernel. Microsoft, Apple, IBM, Novell/USL (Unix Systems Laboratories), and Sun Microsystems are all moving their operating systems in this direction. Taligent, the IBM/Apple joint venture, hopes to leapfrog everybody else with its from-scratch object-oriented operating system. Next, meanwhile, ships Motorola and Intel versions of NextStep, the most advanced microkernel-based and object-oriented operating system available. NextStep lacks the bottom-to-top object orientation that will be Taligent's hallmark, but at least it's available today.

Fully object-oriented operating systems will appeal strongly to systems programmers and users alike. At the system level, objects will enable programmers to dig deeply into the depths of the operating system to customize it to their needs, without disrupting system integrity. At the application level, users will find that they can mix and match features and accessories.

Objects also pave the road to distributed computing. *Objects* are units of code and data that communicate by sending and receiving messages. When built correctly, the objects in a system are highly interchangeable, and it can be a relatively straightforward task to swap remote objects for local objects and thereby extend object communication across a network. Programmers must compensate for the latency inherent in such a distributed system, but that's not the hardest problem that these systems introduce. The tough nut to crack will be uniform directory services that enable programmers to name and search for objects on a network that may be scattered worldwide.

Object-oriented technologies will help the next generation of operating systems evolve in an orderly way and reach out across the network

The seamless nature of object systems will radically alter the way we think about *where* our data is. Data will be encapsulated in objects that will in some cases be able to roam to where they are most needed. We are in the habit of thinking that a document is simply stored on a particular hard disk. Distributed object systems will ask us to surrender that comfortable certainty in exchange for the power and flexibility of location-transparent storage.

If we're to entrust our data to object systems, we'll have to be sure they can handle it securely. What's to prevent a malicious user from forging messages to access information? The next generation of operating systems will include cryptographic protocols that will enable objects to authenticate messages. Complete object systems will also have to provide ways to authorize some forms of interobject communication while denying others.

All this won't happen overnight; it's going to be a long, evolutionary process. But it's important to understand how the technologies available today and those available in the near future—Microsoft's OLE; the OpenDoc standard from Apple, IBM, WordPerfect, Novell, and Borland; IBM's DSOM (Distributed System Object Model); Next's PDO (Portable Distributed Objects); and Taligent's frameworks—will prepare users for life in a world of distributed objects.

The Evolution of Microsoft's OLE

Applications at the top of the object food chain will be most users' first taste of these emerging object systems. For Windows users, that means applications that use Microsoft's OLE technology. With the first version of OLE, which debuted with Windows 3.1, users could insert objects into *client* documents. Those objects referred to (in the case of linking) or contained (in the case of embedding) data in a format recognized by *server* applications. Users double-clicked on the objects to launch the server applications and transfer data to them for editing.

OLE 2.0, available now as a Windows 3.1 extension, redefines the client document as a *container*. When a user double-clicks on an OLE 2.0 object that's been inserted into a container document, it can be activated in place. Suppose, for example, that the container is a Microsoft Word 6.0 document and the inserted object represents a range of cells in Excel 5.0 format. When you double-click on the spreadsheet object, Word's menus and frame controls magically become those of Excel. In effect, the word processor becomes a spreadsheet while the contained spreadsheet object has focus.

Clearly, the user benefits from this compound document model, but for programmers, OLE 2.0 requires a radical mind shift. They're used to writing applications that can, to a large extent, control the user interface. Under OLE 2.0 or similar systems, the programmer must build an application that's prepared to surrender substantial autonomy and function as a cog in a machine. Programs have to conform to rigid interfaces in order to interact successfully with other objects. OLE's designers strove to find the right balance: The interface had to be sufficiently rigorous to ensure trouble-free object interaction, yet flexible enough to allow objects to evolve in interesting and useful ways.

The root interface supported by all OLE 2.0 objects is called IUnknown. It provides a method, QueryInterface, that describes other, more specialized interfaces supported by each object. To inquire about one of these, your program consults QueryInterface, which supplies the name of the interface. How do you know which names to inquire about? They're listed in the system registry.

When you call through an interface to the methods it supports, you're using a virtual function table, or vtable, that is quite similar to the vtables generated by C++ compilers. But while the structures generated by C++ compilers can differ from machine to machine and from compiler to compiler, OLE's vtables present a standard, well-known mechanism.

The similarity to C++ does mean, however, that OLE 2.0 is much easier to use in C++ than in any other language. Calling OLE 2.0 objects from C, for example, requires substantial effort. You have to create and initialize vtables explicitly, duplicating work that's done automatically by a C++ compiler. The C++ bias of OLE 2.0 stands in sharp contrast to the language neutrality of IBM's SOM (System Object Model), the object-dispatch mechanism at the heart of OpenDoc (see the table "OLE vs. OpenDoc").

OLE objects can support a wide range of interfaces to functions for such things as memory management, name binding, data transfer, and object storage. Among the most important are the interfaces that provide a common way for an object to negotiate with the container for display real estate in the container's window and for storage space in the container's document.

The infrastructure required to support these complex object interactions is so extensive that Microsoft has described OLE 2.0 as "one-third of an operating system." Object storage, for example, utilizes a *docfile*, which is really a miniature file system contained within an ordinary MS-DOS file. Docfiles provide their own internal mechanisms for subdirectories, locking, and transaction (i.e., commit/rollback) semantics.

What doesn't OLE do yet? Networking is the most glaring omission, and it's the top priority for future OLE development. The next major iteration of OLE will appear in a distributed, object-based version of Windows called Cairo, which is due in 1995.

Apple's OpenDoc

Apple, along with WordPerfect, Novell, Sun, Xerox, Oracle, IBM, and Taligent—collectively known as the Component Integration Laboratories—is also pursuing an object-oriented compound document architecture called OpenDoc. Designed as a cross-platform technology, the project lags behind OLE 2.0 considerably and won't enter its alpha stage until about the time this article sees print. Apple expects to ship beta OpenDoc development kits this summer, in time for the Apple World-Wide Developer's Conference.

The core technologies in OpenDoc are the Bento storage mechanism (named after the Japanese plates with compartments for different foods); a scripting technology that borrows heavily from AppleScript; and IBM's SOM. In a Bento document, each object has a persistent ID that moves with it from system to system. Storage is not only transactional as in OLE, but it is capable of storing and tracking multiple revisions of each object. If there are several drafts of a document, only the incremental changes from one revision to the next will actually be stored. The upper limit to the number of extant revisions will be user-configurable.

This incremental approach will significantly reduce the disk space that's needed to maintain multiple revisions of a document. Because the Bento system will be transactional and multiuser-safe, it will lend itself to the development

OLE VS. OPENDOC

Two models for object-oriented compound documents.

	OLE	OPENDOC
Openness	Controlled by Microsoft.	Controlled by the CIL (Component Integration Lab). Many vendors, including Apple, Borland, Claris, and WordPerfect, are participating in the project.
Language	C++-oriented.	Language-neutral.
Inheritance	Simulated with aggregation.	Genuinely supported.
Storage Model	Compound file with transaction controls.	Compound file with transaction and revision controls.
Availability	For programmers, now. For users, OLE-2.0 capable applications are now shipping.	For programmers, alpha and beta versions will appear during 1994.

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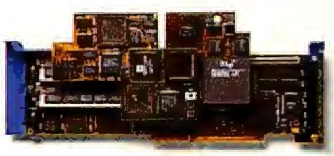

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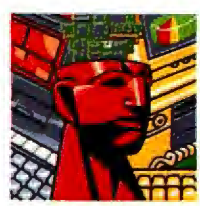

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To Inherit or Not to Inherit?

The ability of objects to be derived from and specialize more general objects is fundamental to any object-oriented system. Yet Microsoft deliberately excluded inheritance from OLE 2.0's object model. The problem, according to OLE developers, is that it's hard to specify a precise interface between a base object and a derived one.

For example, suppose an object inherits half of its behavior from the operating system and provides the other half itself. Now suppose that a new version of the operating system revises the base object while preserving its interface. In theory, the derived object should still work perfectly. This is the major selling point for object-oriented systems. IBM, for example, touts SOM (System Object Model) as a way to achieve binary reuse of objects.

But there can be hidden pitfalls, say OLE developers. Suppose the derived object defines a virtual method that supersedes a method in the base object. Suppose also that the original version of the base object called this virtual method once after all its data was initialized. What if the new base object called the virtual method before some piece of data was initialized? The interface wouldn't be violated—parameters would still be passed correctly—but tacit assumptions made by the derived object's programmer could lead to trouble.

Microsoft therefore came up with the notion of *aggregation*, whereby programmers must explicitly build in the pointers from a derived object to a base object. This approach allows the programmer to build in controls that would stop the object from inheriting something in a dangerous way. The programmer could, for example, force the derived object to check the revision number of the base object.

In IBM's SOM, on the other hand, the dispatcher automatically uses the first instance of a base-class object that it can find. This approach requires more discipline on the part of programmers, who must try to ensure that the derived code they write interacts with base-class objects from one revision to another.

Apple's Kurt Piersol is familiar with this dilemma, because OpenDoc's object model is SOM. He believes, however, that talented programmers deserve the freedom that inheritance brings and can handle the responsibility that it demands. Jim Green, director of the DOE (Distributed Objects Everywhere) project at Sun Microsystems, agrees, and he notes that Microsoft's is the only object system that imposes such strictness.

Who's right? Only time will tell. Objects are not standard equipment yet. When there's a broader base of experience, we'll see whether programmers will run amok with inheritance and come begging for forgiveness like the prodigal son.

---

of collaborative applications. Note that OLE does not currently support revision control, although Microsoft says this feature will appear in Cairo.

OpenDoc's scripting, which is modeled on the Mac's AppleScript, implements a set of standard verbs that are intended to be as general as possible. Fourteen core verbs will apply polymorphically to almost all applications supporting OpenDoc. A verb might specify, for example, "move to next item," which could mean "move to the next word" in a text document and "move to the next cell" in a spreadsheet.

Apple's decision to introduce object-oriented polymorphism to the OpenDoc scripting language grew out of the company's experience with HyperCard, according to OpenDoc developer Kurt Piersol. HyperCard's XCMD mechanism enabled programmers to add arbitrary commands to the HyperCard scripting language. But programmers had to resort to difficult and inelegant tricks that could have been avoided if HyperCard's language model had been stronger.

Apple has learned its lesson, says Piersol. Thanks to IBM's SOM, which is a language-independent engine that implements inheritance and method-dispatching, OpenDoc's script language will enable programmers to write clean, clear code that makes it much easier to integrate different applications.

The team at Apple plans to make OpenDoc compatible with Microsoft's OLE. If the plan succeeds, the OpenDoc system will be able to wrap OLE objects with a layer of message-translation software. An OpenDoc container would see an embedded OLE object as an OpenDoc object, and the OLE object would see its container as an OLE container. Apple says that the reverse translation should also be possible. In that scenario, OpenDoc objects function in OLE containers. The translation layers are being developed by WordPerfect, with help from Borland, Claris, Lotus, and others.

Can it work? It's a tall order, but the fact that both OpenDoc and OLE are built with object technology makes the notion at least conceivable. Given that editing a document involves universal conventions such as "save" and "delete," Microsoft and Apple are certain to express their interfaces in similar ways.

Dueling Object Models: SOM and COM

Underlying OLE and OpenDoc are two competing object models: Microsoft's COM (Component Object Model) and IBM's SOM. Each defines protocols that objects use to communicate with one another. How do they differ? Most visibly, SOM is language-neutral and supports inheritance, while COM is strongly biased toward C++ and eschews inheritance in favor of an alternative mechanism that Microsoft calls aggregation. See the text box "To Inherit or Not to Inherit?" for a summary of the inheritance/aggregation debate.

IBM first used SOM to support the class hierarchy of the Workplace Shell in OS/2 2.0. But that's just one application of what is in fact a fully general system for defining object hierarchies and invoking object methods. When one SOM object invokes another, the SOM run-time engine intercepts the call, locates the target object, activates it, and passes parameters in a standard binary format.

SOM solves a problem that has long plagued OOP (object-oriented programming) languages. Such language systems interoperate poorly because no binary standard supports inheritance and method dispatching across compilers—never mind across languages. You can't take a class library written in Borland C++ and extend it using Microsoft C++. Nor can you inherit from or extend Borland or Microsoft class libraries using COBOL, C, or Smalltalk. But you *can* do all these things if you

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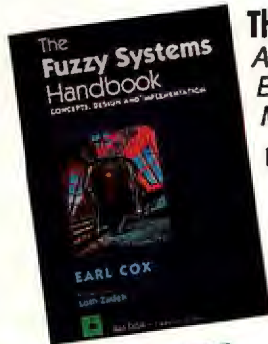

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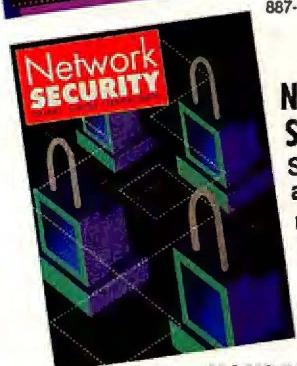

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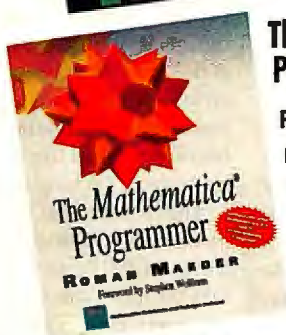

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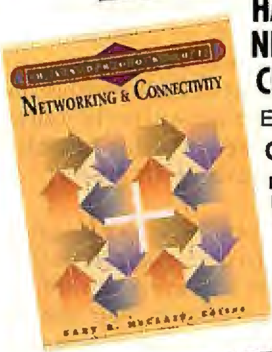

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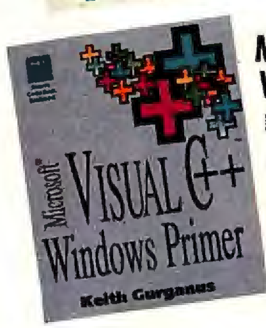

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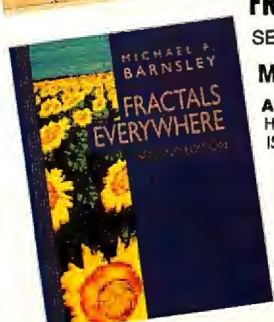

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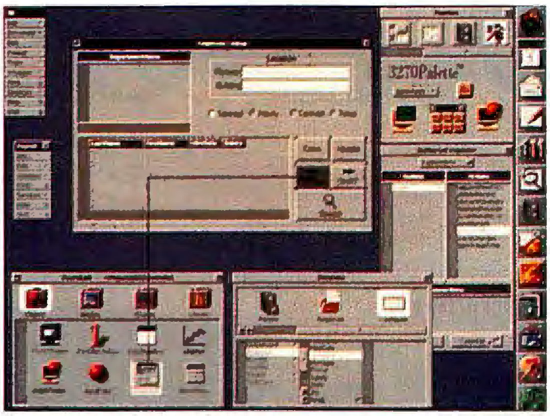
make SOM, rather than C++ or some other OOP language system, responsible for inheritance and method dispatch.

This approach yields another important benefit: rapid development. I quit programming with one set of object-oriented libraries supplied for the Mac because I grew tired of waiting for lengthy compilations whenever I made the slightest modification to the root of the class hierarchy. Everything needed to be recompiled because the parts were in some way dependent on the root class.



The NextStep interface builder. Visual tools are all the rage, but Next's are still the best around.

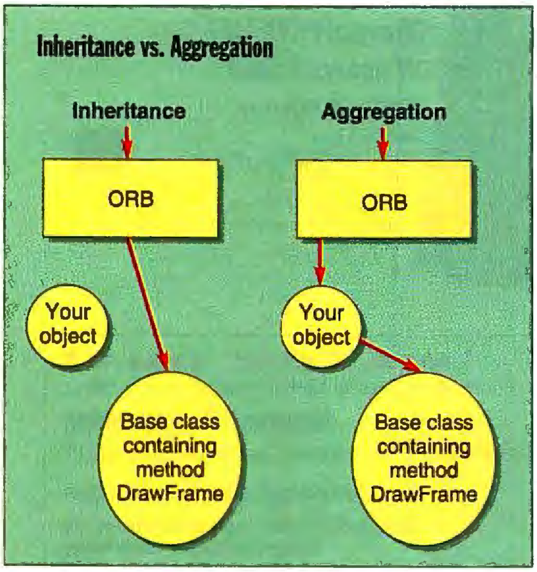
SOM solves this "fragile base class" problem, according to IBM, by eliminating the need to recompile in many cases. You can add new methods and local variables to a base class without recompiling its derived classes, and the derived classes can continue to call methods of the base class as before.

This flexibility is essential if a system is to be extended cleanly. If you use the system's window object and build your application around the features in it, you don't want to have to recompile your entire application when IBM decides to add more features to the system window object. SOM ensures that the new features won't get in your way. You may choose to use them in a later revision of your software, but there is no need to recompile the software to remain compliant with the base system.

This flexibility does come at a price, however. Using SOM means that compilers cannot optimize interobject communications. In conventional OOP implementations, compilers can sometimes place small objects in-line, effectively creating an instance of the object and removing the interobject communication code. A flexible object model like SOM must inevitably trade away such optimizations.

The SOM model was recently extended to work in a distributed manner on IPX/SPX, TCP/IP, and NetBIOS networks. DSOM looks the same as SOM to a programmer, but the DSOM run-time engine can match up objects with requests for their services even when those requests reach across process or machine boundaries.

How will IBM handle the naming of objects in a distributed system? DSOM provides its own, somewhat limited directory service, but for large-scale systems IBM plans to rely on the global directory services of the Open Software Foundation's DCE (Distributed Computing Environment).



In both cases, *your object passes on calls to draw its frame to a method called DrawFrame. In the SOM inheritance model, the ORB (object request broker) vectors the DrawFrame call directly to the base class object where it is implemented. In the COM aggregation model, your object must add to its vtable the necessary pointer to the DrawFrame method in the base class object.*

Microsoft's COM

Microsoft's COM, developed for OLE 2.0, tackles the same problems that IBM's SOM does, yet in startlingly different ways. The most visible difference is that COM doesn't explicitly support inheritance. Instead it offers another mechanism, called *aggregation,* that requires objects to explicitly include pointers to objects higher up in the hierarchy (see the figure "Inheritance vs. Aggregation").

As an example, imagine you're creating a spreadsheet object in a document, but you want it to have flexible column widths instead of the fixed columns provided by the standard object. With conventional OOP you'd inherit most capabilities (e.g., formula translation and constraint propagation) from the base class and then override the display function to implement variable-width columns. The compiler in C++, or the SOM run-time engine in the case of SOM, would redirect the display calls to your code while routing other calls to the ancestral object.

Microsoft's OLE, however, won't do such redirection automatically. You must explicitly expand your object's vtable to include pointers to the reference class. In Microsoft's terms, you "aggregate" the pointers into your object. Why is this necessary? The QueryInterface method in each OLE object only knows how to read local vtables; it can't search upward through an inheritance chain, because there isn't one.

Microsoft's architects chose this approach because they thought that it would be more resistant to the "fragile base class" problems that emerge when a base class is redefined. "It is significantly easier for programmers to not be clear about the actual interface between a base and derived class than it is [for them] to be clear," says Bob Atkinson, one of the principal developers of COM and OLE. "In practice, the base-derived interface will not be well articulated, thus preventing the base-class provider from revising his product," he notes.

But OLE developers didn't want to rule out inheritance completely, so they allowed objects to effectively inherit functions by adding them to their internal dispatch table. In this scenario, the spreadsheet object you've created would contain your own display functions, along with pointers to all the functions in the main spreadsheet object.

The Taligent Revolution

Taligent (Santa Clara, CA) is building a new, object-oriented operating system from the bottom up. Everything in the system, from device drivers to applications, will share a common object model. The company expects that this bold approach will produce a clean operating system that will be completely extensible.

continued

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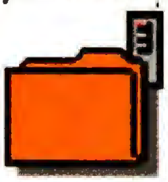

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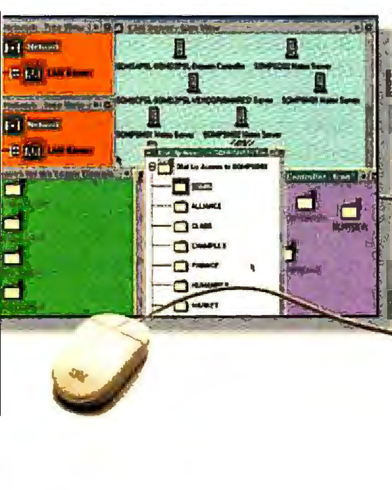

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Taligent engineers talk obsessively about *frameworks*, by which they mean structures that harness collections of objects. Conventional frameworks include Borland's Object Windows Library, or OWL, and Apple's MacApp. These, however, govern only the creation of applications that run under Windows and the Macintosh. They include classes for windows, controls, menus, and other GUI paraphernalia. By relying on these frameworks to handle simple, standard user interactions, programmers can concentrate on more complex and application-specific tasks.

Taligent's frameworks, by contrast, will reach down into the bowels of the operating system. But with this unprecedented freedom will come an equal measure of responsibility. Programmers will have to tread carefully: If you want to add a derived class that takes control of a certain feature of the system, you have to be sure not to violate any of the assumptions built into the base class.

This principle holds true for any operating system, of course, but I have always found programming in frameworks to be like writing sonnets: There are many possible themes, but there are also some rules that just cannot be broken. Nevertheless, Taligent's radical openness and malleability are alluring.

Complicating the future of Taligent is the company's relationship with its parents, IBM and Apple. Taligent plans to release in 1996 its own operating system, which shares IBM's SOM and its microkernel. But the company also plans to release a personality module that sits in IBM's Workplace OS milieu. It is not clear yet whether, or how, Apple intends to move the Taligent technology onto the Macintosh platform.

Next Got There First

The furor surrounding the object-oriented futures of Microsoft, Apple, IBM, and Taligent can obscure the fact that NextStep delivers many of the same benefits today. It allows you to spin together reusable objects to build a slick user interface in no time flat (see the screen on page 144), and Next supplies powerful frameworks for database and 3-D graphics work.

Over the last five years, NextStep's performance has improved dramatically, says Avadis Tevanian, manager of Next's RISC business unit. A key challenge for developers was to optimize memory allocation so that objects were kept together in memory. Early versions of the system swapped excessively because they couldn't achieve locality of reference with respect to objects.

The NextStep compiler now also performs some object-level optimizations. Each method is assigned a unique number, and objects can invoke a method by number rather than by name. This approach speeds up context switching and makes NextStep extremely responsive to the user.

NextStep also tackles the problem of distributing objects across a network. A technology called Distributed Objects simplifies the task of creating systems of objects that communicate across a network. A programmer makes an object available throughout the network by *vending* it—that is, registering its name in the Network Name Service. Programmers who use Distributed Objects can avoid dealing with the lowest level of interaction with Mach, the network, and RPCs (remote procedure calls).

Next is now making Distributed Objects available on other operating systems, in a form called PDO—Portable Distributed Objects. PDO for HP-UX, which shipped in mid-November, contains the Objective C language compiler (i.e., the language in which NextStep objects are written) as well as code for handling distributed object requests. Next intends to ship PDOs for Data General, NCR, and other Unix platforms and eventually non-Unix operating systems, possibly including Windows NT.

Does the requirement to use Objective C limit the appeal of PDO? Not according to Ricardo Parada, software engineer with Pencom Software. "Nothing beats Objective C for objects," he says. "NextStep is the platform that made me see that C++ is not good enough for OOP."

At press time, Next and SunSoft announced a joint licensing agreement that will marry Sun's developing object technology with the NextStep application environment. Next will freely publish a specification describing OpenStep, an operating system–independent software layer encompassing NextStep APIs and application frameworks. Sun will license the OpenStep application layer from Next, along with development tools including Interface Builder, and will make these standard parts of Solaris. The OpenStep specification will be written in terms of Objective C, but it can also be implemented in C++. "We've been investing for three years building low-level object plumbing," said Sun chairman and CEO Scott McNealy at the joint announcement. "OpenStep gives us the application framework we need to layer on top of that plumbing." In exchange for OpenStep, Sun will license that object plumbing to Next.

The CORBA Connection

Hewlett-Packard, Sun Microsystems, and DEC began experimenting with objects long ago. These companies have now joined with many others to fund an industrywide coalition known as the OMG (Object Management Group), which develops standards for object exchange. The OMG's CORBA (Common Object Request Broker Architecture) lays the groundwork for distributed computing with portable objects. CORBA defines how objects locate other objects and invoke their methods.

If this sounds strikingly similar to IBM's SOM, it should. SOM is CORBA compliant. If you're using DSOM under OS/2 (or AIX), you'll be able to invoke CORBA-compliant objects running on HP's, Sun's, or other architectures. Does this mean you will be able to edit an OpenDoc object created on the Macintosh from within a container document on a RISC workstation? Probably not. CORBA can guarantee only a low-level mechanism by which objects can invoke other objects. To interact successfully, the two objects also have to understand each other's messages.

The OMG hopes to synchronize the efforts of many leading workstation vendors. SunSoft, for instance, is working with the OMG to transform much of its technology into open standards. SunSoft's work in the realm of distributed objects has yielded a series of Solaris extensions that have been incorporated into the Common Object Services Specification, or COSS, which are now approved as OMG standards.

The naming service links an object to a human-readable name that a programmer or system can use to find the object on a network. The event notification service, which enables objects to synchronize their operations, supports client/server or peer-to-peer interaction. The association service joins objects together into collections. The properties service lets anyone bind annotations to objects. This object-level graffiti could support store-and-forward messaging or store configuration data.

Security in a World of Distributed Objects

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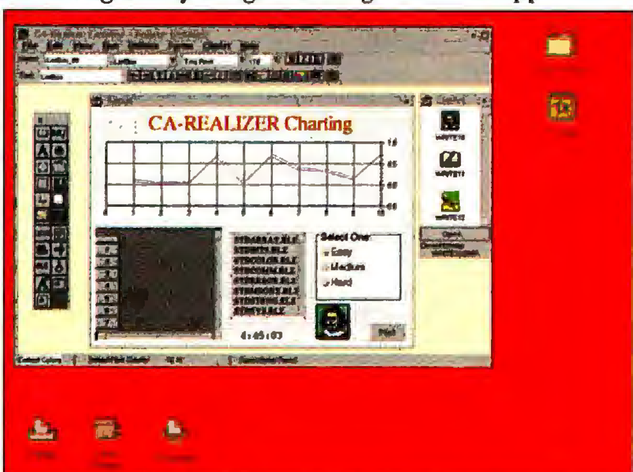

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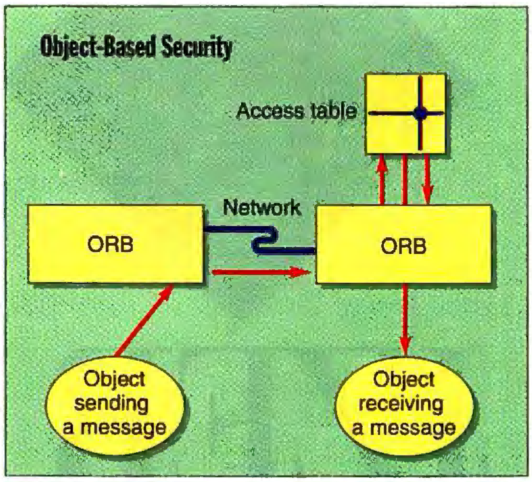

In a CORBA environment, *ORBs ensure that only authorized objects can transmit messages. The access table specifies which connections are permitted.*

lems become. The inherent flexibility of distributed object systems brings new security challenges. Designers want to make it easy for one object to call another object, even if the two occupy different address spaces, ZIP codes, and time zones. Speedy communication is critical.

Unfortunately, security gets in the way. There are strong mathematical algorithms for sealing messages from prying eyes and proving that the identity of an object or a person is authentic. But the problem is that these algorithms chew up compute cycles. That's acceptable on an occasional basis—say, once per log-in session—but too burdensome if every object call needs to pay this extra computational price.

Emerging solutions take two basic forms. Novell and Apple are concentrating on public-key algorithms based on patents held by RSA Data Security (Redwood City, CA) and Public Key Partners (Sunnyvale, CA). In these systems, keys come in pairs. One is published while the other is kept private to the owner. A central authority dispenses public keys to users.

The other common method, which is used by Apple, IBM, DEC, and many other Unix manufacturers, is based on the Kerberos system developed at MIT during the 1980s. This system is based completely on private keys that are dispensed by a central, trusted authority. In this case, though, the central authority must provide a new key whenever a secure link between two entities must be generated. In public-key systems, the central authority is consulted only when two computers first communicate.

The latest security provisions come bundled in Apple's latest revision of the Macintosh operating system, called System 7 Pro. Apple is recommending that all users in networked environments shift over to this version because it offers a variety of options for building collaborative environments. The security provisions take two different forms: digital signatures and secure collaborative sessions.

Digital signatures are generated with an RSA algorithm. When you join the network, a pair of keys, one public and one private, are issued in your name. When you want to "sign" a document, you drop it onto the DigiSign program. This action will fetch your private key from disk, where it is kept in encrypted form. You type in a password that decrypts the private key (which is too long for a user to remember), and a signature is then generated and attached to the document's resource fork.

Apple hopes that this technology will reduce the flow of paper in offices. If you want to question the veracity of a signature, you ask the central authority for the person's public key. It will verify signatures generated with the corresponding private key. The only way that someone can forge a signature is by obtaining the private key or the password. Apple has designed the algorithm so the private key is held in memory in unencrypted form only for as long as it's needed.

Object-Based Security

IBM is working with the OMG and with other companies to add a layer of security software on top of the SOM and DSOM object managers. The challenge is to ensure that messages can reach objects only when the sender has the appropriate authorization. The goal is to provide a secure standard that meets or exceeds the Orange Book criteria formulated by the National Security Agency.

IBM's approach is to delegate authentication work to the ORBs (object request brokers) that make connections between the objects over the network (see the figure "Object-Based Security"). While it's possible to add a layer of protection to the objects themselves, this severely constrains an object's reusability in applications that do not require security. IBM plans to embed access control in the ORB, which will filter out unauthorized requests. Programmers can then create objects without worrying about security precautions.

Secure ORBs will maintain access tables that control which outside objects can access objects under its control. The ORB will be able to check the identity of the message sender by using public-key algorithms. It will also negotiate keys for encrypting messages. Messages will be decrypted before they are passed to their target objects.

Windows NT takes a similar approach with its built-in security. Each object's creator sets its access privileges. The object broker in the kernel controls the connections so that only authorized messages get through.

The U.S. government issues standards that specify degrees of security. At level C2, for example, a system guarantees that any object can be made secure at the discretion of its creator. Windows NT systems can be made C2-secure because all interactions must pass through the object dispatcher. The simplicity of the model makes it possible to analyze the system and ensure that there are no "trapdoors" available for anyone to exploit. Sun Microsystems, HP, and DEC also produce operating systems that are C2-secure or better.

Objects Are Closer Than They Appear

The transition to object-oriented operating systems will dominate the rest of this century. Programmers will need to rewrite huge quantities of code to exploit the benefits of these new systems.

The OLE 2.0–compatible applications that are now emerging are an important first step. OLE 2.0 is the carrot and stick that Microsoft hopes will ensure a supply of applications for Cairo when it emerges. The members of the OpenDoc consortium are pursuing a similar strategy that, unlike OLE 2.0, is not tightly coupled to the Windows platform. And Unix vendors, always advanced in their network orientation, are rapidly converging on interoperable CORBA-compliant distributed object systems.

Not everything must be described in the future tense, however. IBM's CORBA-compliant DSOM toolkit is shipping now, as is Next's PDO. Adventurous and forward-looking developers can today explore the kinds of object technologies that will appear on the mainstream platforms of tomorrow. ■

Peter Wayner is a BYTE consulting editor based in Baltimore, Maryland. He can be reached on the Internet or BIX at pwayner@bix.com.

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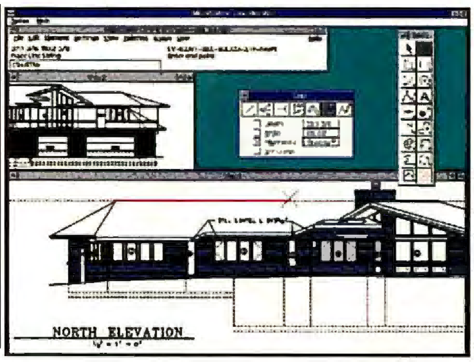

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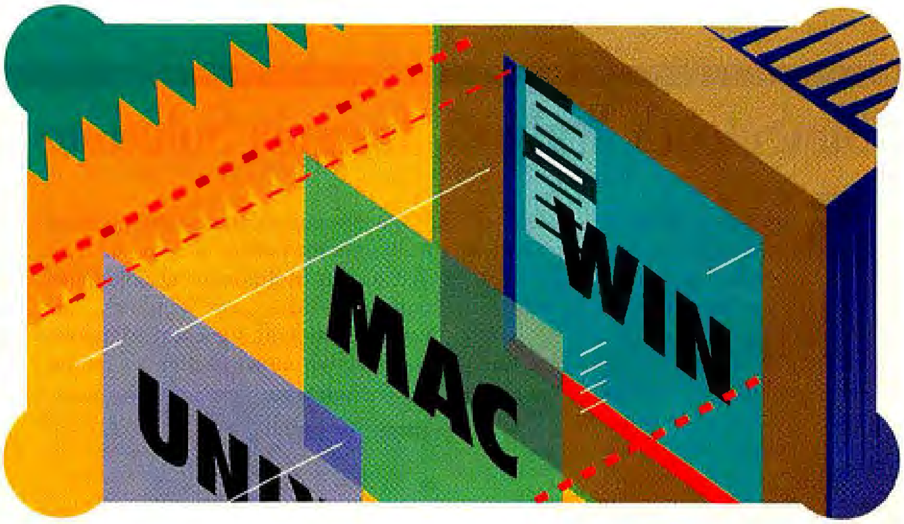

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The new breed of operating systems won't just do the same old things better. Instead, they'll offer capabilities that we've never expected before. Some of these (e.g., microkernels and objects) will live deep in the bowels of the systems, and users may never know they exist. But one new capability will affect almost every desktop computer user: the ability to run foreign applications.

Currently, add-on software lets Mac and Unix users run DOS and Windows applications. But in the generation of operating systems now emerging, the ability to run foreign software will be a standard part of the system and will work well. Your choice of operating system will no longer drastically limit your choice of applications. The collision of user interfaces that occurs when Mac, Windows, and Unix applications all share the same screen will take some getting used to. Still, multiple operating-system personalities are here to stay, and soon they'll be as standard as mice and menus.

What won't be standard, though, is the way in which operating systems implement their ability to run nonnative applications. OS/2, Windows NT, Unix, Workplace OS, and the Mac will all take distinctively different tacks. These differences will affect how well you are able to take advantage of the wider range of applications that the extra personalities will support.

There are two competing sets of requirements. The mission of a foreign personality is to run existing applications, so it must support them as fully and faithfully as possible. But the needs of those applications may conflict with the design of an advanced operating system. Specialized device drivers may be at odds with the need for security. Memory management schemes and windowing systems may conflict. Business issues (e.g., the cost of licensing code and threats of legal action) also affect the design of foreign personalities. But the biggest potential issue is performance: A personality must run applications at an acceptable speed.

The Emulation Equation

For one computer to run software intended for another (e.g., a Mac running DOS software), the computer must perform instructions that it doesn't natively understand. For example, a Mac's 680x0 processor must execute binary code that was intended for a PC's 80x86 CPU. The 80x86 comes with its own instruction decoder, registers, and internal architecture; it executes each instruction through hard-wired circuitry or by executing a microcode routine within the CPU.

The ability to run Windows and Macintosh software is the order of the day, and the name of the game is "multiple personalities"

The 680x0 doesn't understand 80x86 code, so typically it has to collect each instruction, decode it to determine what it's intended to do, and perform the equivalent routine using external 680x0 code rather than internal microcode. Because the 680x0 also doesn't come equipped with exactly the same registers, flags, and internal arithmetic and logic units as an 80x86, it must also imitate those elements, either in its own registers or in memory. And it must accurately reproduce the results of each instruction, which requires 680x0 routines specifically written to make sure that the emulated registers and flags will be exactly the same as they would be on a real 80x86 after executing each instruction.

For the CPU, it's not hard work, just exacting and very tedious—the sort of job at which computers excel. But it's also very slow work, because the microcode inside a real 80x86 runs at a much faster clip than the external 680x0 instructions that must emulate it. In the time it takes the 680x0 to perform one 80x86 instruction, a real 80x86 CPU might be able to execute dozens of instructions. The result: A DOS program running under pure emulation on a Mac is certain to be incredibly slow compared to one running on a PC.

The problem isn't the Mac, though—Macintosh software being emulated instruction-by-instruction on a Unix workstation runs like molasses, too. The emulation equation is easy to understand: The processor's ordinary performance, minus all the overhead of emulation, will equal how much work it can do. Thus, unless the processor performing the emulation is spectacularly faster to compensate for the emulation overhead, the software running under emulation will simply be very, very slow.

A Dime a Dozen

What makes the new personalities better than emulation in the past? Faster processors help, of course. But the big difference is that many of today's applications run under GUIs like Windows, the Mac, or Unix's Motif. That means the new personalities can "cheat" on the emulation process.

An application running under a GUI spends much of its running time doing

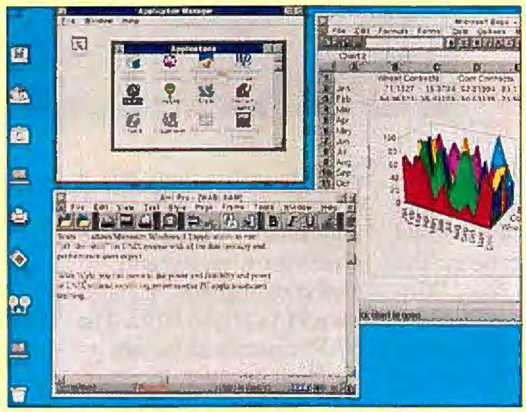
SunSelect's Wabi vs. Insignia Solutions' SoftWindows

SunSelect's Wabi (Windows Application Binary Interface), which will be bundled with many Unix workstations, uses the workstation's normal X Window System display protocols for creating the images called for by a Windows application and Unix's usual facilities for handling files, memory, and other resources.

Wabi is based on technology acquired by SunSelect from Praxsys Technologies, but it functions much like other personality translators. While working its way through the code in a Windows application, Wabi decodes and mimics individual 80x86 instructions until it encounters a call to a DOS or Windows function. Then the emulator switches to native mode, performing the DOS or Windows function by making the appropriate calls to X, Unix, or other facilities. The technical challenge comes in translating the parameters of each Windows call to the appropriate format for Unix and then translating the results from the function call into the appropriate information to be returned in the appropriate Windows data structures.

The first release of Wabi claims to support the Windows 3.1 API, with DDE and OLE supported only as external DLLs that must be interpreted by Wabi's 80x86 emulator. Networking is limited to access to remote file systems and printers. SunSelect says improved network support and native versions of DDE and OLE will come in a future release of Wabi.

Windows applications running under Wabi have the look of an X-based Unix GUI such as Motif or OpenLook, rather than that of Microsoft Windows. And instead of running the entire Windows desktop environment within a window,



Wabi running Windows applications on the Solaris desktop.

as Insignia Solutions' SoftPC and SoftWindows currently do, Wabi opens a new window on the Unix desktop for each Windows-based application. Using a standard X display means both text and graphics can be cut and pasted between Windows and Unix applications (although most Unix applications can't automatically convert to and from the Windows bit-map format).

However, SunSelect isn't religious about its X implementation of Windows. To make sure TrueType fonts are properly handled for the Windows applications, the company has licensed font-handling technology from Bitstream. As a result, when a Windows application issues a call to display text in a particular TrueType face, Wabi converts the request to X calls but also provides the appropriate fonts for the display.

Wabi can't currently handle plenty of Windows-related features, including multimedia extensions, ODBC (Open Database Connectivity), MAPI (Messaging API), and networking beyond access to remote file systems and printers. Are those limitations Wabi-killers? SunSelect doesn't think so, arguing that Wabi's purpose is to run the popular Windows applications Sun's customers have asked for, not to convert Unix into a close copy of Windows. The current list of "Wabi-certified" applications is short. Only 13 packages from Lotus, WordPerfect, Microsoft, Borland, and other major Windows software vendors are guaranteed to run under Wabi.

According to SunSelect's director of research and development, Andy Halford, another 50 packages seem to work fine, but they haven't been run through the Wabi testing and certification program. Software that uses APIs Wabi doesn't support may fail to install or exit gracefully with an option to close files—or even cause Wabi to abort.

But a Microsoft-backed competitor thinks Wabi's approach is far too limited. The day before SunSelect unveiled Wabi, Microsoft launched a preemptive strike by announcing it would license Windows source code to Insignia Solutions. The product that Insignia produced from that agreement, SoftWindows, runs Windows applications on Unix workstations, but there the similarity to Wabi ends.

SoftWindows is actually Windows 3.1 and MS-DOS, recompiled for Unix. Initially, SoftWindows fully supports OLE, DDE, and DLLs; Insignia says it is now working on multimedia and other extensions. The image that appears in a some very predictable things. It repeatedly makes calls to the GUI's libraries to manipulate windows and perform other GUI-related functions. And that's where a personality can make up for some of the time lost doing instruction-by-instruction emulation. A carefully crafted personality can come complete with libraries that mimic the GUI's own internal libraries but that are written in native code. Some vendors call this approach *translation*, to distinguish it from the slower process of emulating code one instruction at a time.

For example, on a Mac executing a Microsoft Windows program, performance might be very slow when it's interpreting 80x86 instructions. But when a call is made to open a window, the personality module could switch to a precompiled 680x0 window-opening routine. Because the GUI libraries don't have to decode and imitate each 80x86 instruction, performance can speed up dramatically in sections of the code that call the GUI's ABI (Application Binary Interface). The result is that in those sections of the code, the application can approach (or possibly exceed) its performance on its native processor.

And there's a *lot* of code that calls the GUI ABI in typical applications today. Apple claims that a Mac application spends up to 90 percent of its processing time performing Mac toolbox routines, rather than executing code that's unique to the application. SunSelect says that Windows applications spend 60 percent to 80 percent of their time in the Windows kernel. As a result, there can be a much smaller performance penalty for emulation of GUI-based applications. In fact, SunSelect claims that its new Windows personality, Wabi (Windows Application Binary Interface), can outperform real Microsoft Windows on the same hardware when running some benchmarks, thanks to highly optimized libraries.

The rise of GUIs has also resulted in another change in the way most desktop applications software is written today. Until the advent of the Mac, most desktop software treated operating-system calls with a sort of "do-it-yourself" philosophy. If the programmer didn't think the operating system would perform the routine fast enough, he or she would often dispense with the available operating-system calls and write an equivalent routine that directly manipulated hardware or software. This approach was commonly used for time-critical functions like display scrolling and getting data from a serial port.

"Programming on the metal" for performance was a nightmare for emulator writers, because they had to mimic software that was going directly to hardware that usually didn't exist on the computer doing the emulation. It was also a major problem for computer makers such as IBM and Apple, because it locked them into using exactly the same hardware architecture in generation after generation of the IBM PC and the Apple II. Changing many hardware details was out of the question, even if the changes would mean dramatic improvements, because changes would also break lots of software.

Lessons Learned

Apple learned its lesson from the Apple II experience. With the Mac, Apple

SoftWindows window is that of a complete Windows desktop, and because the source code is the same as the original 80x86 version, every nuance of Windows is preserved. When SoftWindows' 80x86 emulator reaches a Windows function call, it doesn't simply mimic the function. It actually performs it, at full processor speed, with appropriate calls made to Unix instead of DOS.

Because it uses authentic Windows source code, SoftWindows is able to run a far wider range of Windows applications than Wabi. By comparison, says Insignia, Wabi offers very little.

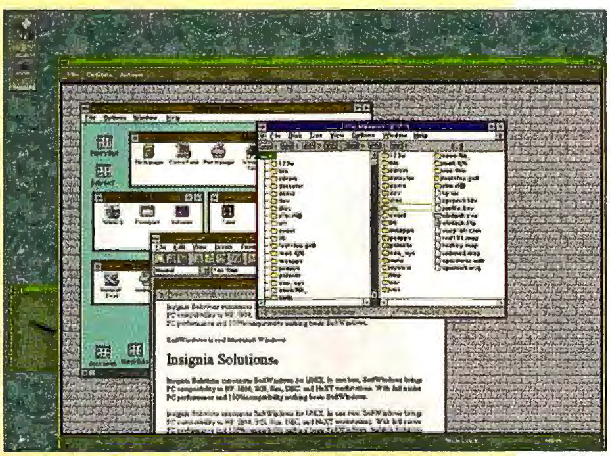
But according to SunSelect, Wabi does claim one major advantage over SoftWindows: blinding speed. Executing every line of authentic Windows code for each function creates an awful lot of overhead, particularly because Windows was designed as a 16-bit application running on top of MS-DOS and was built to perform its own memory management and other advanced functions. By contrast, Unix is a 32-bit operating system that has finely tuned memory management and other facilities.

SunSelect argues that by using Unix to mimic Windows rather than slavishly performing every line of the authentic code, Wabi can outperform genuine 80x86-based Windows. A demonstration performed at SunSelect's original Wabi announcement appears to bear out the claim. Running the Wintach benchmark, a PC running the Intel version of Solaris with Wabi performed 50 percent faster than an identical PC running Microsoft Windows, according to SunSelect.

In response, Insignia points out that Wintach is just one benchmark, and it's strongly geared to graphical functions—the kind of functions where Wabi would be expected to do well. Insignia claims it uses a battery of benchmarks to make sure its RISC Unix versions of SoftWindows will perform at least as well as a 25-MHz 486-based PC in every area. The company says it has not yet benchmarked SoftWindows against Wabi but that the two initially look "competitive."

Ironically, SunSelect is an Insignia customer. The company sells an enhanced version of Insignia's SoftPC as SunPC, and SunSelect acknowledges that for SPARC customers who need more complete PC emulation, that's the way to go. But for those who need to run only the top Windows applications, says SunSelect, Wabi is a better solution.

The choice between SoftWindows and Wabi comes down to whether a customer wants to run full-scale Windows or full-speed Windows applications.



SoftWindows running Windows applications.

worked hard to discourage programmers from "going to the metal" or otherwise departing from a strict set of programming guidelines. (Apple's programmers weren't immune to the temptation to program on the metal, though. Some Apple telecommunications software for early, relatively slow Macs programmed the hardware directly.) The result of that discouragement was that Mac applications software was much less likely to break the rules than PC software. With fewer hardware dependencies, Apple has been able to evolve the architecture of the Mac over time.

The biggest reason programmers used the Mac's "toolbox" of GUI library routines was not a stick, but a carrot. The toolbox routines were so complex and powerful that using them was significantly easier than writing your own version of the code. Microsoft Windows also included a powerful GUI ABI, as did Microsoft and IBM's OS/2 Presentation Manager and Unix GUIs based on the X Window System. When Windows rocketed to popularity in 1990, the tide turned for emulation. Finally, a large body of applications software that spent a large part of its time in a GUI ABI could be mimicked.

With the technical barriers down, there are pressing business reasons why vendors believe multiple personalities are a crucial part of any successful new operating system. DOS, Windows, and Mac programs pack the shelves in software stores; obtaining shelf space for a new incompatible type of software is practically impossible. More important, users have plenty of Windows and Mac software, and they're not about to give up the software they know well, no matter how impressive a new operating system promises to be. In fact, for an increasing number of business customers, the ability to run particular PC applications (e.g., Lotus 1-2-3 and WordPerfect) is becoming a standard requirement for desktop computer purchases, even if the purchase also requires technical applications available only under Unix.

Luckily, the modularity of the new generation of operating systems makes it far easier to support multiple personalities. Unlike older operating systems, which often consist for all practical purposes of a single large block of code divided into arbitrary parts, newer systems are modular, with clearly defined interfaces between the parts. That makes it much easier to design additional modules that bundle together processor emulation and GUI library translation.

So the pieces have all come together, both technological (software style, processor speed, and modular operating systems) and business (popular "must-run" software packages). Multiple personalities are the wave of the future for operating systems.

Who's Got What?

Among the advanced operating systems that will specifically incorporate multiple personalities are IBM's OS/2 2.x and Workplace OS; Microsoft Windows NT; the PowerOpen Association's PowerOpen; and versions of Unix from Sun Microsystems, IBM, and Hewlett-Packard. In addition, some companies are repackaging their user interfaces as personality modules, and still other vendors offer emulation and personality-translation products that can run as applications.

continued

EXISTING AND FORTHCOMING OPERATING SYSTEMS OFFERING MULTIPLE PERSONALITIES

	OS/2 2.x[1]	Workplace OS[2]	Windows NT[3]	PowerOpen[4]	Unix (with Wabi)[5]
Vendor:	IBM	IBM	Microsoft	PowerOpen Association	SunSoft (Solaris), IBM (AIX), Hewlett-Packard (HP-UX), USL (SVR4.2)
Availability:	Now	Future (this year)	Now	Future	Now (Solaris)
Personalities available:	DOS, Windows 3.1	DOS, Windows, OS/2, AIX (Unix), others	DOS, Windows 3.1, Win32, OS/2 1.x, Posix	Macintosh, AIX (Unix)	Windows 3.1
Look and feel:	OS/2 or complete Windows environment within a window	OS/2 Workplace Shell or Unix CDE	Windows	Motif; Mac desktop in a self-contained window	Motif or OpenWindows
Applications supported:	Windows 3.1 applications and device drivers	Unknown (prerelease)	DOS and Windows applications that do not require access to hardware; character-based 16-bit OS/2 applications	RS/6000 AIX, System 7	13 Windows applications from major vendors "certified"; others may run

[1] OS/2 2.x is based on code licensed from Microsoft. OS/2 for Windows incorporates no Microsoft code.
[2] Additional proposed personalities include Mac and BSD Unix. Currently a product in development.
[3] Posix support requires recompilation of source code.
[4] Mac support via Macintosh Application Services.
[5] Wabi Windows personality was reverse-engineered from Windows API. Wabi has been licensed to IBM, Novell, and HP and will be available with every Sun workstation and copy of Solaris for Intel.

THIRD-PARTY PERSONALITY SOFTWARE

	Macintosh Application Services[1]	Liken[2]	Equal Application Adapter[3]	SoftPC[4]	SoftWindows[5]	Merge[6]
Vendor:	Apple	Andataco	Quorum Software Systems	Insignia Solutions	Insignia Solutions	Locus Computing
Availability:	Future (this year)	Now	Now	Now	Now	Now
Operating systems supported:	Unix (PowerOpen, others)	Unix (Solaris, HP-UX)	Unix (Solaris, Silicon Graphics)	Mac and Unix (many varieties)	Unix (Solaris and HP-UX now; AIX, Silicon Graphics, and DEC OSF/1 in March)	Unix (80x86 versions)
Personalities available:	Mac	Mac	Mac System 7	DOS, Windows 3.1	Windows 3.1	DOS
Look and feel:	Mac using X Window System widgets	Complete Mac desktop in a window	Motif or OpenWindows	Windows, character-mode DOS in a window	Complete Windows environment in a window	Character-mode DOS
Applications supported:	Unknown	Monochrome System 6–based applications	Microsoft Word and Excel "certified"; others run but are not guaranteed and may end Equal session unexpectedly	Most DOS and Windows applications that do not require direct hardware access	Most existing Windows applications and device drivers that do not require direct hardware access	Most DOS applications that do not require direct hardware access

[1] "Statement of direction" from Apple.
[2] Requires a copy of System 6.0.7. Emulates 680x0 CPU and Mac hardware environment.
[3] Reverse-engineered from System 7 specifications. Runs Mac applications but does not mimic entire Mac environment.
[4] Emulates 80x86 and PC hardware environment.
[5] Based on Windows source code licensed from Microsoft.
[6] Microsoft Windows can be run over Merge.

Perhaps the most familiar multiple-personality operating system is also the one that opened the floodgates by showing that the ability to run other systems' software can be a big plus. OS/2 2.0 ran DOS and Windows 3.0 applications, and version 2.1 improved on this, upgrading to Windows 3.1 software and making the Windows windows a regular part of the desktop.

At first glance, IBM developers would seem to have had a comparatively easy task in adding the Windows personality to OS/2. After all, like Windows, OS/2 runs on 80x86 CPUs, so no processor emulation was required. In addition, IBM had access to actual Microsoft Windows source code and the right to use it, for a licensing fee, in OS/2. So IBM's work largely consisted of integrating the Windows code into OS/2.

But it still wasn't easy. The requirements of the two environments created difficult problems, some of which IBM has never satisfactorily resolved. For example, Windows incorporates its own memory manager. So does OS/2. Unable to modify the Windows code to use OS/2's memory management services directly, the OS/2 developers settled on using the Windows memory manager within the OS/2 memory manager. Windows' manipulations of memory can spill over into the OS/2 swap file. Similarly, OS/2's "seamless Windows" mode required major work on the display drivers to enable the

two window systems to share screen real estate.

Windows NT offers five operating-system personalities: DOS, Windows, an advanced 32-bit version of Windows, OS/2 1.x, and a Unix-like personality that meets the IEEE's Posix.1 specification. NT runs on several different CPUs, including the Mips R4000/R4400 and DEC's Alpha, as well as the 80x86. To run DOS and Windows applications on non-80x86 platforms, NT incorporates emulation technology licensed from Insignia Solutions, which also makes the DOS emulator SoftPC for the Mac and Unix workstations. (NT's OS/2 personality is not supported on non-80x86 processors.)

Naturally enough, to provide the ability to run Windows applications, Microsoft used its own Windows source code, modified and recompiled for each CPU that NT runs on. The 16-bit Windows and DOS personalities run on top of the 32-bit Windows (Win32) NT subsystem. On 80x86 machines, where the CPU is not emulated, DOS and 16-bit Windows applications run in V86 mode, and 16-bit calls are "thunked" (converted to 32-bit versions) and serviced by Win32.

NT's major trade-off in DOS and Windows support is that, in keeping with NT's security and reliability goals, device drivers and other DOS and Windows programs are not allowed access to the hardware. As a result, some DOS and Windows programs simply won't run under NT. (In contrast, OS/2's DOS and Windows support allows more complete DOS and Windows support, but for that capability trades away robustness.)

NT's OS/2 support has special limitations compared to the DOS and Windows personalities, but it is still a thoroughly usable version. It is available only on 80x86 NT, does not support the PM GUI, and is designed to handle only software written for OS/2 1.2 and earlier versions, which limits applications to 16-bit versions. In practice, though, NT's OS/2 personality can run current versions of many OS/2 packages—particularly server applications, which don't require PM.

In contrast to the OS/2 personality, NT's Posix personality isn't actually mimicking an existing operating system at all. Although there are versions of Unix (on which Posix is modeled) for each CPU that NT runs on, NT's Posix can't run shrink-wrapped Unix software; it requires programs to be recompiled before running.

The Unix Strategies

While Windows NT can't run Unix binaries, some Unix vendors are convinced they need the ability to run Windows software. That ability has been available for several years through third-party software like SoftPC (now available with Windows), which runs on Macs and Sun, HP, IBM, Next, and Silicon Graphics Unix workstations. On 80x86-based computers, Locus Computing's Merge also enables DOS applications to run under Unix. Merge runs a standard copy of Windows on top of the DOS environment.

In addition, Insignia's new SoftWindows was scheduled to begin shipping in December. SoftWindows uses a recompiled version of the Windows source code to speed up Windows applications running on Sun, HP, IBM, DEC, Next, and Silicon Graphics Unix workstations. If that approach sounds familiar, it should: It's almost exactly the same approach used for non-80x86 versions of Windows NT. But while SoftWindows and NT are conceptually close cousins, NT can also run 32-bit Windows code, while SoftWindows is limited to running16-bit Windows applications.

However, the most aggressive approach to bringing Windows and Unix together comes from Sun Microsystems' SunSelect division, which has developed Wabi. While SoftWindows uses recompiled Windows source code from Microsoft, Wabi is an attempt to reverse-engineer Windows based on its functional specifications, with all operating-system-related functions (e.g., display, memory management, and interprocess communication) handled by Unix. Instead of the Windows desktop, each Windows application running under Wabi appears in its own screen window and uses the Motif or OpenLook screen appearance rather than that of Microsoft Windows.

The result is a mixed success. SunSelect initially guarantees that Wabi can run only the most popular Windows software, including Lotus 1-2-3 and Ami Pro; WordPerfect; Microsoft Word, Excel, PowerPoint, and Project; Borland Paradox and Quattro Pro; Aldus PageMaker; Harvard

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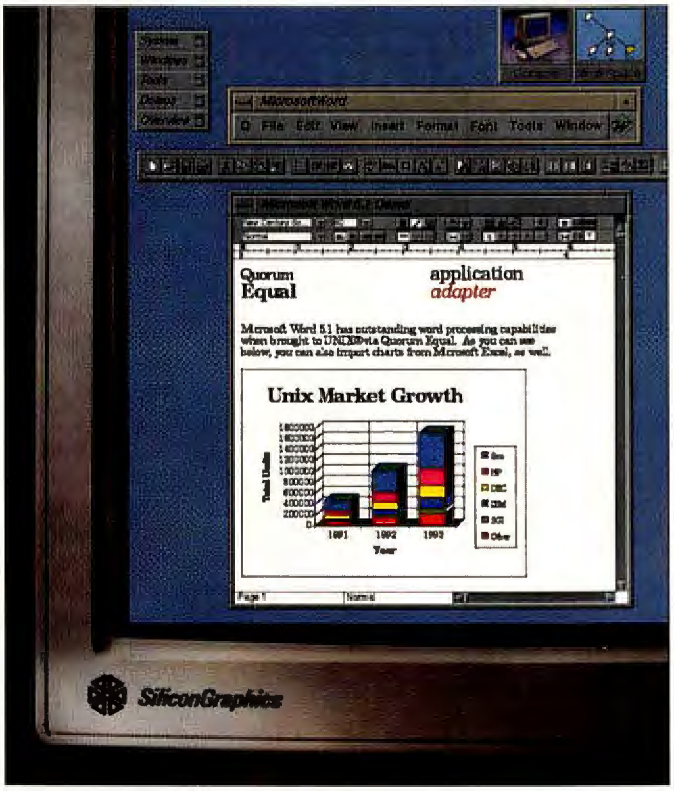
Graphics; CorelDraw; and Procomm Plus. The company says that the list of "certified" applications will grow. In the meantime, while some noncertified applications will run, others may not install, or may fail while the application is running due to use of unsupported API calls.

SunSelect says its focus is on running popular applications rather than mimicking



Quorum Software Systems' Equal running the Macintosh version of Microsoft Word on a Silicon Graphics workstation.

Windows in its entirety. But all Windows applications function in a complex environment, with subtleties that may show up only when Wabi's developers tackle support for applications outside the most-wanted list. In addition, Windows will continue to be a moving target; SunSelect may be hard-pressed to keep up with future changes required by new versions of Windows software.

However, Wabi has one huge advantage in any popularity contest for Windows-on-Unix software: SunSoft is making Wabi available with every copy of its Solaris version of Unix, and SunSelect has licensed the product to IBM, HP, and Novell to include in their versions of Unix. If all these vendors include Wabi in their systems as Sun does, Wabi will be shipped with more than 70 percent of all Unix workstations.

Not to be outdone, Apple is working on its own Mac personality translator to run on Unix systems. The first version, Macintosh Application Services, will run on PowerPC-based workstations running the PowerOpen version of Unix. MAS will let PowerOpen workstations run both Unix applications and shrink-wrapped software intended for 680x0-based Macs. (MAS should not be confused with the new PowerPC-based Macs, which also use processor emulation and GUI translation to run 680x0 Mac software.)

MAS will appear as a "Macintosh window" on PowerOpen-based workstations. Although Apple says that MAS will be compatible with X, Mac applications running under MAS will still have the distinctive Mac look and feel.

In addition, Apple has announced that it will eventually support other Unix workstations. Apple hasn't released details of its plans, and they clearly fall under the category of future product development. However, Sun, HP, and IBM have already said they hope to use the forthcoming Apple technology to let their Unix workstations run unmodified shrink-wrapped Mac software.

In the meantime, two ISVs (independent software vendors) are already emulating the Mac on Unix systems—although with limits. Andataco's Liken is a pure processor emulator; it runs on Sun and HP workstations and mimics the Mac's 680x0 CPU, as well as the Mac hardware environment. However, Liken doesn't try to copy the Mac's toolbox GUI libraries; for that, you need a copy of System 6.0.7.

In contrast to Liken, Quorum Software Systems' Equal is designed to mimic both the 680x0 processor and all Mac system calls, so that Mac applications can run on Sun and Silicon Graphics Unix workstations. Like Wabi, Equal puts each Mac application in its own window, using X to display Motif- or OpenLook-style window decorations. Also like Wabi, Equal currently has a limited set of "certified" applications. Initially, it includes only the Mac versions of Microsoft Word and Excel, although Quorum plans to expand the list of certified software early this year to include Microsoft PowerPoint, QuarkXPress, and other popular Mac software. (According to Quorum, many "uncertified" Mac applications run with no problems.)

Closing the circle is IBM's Workplace OS, the OS/2 successor based on the Mach 3.0 microkernel. Standard Workplace OS personalities will include Unix and OS/2 (along with its DOS and Windows personalities). But IBM hints that other personalities may also be available for the system. Because the Workplace OS interfaces are being developed in close communication with Taligent, the IBM/Apple joint venture to develop an object-oriented operating environment, both Taligent and the Mac GUI are likely candidates as Workplace OS personalities.

Who Wins, Who Loses

The ability to run Windows and Mac software is no longer a minor consideration when it comes to advanced operating systems. But beyond that simple point of agreement lie a welter of strategies for putting the multiple-personalities idea to work—and some of those strategies are diametrically opposed to others. A careful examination of the strategies operating-system vendors are using makes it apparent that there's no single correct way to implement multiple personalities.

In the case of Unix, the personality translator is typically designed to float along the surface of the operating system, like any other application. For more recent operating systems like Windows NT and Workplace OS, the personality module is much more closely linked to the operating system, although it is still highly modular. And for OS/2, with its simpler, less modular structure, the personality capability appears to be deeply embedded in the operating system.

But while operating-system vendors are juggling their approaches to run the largest number of popular applications most effectively, the biggest impact of the trend toward multiple personalities may be on applications software developers. Windows and Mac applications are likely to sell slightly better than before. The big winners will be those Windows applications that are already the most popular, because the ability to run them will be

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Windows NT and Workplace OS: Plug It In

While Unix personality modules are designed to function as if they were applications, both Microsoft's and IBM's entries in the portable 32-bit operating-system sweepstakes take a more integrated approach. Microsoft Windows NT and IBM's forthcoming Workplace OS have been specifically designed to support emulation of multiple operating-system personalities, although the difference between the two systems' approaches is striking.

Windows NT supports five operating-system personalities: MS-DOS, 16-bit Windows, OS/2 1.x, Posix, and 32-bit Windows. All five personalities are implemented as NT "environment subsystems"; each runs in its own protected user space. The Win32 subsystem handles display, keyboard, and mouse support for the other four personalities.

DOS and 16-bit Windows applications run via VDMs (virtual DOS machines), each of which emulates a complete 80x86 computer running MS-DOS. In NT, a VDM is a Win32 application; thus, like a typical Unix personality module, NT DOS and 16-bit Windows applications effectively float in a layer directly above the Win32 subsystem.

The OS/2 and Posix subsystems are a different matter. As full-scale NT subsystems themselves, they communicate with the Win32 subsystem for user input and output, but they also communicate directly with the NT Executive for other operating-system services. The OS/2 subsystem can run many current character-mode OS/2 applications, including OS/2 SQL Server, and it supports named pipes and NetBIOS.

But the Posix subsystem is remarkably limited, despite direct access to kernel services. Posix applications must be compiled specifically for Windows NT; NT does not support binary code intended for any other Posix-compliant operating systems, such as Unix. In addition, NT's Posix subsystem does not directly support printing, does not support network access except for remote file systems, and does not support any facilities of the Win32 subsystem such as memory-mapped files or graphics.

Compared to NT, IBM's forthcoming Workplace OS uses a more straightforward organization. While some NT personalities go through the Win32 subsystem and others deal directly with the NT kernel, all Workplace OS personalities have direct access to kernel services. Workplace OS currently supports three personality servers: an OS/2 server for OS/2 applications, an AIX server that mimics IBM's version of Unix, and an MVM (multiple virtual machines) server for DOS and 16-bit Windows applications.

Workplace OS is built on a version of Mach 3.0. The IBM microkernel supplies only a very limited set of services; it is essentially a software backplane into which other modules, called servers, connect. The personality servers function exactly like any other Workplace OS servers. Each runs in its own protected memory space and communicates directly with the microkernel and, through it, other servers.

However, all personality servers are not created equal. IBM initially plans two versions of Workplace OS, one the OS/2 Workplace Shell, the other, Unix CDE (common desktop environment). In each case, the *dominant* personality will do double duty, providing both the capabilities required for its own applications and the desktop GUI and default execution semantics for the other personalities. On a standard Workplace OS system, the OS/2 (or Unix) personality is dominant. The other personality servers, known as *alternative* personalities, don't contain code to provide these services.

However, dominance is entirely arbitrary in Workplace OS. The Workplace OS could be given a Windows look and feel, although IBM has no plans to do so. IBM says the server interfaces for Workplace OS will be published, so constructing dominant and alternative personalities will be practical for ISVs (independent software vendors). Additional personalities can also be added by IBM or other vendors; although none have been announced, a Mac personality is rumored as a future addition.

In practice, announcements and demonstrations are currently the limit of Workplace OS's functionality, because it is a product in development rather than a shipping package like NT. In recent demonstrations, for example, Workplace OS's Unix and DOS personalities were both character-based, and users could only hot-key between them and the OS/2 GUI.

Technically, both Windows NT and Workplace OS use modular subsystems to support multiple operating-system personalities. Paul Giangarra, lead architect for Workplace OS, is enthusiastic about the idea of other software vendors developing additional personalities (or, alternatively, personality-neutral services). Microsoft's director of business development, Bob Kruger, says the whole reason NT includes Posix support is to demonstrate that subsystems can be added, either by Microsoft or other vendors, that connect directly to the NT Executive without running as Win32 applications.

In fact, the two approaches seem very comparable at a technical level. Then why does Workplace OS's approach to multiple personalities seem so robust, promising the potential ability to run every significant desktop operating system, while NT's non-Windows personalities seem thoroughly undeveloped? One reason may be that it's easier to create a robust plan than a working operating system with robust implementations of multiple personalities.

But there's also clearly a difference in business philosophy. IBM is pursuing multiple personalities, while Microsoft appears to be discarding them. "How many people are actually going to write a Posix application?" asks Kruger. And he downplays NT's ability to run OS/2 applications: "At the end of the day, people will buy Windows NT because it runs Windows," Kruger insists. It's true that with good support for Windows applications, NT already has many of the benefits that multiple personalities promise. But only time will tell if a Windows-only philosophy will help or hurt NT in its competition with other advanced operating systems.

A Better OS/2 Than OS/2?

Ironically, the first major operating system to demonstrate the commercial value of supporting multiple personalities is now demonstrating a new way to support them. OS/2 was a serious disappointment to development partners Microsoft and IBM when it was first released. When it was first introduced, analysts predicted that within five years, OS/2 would account for more than half the sales of business PCs, displacing MS-DOS as king of the desktop. Instead, early versions of OS/2 sold fewer than a half-million copies per year—a tiny fraction of expectations. And with OS/2's downfall came the collapse of the close relationship between IBM and Microsoft.

So when IBM relaunched OS/2 in 1992, Big Blue needed an edge. It found that edge by beefing up OS/2's ability to run DOS-based applications software and adding support for Windows applications. While OS/2 1.x offered only a single window for running DOS software, version 2.0 let users run several DOS sessions at once. Windows support in version 2.0 was initially limited to running Windows 3.0 on a full screen, but OS/2 eventually supported both "seamless" Windows applications (each appearing in its own desktop window) and, in version 2.1, support for Windows 3.1 applications.

OS/2's DOS and Windows support came through MVM (multiple virtual machines), an OS/2 subsystem that could imitate a series of DOS PCs. In contrast to the modular approach to multiple personalities used by Unix, Windows NT, and Workplace OS, OS/2's DOS and Windows support was firmly embedded in the operating system's code, which seriously limited its flexibility in adding new operating-system personalities.

What proved to be most important, though, was simply that DOS and Windows support was there. Despite a dearth of OS/2-specific software, OS/2 sold some 2.5 million copies since OS/2 2.0 appeared—far more than in its previous history. While that was less than one-quarter of Microsoft's annual sales of Windows, it represented an astonishing comeback for OS/2 and provided convincing proof that the ability to run popular software could prove to be the difference between success and failure for a new operating system.

The comeback came at a high price. OS/2's Windows support used source code that was provided to IBM by Microsoft as part of the companies' technology-sharing agreement. To use the Windows code, however, IBM was required to pay a royalty to Microsoft for every copy of OS/2 that the company shipped. Although IBM never made public the details of the license, the company has reportedly paid Microsoft $20 per OS/2 copy, or more than $50 million since launching OS/2 2.0. Also, that royalty fee pushed OS/2's list price to more than $200.

But a new version of OS/2 changes both the economics and the technology of its Windows support. Code-named Ferengi when it was under development at IBM's Personal Software Products Division in Boca Raton, Florida, the new version is officially named OS/2 Special Edition for Windows, or OS/2 for Windows for short. As its name suggests, it functions as an upgrade to OS/2 for users who own Microsoft Windows. To install, it requires a system with DOS 5.x or higher and Windows 3.1. Once in place, OS/2 for Windows loads the actual Windows environment, modifying it on the fly, so that Windows support is virtually identical to that under previous versions of OS/2.

The business impact of OS/2 for Windows is clear: Because it incorporates no Microsoft Windows code, IBM pays no royalty to Microsoft. As a result, the list price of the package is less than half that of conventional OS/2.

The technical impact may be just as dramatic, at least for IBM's development team. In effect, OS/2 for Windows lifts up Windows and slips an OS/2 jacket around it. That approach will pose a major challenge for IBM developers with each new release of Windows; developers will have to work feverishly to upgrade OS/2 for Windows to tweak the new Windows binaries correctly. Still, their efforts may be no greater than the work required to integrate a new version of the Windows source code would have been.

Whether IBM's new OS/2-jacket approach to Windows support will have as great an impact on OS/2 sales as the improved DOS and Windows support of OS/2 2.0 remains to be seen. What is clear is that OS/2 for Windows effectively turns OS/2's DOS and Windows inside out.

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bundled with a large percentage of Unix workstations in the form of Wabi. Ironically, because they are so popular, the additional software sales may not make a big impact on them.

And the big losers? They're likely to be single-user productivity applications written specifically for Unix. Unix software developers already face major problems. Popular Unix workstations sell in the hundreds of thousands, not millions (like the Mac) or tens of millions (like the PC). Few software retailers carry any Unix applications at all. The combination of low volume and limited distribution means that Unix software vendors will be hard-pressed to compete against similar Windows or Mac programs. That could spell the end of the line for applications that don't take advantage of the special features of Unix—or any other advanced operating system.

In the end, the real impact of multiple personalities will be on users, in the form of easier access to better software and more freedom of choice in operating systems. That may not be great news for all operating-system or applications vendors. But for users who have ever needed software they couldn't run, multiple personalities are an important step toward sanity. ■

Frank Hayes is a writer, communications consultant, and former West Coast news editor for BYTE. You can contact him on BIX as "frankhayes."

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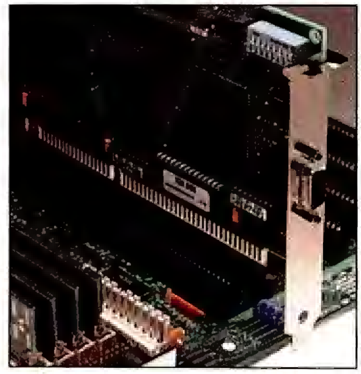

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Paths to Platform Independence

Building applications that run on the Mac, under Windows, in the Workplace Shell, and on the X desktop—from a single set of sources

STEVE APIKI

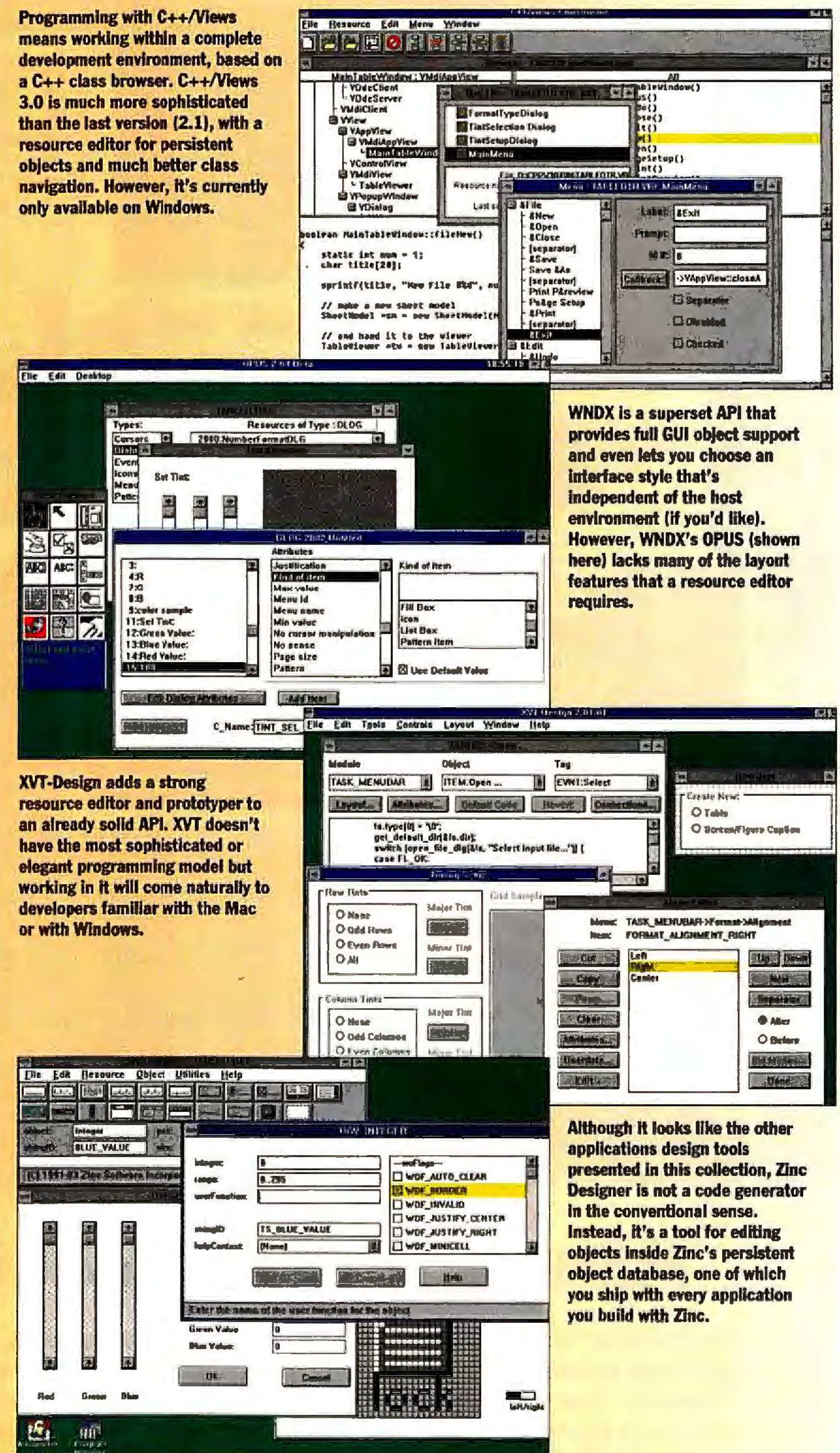
Portability tools won't forever settle the rivalry among the major computing platforms. Debates will continue to rage over whether the Macintosh is really easier to use than Windows, on the merits of Unix compared to Windows NT, or on the future of OS/2. But if you're a developer building applications using a multiplatform toolkit, you won't have to continue to bet your livelihood on the outcome.

Multiplatform toolkits provide an API and a set of libraries that allow you to develop an application one step removed from the underlying operating system. All four toolkits I'll review here provide these libraries for Windows, the Mac, X/Motif, and OS/2 Presentation Manager; some support many more platforms. When you build your application on top of the footing provided by these tools instead of directly on the underlying GUI, your software can run in a more-or-less native manner on whatever platforms the toolkit supports.

Common Groundwork

Fundamentally, all GUIs share a common groundwork: Whether you are running on a Mac or on OS/2, there are always elements like windows and dialog boxes. And all native GUI APIs provide ways to control these elements, as well as provide methods for handling other graphical entities like icons and bit maps. So all these toolkits must, at the very least, abstract these capabilities. But there are also fundamental differences among GUI operating systems, such as differences in file structure and platform-specific features like the Windows MDI (Multiple Document Interface) or the Mac's single-system menu bar. Effective abstraction means providing a single API that allows an application to act differently on each platform, to look and act the way you expect native applications to look and act.

I used each of these toolkits to build the guts of an application I've been wanting to write for some time, a simple spreadsheet-like tool that handles text formatting for tables. These packages really are toolkits—besides the library itself, each product (ex-



Programming with C++/Views means working within a complete development environment, based on a C++ class browser. C++/Views 3.0 is much more sophisticated than the last version (2.1), with a resource editor for persistent objects and much better class navigation. However, it's currently only available on Windows.

WNDX is a superset API that provides full GUI object support and even lets you choose an interface style that's independent of the host environment (if you'd like). However, WNDX's OPUS (shown here) lacks many of the layout features that a resource editor requires.

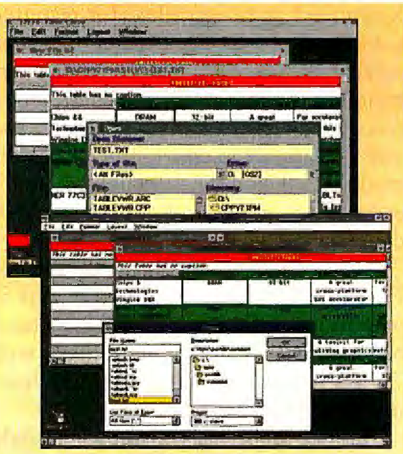
XVT-Design adds a strong resource editor and prototyper to an already solid API. XVT doesn't have the most sophisticated or elegant programming model but working in it will come naturally to developers familiar with the Mac or with Windows.

Although it looks like the other applications design tools presented in this collection, Zinc Designer is not a code generator in the conventional sense. Instead, it's a tool for editing objects inside Zinc's persistent object database, one of which you ship with every application you build with Zinc.

cept C++/Views 2.1) provides a tool for building applications elements (e.g., menus and dialog boxes) graphically and for hooking code to these graphical elements. I built the graphical structure of the table editor using the resource editor or prototyper each development environment provides. After doing the initial development under Windows, I ported the applications to the Mac, OS/2, and X/Motif (OSF/Motif from Integrated Computer Solutions running on Solaris 2.1).

I found that each of them will serve: All of them let you build real GUI applications with fairly sophisticated features and let you take an application across platforms with only a few tweaks. The difference is where each package chooses to make the trade-off between the ease with which you can get to that final port and the level of platform-specific customization you can provide when you're through.

C++/Views



- **Outstanding development environment based on a SmallTalk-like browser**
- **Simple programming model provides full GUI coverage and includes non-GUI objects**
- **Closed system makes it more difficult to migrate existing projects or manage projects with multiple programmers**

Liant Software's C++/Views is a high-level, strongly object-oriented multiplatform toolkit. Its dazzling array of classes abstract not only the underlying GUI but also the entire framework of an application, from classes that represent objects as real as buttons and windows to those that represent abstractions like collections and sets.

C++/Views is like SmallTalk both in its set of classes and in the way it lets you design your applications. You work with C++/Views through a class browser. The browser presents C++/Views' entire class hierarchy in a window; you build your application by choosing appropriate classes out of the hierarchy and deriving appropriate classes from them.

I built the table editor as an MDI application (C++/Views supports MDI functions on all supported platforms) by deriving my main window from C++/Views' MDI-application class. When you derive a class, C++/Views creates new C++ source and header files in the background. It presents class members in another window and lets you view headers or edit member functions in a third. During the entire application-building process, you never see an entire source file; your view on the project is always through the browser's class orientation. The result is a much clearer view of the overall structure of your application, and it's easier to focus on the design of the application, rather than the drudgery of keeping track of C++ source and header files.

The high-level classes in C++/Views can mask the structure of the underlying GUI. Although there is an event class for handling system-specific events, I never had to worry about these low-level events when building the table editor. Instead, I just built member functions like `paint()` and `mouseDn()` to override the default members of the window class from which I derived my view window and responded to those events inside those functions.

Despite its high level of abstraction, C++/Views makes concessions to more procedural techniques when it makes sense. To open a standard file status dialog box, for example, you call a static member function of the file status dialog box class, which simply constructs a modal file dialog box and returns when the dialog box is complete.

C++/Views is currently shipping in two distinct versions: 2.1 and 3.0. The differences between the two are significant enough to have an impact on the way you build your applications. Version 2.1 totally lacks resources; you have to build menus, dialog boxes, and other objects that are usually built from resource templates from scratch, programmatically. Although C++/Views provides classes (e.g., dialog box and menu-handling classes) that reduce some of the work involved, this is still a serious lack.

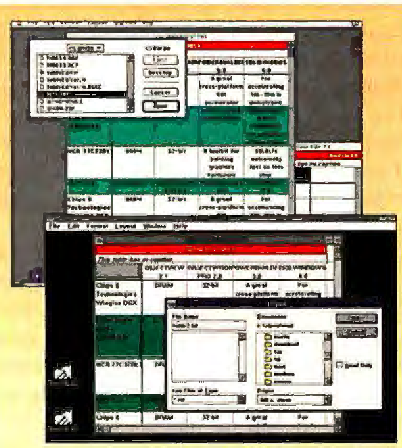
Version 3.0 fixes this problem (and goes well beyond) by adding persistent object storage, which not only gives you a mechanism for storing these menu and dialog box objects but also gives you a repository for objects of your own design.

Version 3.0 also adds a nicer browser interface (e.g., adding the capability to find a class, rather than searching the hierarchy as you must do in 2.1) and a resource editor. Unfortunately, version 3.0 was only available on the Windows platform as this article went to press, so it wasn't very useful as a cross-platform tool. Liant plans to ship Mac, Presentation Manager, and Motif versions by the beginning of this year.

Even in version 2.1, C++/Views is a great environment; almost good enough to choose regardless of its multiple-platform support. It was the most immediately productive toolkit in this review. But even though it is excellent for single-user projects, C++/Views abstraction of the collection of source files makes it difficult to coordinate work among several programmers on a single set of sources and to migrate an existing set of C++ sources into the environment (although it has an import utility).

Some minor pieces are missing (e.g., the ability to add bit maps to menus) and some extra strengths (e.g., great handling of fonts and text). I found C++/Views an outstanding tool, but ultimately, your reaction to C++/Views will depend on whether you're willing to work at a considerable distance from the underlying native GUI for the gain in simplicity of design.

WNDX



- **Can create GUI styles independent of host environment**
- **Some native features hard to reach**
- **Comprehensive set of GUI elements**

With most multiplatform libraries, the underlying interface is abstracted into elements like the screen, windows, and controls. As a programmer, you don't know whether or not the scroll bar that's sending you messages is a Windows-style scroll bar attached to the window frame or a Motif-style proportional scroll bar. WNDX takes a different approach by emulating non-native window elements on all the platforms it supports—if you want to work with a Motif-style interface, WNDX will create it for you even if you are on Microsoft Windows. This is a slick feature, and it works well, but unless you want an application that will look and feel exactly the same on Motif as it does under Windows, you are probably better off sticking with native controls, which WNDX also supports.

Ironically, although WNDX can add non-native behavior, it's difficult to get to some native functions. For the table editor, I wanted a view window with horizontal and vertical scroll bars attached to the window frame, an interface feature that both the Mac and Windows support directly. However, there is no style that lets you do this under WNDX, and I ended up having to float scroll bars near the edge of the window to emulate this behavior in my program. Since I couldn't get system scroll bar widths on the WNDX for Mac beta version I tested (a shortcoming WNDX says will be addressed shortly), the scroll bars I tried to draw in the usual scroll bar area didn't quite fit or look like Mac scroll bars.

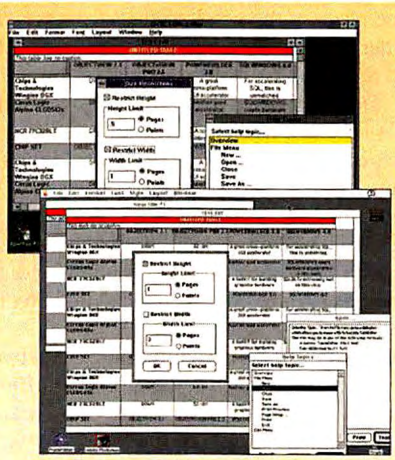
In addition, WNDX's full customization extends to icons; therefore, it provides a set of icons to which you can refer inside the library (other resource template information is stored in an ASCII file that ships with your completed application). The icons can look a little out of place, for example, in a Windows MDI window. If you want to add native icons, you have to tack them on in a platform-dependent manner.

The positive side to customization is a rich set of built-in windows objects, like 2-D lists that work almost exactly like Macintosh lists. I couldn't use lists as a base for the table editor because I wanted a grid that appeared to be infinite; however, the WNDX list supports almost every other behavior I wanted for the table editor and would be good for simple spreadsheets.

In the design of the WNDX library, almost all Window behaviors are controlled through attributes. WNDX elements have some degree of object orientation: WNDX elements that share common attributes are plug-compatible since you get and set all attributes through a common interface. But I found working within this framework a little disorienting for two reasons: First, because the attribute list is so large, it's hard to find the attribute you want to set when you aren't an experienced WNDX programmer, and second, I found it unnatural to initiate what I would think of as an action (e.g., moving a window) by setting an object's position attribute. However, the WNDX API is large, and in addition to handling every GUI event, there are many cover functions (e.g., `WND_Move()`) that mask the attribute setting calls. Once you get a handle on the API, programming WNDX is straightforward. The `main()` function handles and dispatches events to other parts of the system; you trap those events through callbacks and then you respond.

You can create resources and set up callbacks using WNDX's OPUS prototyping tool. OPUS was probably the weakest prototyper among those provided with these libraries. There's little layout support in dialog boxes (i.e., no alignment or spacing capability), and OPUS doesn't build make files for its projects. You have to run an external `mkmake` utility that builds a simple make file from the sources themselves.

XVT



- **Complete platform coverage and the most well-supported API**
- **Uses native resources built from common scripts**
- **API familiar to Mac and Windows programmers**

XVT Software's XVT doesn't really have any razzle-dazzle features—no object orientation, no low-level customization, and no emulation of non-native controls. But it has what I'd consider most important: an obvious and comprehensive API, a great design tool, and third-party support that the other products don't approach.

If you're already familiar with Mac or Windows programming, you probably won't find a more comfortable API than XVT's. The programming model of XVT is close to that of the Mac, and I was able to transition more easily to XVT from full-time Windows programming in C than to any other cross-platform tool.

XVT's resource handling is also the simplest; you build resource templates for XVT's resource format using a simple resource description language, or by using the design tool, XVT-Design. Once a resource is built, you use CURL (XVT's resource compiler) to build a native binary format that gets attached to the executable file. XVT's greatest shortcoming in resource handling is a lack of support for bit-map formats that can move between platforms; an upcoming release of XVT should address that problem.

XVT-Design is an easy-to-use resource editor and prototyping tool that builds entire projects, including URL (Universal Resource Language) files (for resource compilation by CURL), source files, and make files. You can attach common event handlers like XVT standard dialog box functions directly within XVT-Design, and you can also type entire procedures directly into the editor, although I found it easier to edit templates later in a more standard fashion.

XVT-Design can automatically include File, Edit, and other standard menus in your resource file. XVT-Design also has a built-in Font menu that goes nicely with XVT's transparent handling of system-independent fonts.

Besides fonts, XVT also handles help information in a portable, standardized way. However, the format of the help file is rudimentary (it handles only one level of help, and there's no real index), so you may be better off skipping this standard feature.

Most cross-platform toolkits don't abstract memory handling very well, so moving between a 32-bit flat model to a segmented pointer architecture can be messy. If you know you are going to need large memory objects (as I'd like to be able to handle for the table editor), you can use XVT's global allocation functions to get handles to memory that can extend past 64 KB. This is slow under 16-bit Windows, but the protection from faults when moving from platform to platform is worth the trouble for a few large objects.

Had XVT Software released its promised PowerObjects custom controls in time

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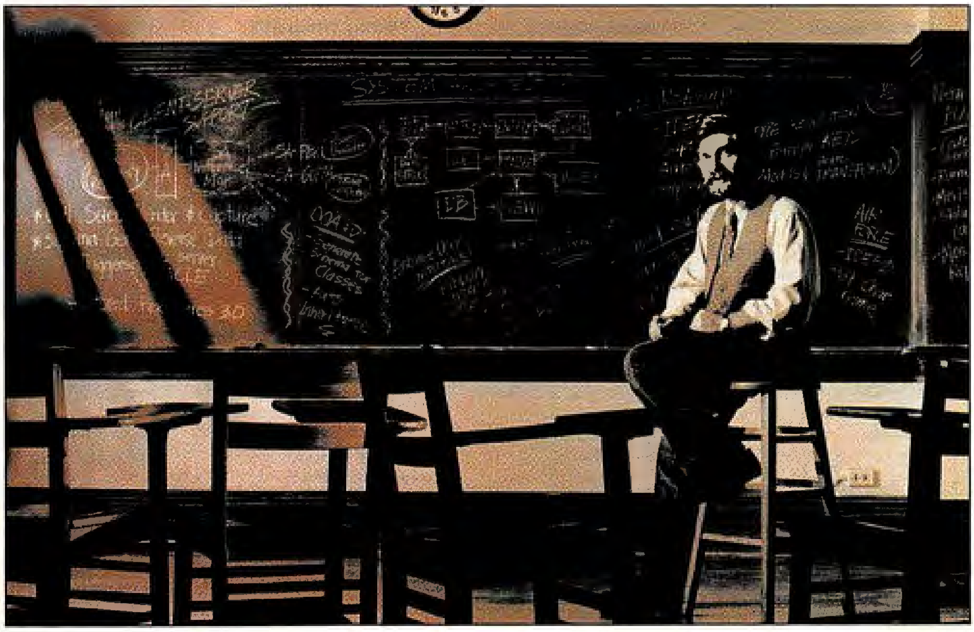

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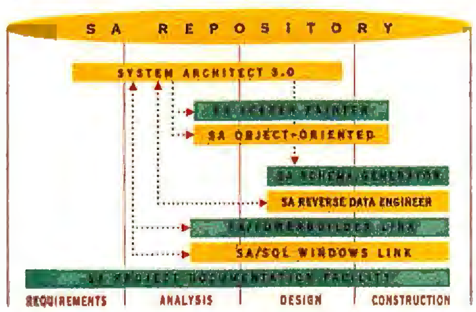

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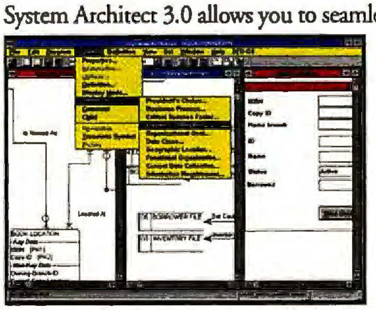

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MULTIPLATFORM TOOLKITS

A portable development tool has to cover your requirements for platform support. XVT and Zinc have the most complete coverage, but if you don't need to handle some of the more exotic platforms, WNDX and C++/Views cover the most popular desktop systems.

	C++/VIEWS	WNDX	XVT	ZINC APPLICATION FRAMEWORKS
Platform support	Windows, Macintosh, X/Motif, OS/2 PM	Windows, Windows NT, Macintosh, X/Motif, OS/2 PM, DOS Graphics	Windows, Windows NT, Macintosh, X/Motif, X/OpenLook, OS/2 PM, Character Interface, DOS Graphics[1]	Windows, Windows NT, Macintosh, X/Motif, Curses, OS/2 PM, DOS Text, DOS Graphics, PenDOS
Libraries				
Versions reviewed				
Windows	C++/Views 3.0	WNDX 2.04 for Windows	XVT/Win 3.02	Zinc Application Frameworks 3.5
Macintosh	C++/Views 2.1	WNDX 2.04 for Macintosh	XVT/Mac 3.02	Zinc Application Frameworks 3.5
X/Motif	C++/Views 2.1	WNDX 2.04 for X/Motif	XVT/XM 3.02	Zinc Application Frameworks 3.5
OS/2	C++/Views 2.1	WNDX 2.04 for OS/2	XVT/PM 3.01	Zinc Application Frameworks 3.5
Library source code provided	Included	Partial[2]	Optional	Included
Tools				
Resource editor	Windows (version 3.0) only	Yes	Yes	Yes
Visual prototyper/designer	Windows (version 3.0) only	Yes	Yes	Yes
Class browser/editor	Yes	N/A	N/A	No
Language	C++	C	C, C++[3]	C++
Compiler support				
Windows	Microsoft C/C++ 8.0, Borland C++ 3.1, Symantec C/C++	Microsoft C/C++, Borland C++ 3.1, Watcom C/38 9.5	Microsoft C/C++ 8.0, Borland C++ 3.1	Microsoft C/C++, Borland C++ 3.1 Symantec C/C++
Mac	MPW 3.2	Think C 5.0, Symantec C++ 6.0	MPW 3.2, Think C 6.0	Symantec C++ 6.0
X/Motif	Sun, HP-UX, SCO	ANSI-compliant C with prototypes	Native Compilers for Platforms, GNU C	Cfront 2.1–compatible
OS/2	Borland C++ for OS/2	Borland C++ for OS/2	Borland C++ for OS/2, IBM C/Set	Borland C++ for OS/2, IBM C/Set
DOS	None	Microsoft C/C++, Borland C++ 3.1, Watcom C/386 9.5, MetaWare High-C 3.0	Microsoft C 6 and C/C++ 7.0, Borland C++ 3.1	Microsoft C/C++, Borland C++ 3.1, Symantec C/C++
Portable feature support				
Resource/portable data mechanism	Version 3.0: persistent objects Version 2.1: none	ASCII data file	Native resources built from common scripts	Persistent objects
Printing/print dialog boxes	Yes	Windows, Macintosh, OS/2 PM only	Yes	No
Help	No	Yes	Yes	Yes
Icons	No	Yes	No	Yes
Strings	No	Yes	Yes	Yes
Bit maps	Yes	Yes	No	Yes
Toolbar	Yes	Yes	No[4]	Yes
Custom controls	No	Yes	Yes	No
Native standard dialog boxes	Yes	Yes	Yes	No
Undo support	Yes	No	No	No
DOS graphics[1]				
Resolutions supported	N/A	EGA, VGA, SVGA	—[1]	CGA, EGA, VGA
Fonts supported	N/A	Metagraphics fonts	—[1]	Up to 10 bit-mapped fonts
Printer support	N/A	Some	—[1]	—[1]
Third-party tools available	None	Database tools for Windows, X/Motif, DOS	Extensive support	For DOS, including graphics tools
Technical support	Included	30 days included, then optional	Six months included, then optional	60 days included, then optional
Pricing[5]	Windows (version 3.0): $749 Macintosh: $1499 X/Motif: $1999 OS/2 PM: $999	$695 per platform	Workstation platforms: $6300[6] All other platforms: $1950[6]	Engine: $499[7] X/Motif Key: $1499 OS/2 Key: $299 PenDOS Key: $299 Windows NT/Win32 Key: $299 Macintosh Key: price not set Curses Key: price not set
Platform-specific				
Windows				
Create DLLs	Yes	No	Yes	No
Mac				
Multiple screen support	No	Yes	No	No
OS/2 PM				
Create DLLs	Yes	No	Yes	No
Drag and drop	No	No	Yes	No

[1] No direct support; supported through third-party tools
[2] Source for custom controls, style guides, examples, and tutorial
[3] C++ support from Power++, currently prerelease
[4] Supported by XVT PowerObjects
[5] All prices listed include design tools, libraries, and documentation
[6] Designer and libraries also sold unbundled
[7] Zinc installations require an engine and one key per platform
N/A = not applicable.

How Do You Know You've Got The Right Software Protection?

Your software protection strategy shouldn't be a hit or miss proposition. But with so many conflicting claims about one vendor's product being better than another, we can understand why you might want to leave it to chance.

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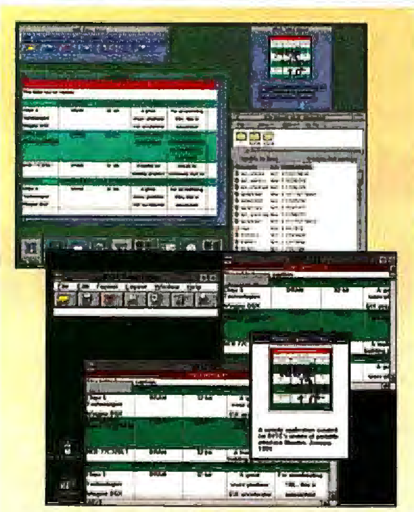
for this evaluation, I would have based my table on a spreadsheet PowerObject. As it was, I ended up building a more limited table in my own code.

Where XVT falls shortest versus C++/Views and Zinc is in customization. The C++-based systems, both of which provide source code, are readily customized, while XVT's C-based library is not. As I wrote this review, XVT Software was nearing release of Power++, its C++ product. Power++, unlike XVT++ (XVT's earlier C++ product), is a high-level application framework that will eventually form a foundation for PowerObjects. It won't yet bring XVT into the highly abstracted realms occupied by C++/Views and Zinc Application Frameworks.

Nevertheless, XVT today is the most straightforward and stable path between Windows and Mac programming and programming to an abstract GUI. Pending improvements like portable bit maps and PowerObjects will make XVT an even stronger contender.

Zinc Application Frameworks



- **Totally flexible and configurable framework**
- **Event-centered class model is complex and difficult to learn**
- **Excellent collection of window objects for input**

Both Zinc and C++/Views are based on C++, but the similarities end right about there. While C++/Views takes a very high-level, abstract view of the problem domain, Zinc uses the benefits of C++ to provide powerful customization features and an extensible, extremely flexible API.

Zinc abstracts low-level features such as devices, window objects, and events; it does not abstract event handling for every window object. In fact, direct handling of events are the model in Zinc—you handle system events, logical events sent by Zinc, and even use events sent through the event queue to communicate with other objects inside your program.

This abstraction of features like events and devices makes handling custom behaviors on different platforms easy; you can get a logical event from the system that tells you to redisplay a window, or you can translate the actual WM_PAINT message that it represents when you're running on Microsoft Windows. You can build a single executable file that can handle DOS graphics and DOS text simply by setting the appropriate virtual display; all the other code in your system remains intact.

It's not all low-level. Zinc does provide powerful, high-level classes like toolbars, and a systemwide help system that allows you to maintain context-sensitive help just by assigning help contexts to objects. Zinc also has the most complete collection of input objects, like formatted strings and other windows objects that can verify entry. And Zinc's window objects are true objects, so they connect together as easily as Lego blocks. For example, you can build a scrolling list box with text objects, then use the same code to present a list box that includes bit maps. You just have to hand bit-map objects to the list box instead.

One of Zinc's most powerful features is its object repository, which stores resource-type and other objects in a persistent object database. The Zinc Designer, Zinc's analog to a resource editor, actually instantiates these objects as you work interactively with the design. The database is hierarchical, which lets you store multiple, linked copies of objects, say one menu object in English and another in Spanish, for later retrieval. In upcoming releases, Zinc plans to add unicode support to accommodate double-byte languages.

Unfortunately, all this flexibility gives Zinc a steep learning curve. It's always hard to find the handle on C++ application frameworks, because it takes some time to know where you should look for the entry point in a class hierarchy. C++/Views addresses this to some extent with the browser, but there is no similar feature in Zinc.

I got most of my sample application done using Zinc, but I confess that I never knew whether I was using the best design to handle a problem or whether I'd used the right class or done things the easiest or most efficient way. Keeping track of events and grappling with the class hierarchy was a daunting task. If you have the time to learn it well, Zinc is potentially the most powerful package in this collection; however, don't expect to become skilled at Zinc programming quickly.

Cross-Platform Picks

Choosing a cross-platform development environment is not a trivial undertaking. Once you've made the choice, you will have to commit a great deal of development effort to building code that is completely dependent on the toolkit and the toolkit's future. But that investment is made worthwhile by the elimination of learning new native APIs and by the effort saved in not having to maintain multiple code bases.

The payoff to this investment makes learning even a complex package like Zinc potentially worthwhile. Or, if you're looking to C++ to provide an elegant, design-focused development model, C++/Views would be an excellent choice. But I'm going to finish only one version of my table editor, and I'm going to do it in XVT. XVT's simple API, strong tools, and strong industry-support guarantee that the time and money invested in shifting to a platform-independent GUI will pay off in reduced effort down the road. ■

Steve Apiki is senior developer at Appropriate Solutions, Inc., a Peterborough, New Hampshire–based consulting firm specializing in cross-platform development. He is also a BYTE contributing editor. You can reach him on the Internet or BIX at apiki@bix.com.

About the Companies

Liant Software
(C++/Views)
959 Concord St.
Framingham, MA 01701
(800) 237-4873
(508) 872-8700
fax: (508) 626-2221
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The WNDX Corp.
(WNDX)
1550 8th St. SW,
Suite 305
Calgary, Alberta,
Canada T2R 1K1
(403) 244-0995
fax: (403) 244-1030
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XVT Software, Inc.
(XVT)
4900 Pearl East Circle
Boulder, CO 80301
(800) 678-7988
(303) 443-4223
fax: (303) 443-0969
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Zinc Software, Inc.
(Zinc Application Frameworks)
405 South 100 E
Pleasant Grove, UT 84062
(800) 638-8665
(801) 785-8900
fax: (801) 785-8996
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Opening Night for Premiere 3.0

If you've got the hardware to handle it, the newest version of Adobe Premiere delivers powerful tools for multimedia productions

BOB LINDSTROM

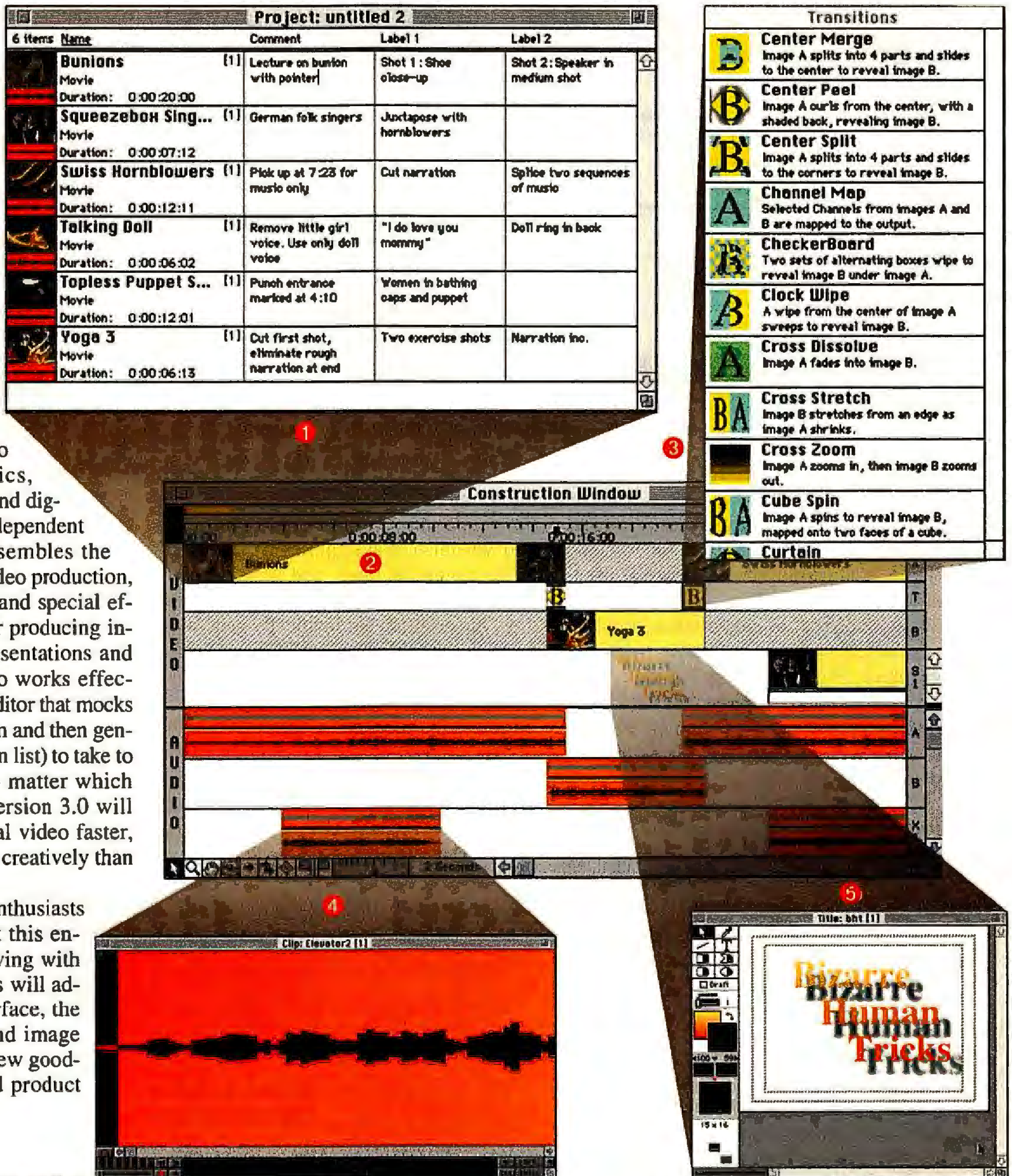
Adobe Premiere was a landmark program when it came out in December 1992. As one of the first video creation and editing tools for the Macintosh, it introduced a whole new audience to the possibilities of desktop video and helped boost the legitimacy of Apple's QuickTime video standard.

Premiere's greatest strength has always been its intuitive interface. Video editors can place graphics, animations, digital video, and digital audio onto rows of independent tracks. Premiere then assembles the tracks into an integrated video production, complete with transitions and special effects. It is an ideal tool for producing inexpensive multimedia presentations and training videos, but it also works effectively as an off-line video editor that mocks up a final cut in digital form and then generates an EDL (edit decision list) to take to a professional studio. No matter which way you use Premiere, version 3.0 will have you producing digital video faster, more efficiently, and more creatively than ever before.

While some Premiere enthusiasts may be disappointed that this enhancement is not overflowing with major new features, others will admire the streamlined interface, the improved performance and image quality, and a few brand-new goodies that make a very good product even better.

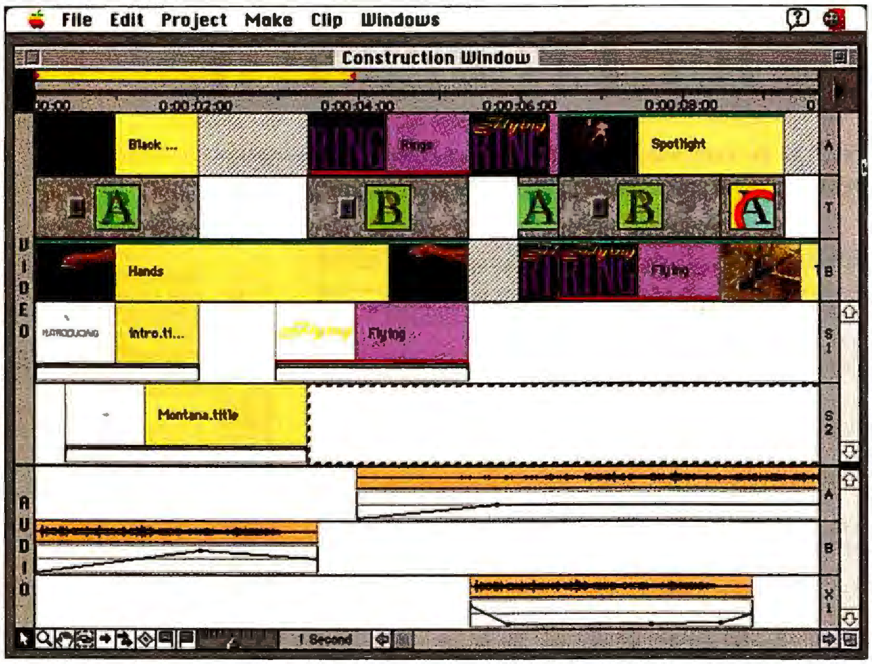
The Way It Works

Using the familiar multitrack audio/video interface that is fast becoming the standard for multimedia presentation software, Premiere lets you mix several audio tracks and cut between two digital video/graphics tracks in the style of an analog A/B Roll videotape-editing system (i.e., two players feeding into a single



❶ In creating a Premiere movie, you start by assembling video, audio, and graphics in the Project Window. ❷ You then drag-and-drop clips onto a track in the Construction Window. Note the time line across the top of the window. Premiere saves the SMPTE time code that identifies the clip. ❸ You select special transition effects from the Transitions screen and place them on an effects track of the Construction Window. ❹ From the Audio Clip Editing Window, you can edit a sound file and drop the finished clip onto an audio track. Premiere combines all the digital audio tracks into a single soundtrack. ❺ Gradient-filled titles are created in the Title Window and added to the Superimpose track. You can preview your work before committing it to tape or disk. When you're finished, Premiere assembles all the elements into an integrated digital movie or generates an EDL in one of several common formats.

Opening Night for Premiere 3.0



Adobe Premiere 3.0 *provides up to 99 video and 99 audio tracks for placing and synchronizing video, audio, graphics, and text in elaborate QuickTime movies.*

recorder). Not only can you process the basic video quality of the images, but you can also apply elaborate transitions and manipulation operations (e.g., fades, blurs, wipes, distortion, zooms, posterization, and tumbles) to video tracks. You can even combine effects to create mind-boggling special effects or superimpose titles and graphics. Premiere compiles the results into a digital movie, either in QuickTime or, when enhanced by a Premiere Plug-In extension, in some other digital video compression format.

Creating a video is as easy as creating a Project window that contains your raw audio, video, and other materials, each represented by a small icon or thumbnail representation. To place the clip in the video, you drag its icon onto an audio/video track and position it within the time line.

You can get a relatively quick Preview of the movie, or you can send the Mac off into number-crunching land for several minutes and output a completed movie to a digital file or videotape. Generating even a relatively brief QuickTime movie with extensive effects, however, will take 15 to 30 minutes or more, even on a fast Mac.

Premiere's digital video muscle has made it a top-of-the-line QuickTime movie creator. However, when used with a professional computer-controlled videotape deck, Premiere can also function as an off-line video-editing system.

From within Premiere, you can control your tape transport and save digital video clips with an internal capture board. Premiere remembers and saves the SMPTE time code that identifies the clip. When you've finished assembling your audio/video materials, titles, and transitions in Premiere's multitrack Construction window, the program automatically generates an EDL in one of several common formats, including Sony BVE, Grass Valley, CMX 3400, or any format supported by a Premiere Plug-In extension.

The admission cost for all this video magic is a relatively powerful Macintosh system. Premiere 3.0 requires a Mac with a 68040 processor, 4 MB of free RAM (6 to 20 MB is recommended), an 80-MB or larger hard drive, System 6.0.7 or higher, QuickTime 1.6 or higher, and 32-bit QuickDraw 1.2 or higher.

The list price for Premiere 3.0 is $695. A CD-ROM-based deluxe edition is $795; it includes QuickTime tutorials, Adobe Acrobat Reader software, video clips, and Adobe's Type On Call font CD-ROM. Current Premiere owners can upgrade to the floppy disk version for $179 or the CD-ROM version for $249.

You can proof digital clips and transitional effects, like the center peel effect shown here, in Premiere's preview window.

Even More Tracks

With version 3.0, Premiere wizards will be able to develop enormous projects. The program now includes up to 99 audio tracks and 99 video tracks.

The gain on each audio track can be controlled separately for refining the mix. When you create a movie, Premiere combines all the digital audio tracks into a single soundtrack. The miracle of digital sound mixing is very apparent: The audible results are clean and noise-free, even when a dozen tracks are being mixed together. While few users will exhaust all these audio resources, the additional tracks let Premiere produce unusually complex, layered soundtracks.

Similarly, the additional video tracks, actually added as Superimpose tracks, provide the power to concoct extensive visual overlays, animations, titles, and other tricks, each with individually controlled motion paths, display transparency levels, and video filters. More video tracks add up to increased flexibility when designing Chromakey-like mattes.

Another new feature, the *virtual clip*, exploits the abundance of video tracks. Any multitrack segment can be defined as a virtual clip and subjected to as many as eight levels of processing and transition effects. You could, for example, define a dissolve between two video segments as a virtual clip, add a motion setting to that clip, and then wipe from the dissolving clips to a third clip. The virtual clip takes Premiere 3.0 a quantum leap forward in producing intricate video effects.

Better Video

Even if you aren't prepared to challenge MTV with a virtual-clip crazy quilt, the new tools and features in Premiere 3.0 can improve the fundamental video quality of all your work. When you are using a QuickTime-compatible video-capture board to store digital video from within Premiere, the video Waveform Monitor and Vector Scope contain new tools to fine-tune the quality of your capture.

A lineup of on-screen sliders gives you the usual controls over hue, color saturation, brightness, contrast, sharpness, black level, and white level. The Waveform Monitor charts the luminance and color saturation. The Vector Scope shows the hue and saturation levels. The best way to exploit these new tools is to play back a color-bar pattern from your input source and then adjust the sliders to maximize the quality of your source video capture,

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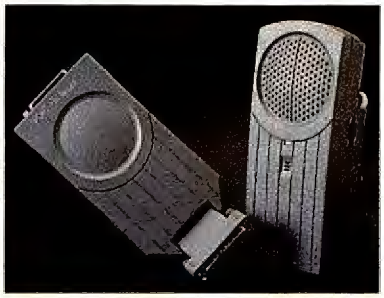

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just as if you were using analog instruments in a video studio. If you lack the color-bar display, a Source Video preview window lets you make adjustments to please your eyes.

Veteran Premiere users may also notice an improvement in the quality of transitions and motion effects. The program is now able to apply subpixel motion (down to 1/256 pixel) and field rendering to all effects to guarantee the smoothest possible movement with no image breakup. Even convoluted digital effects can now be executed, with polished results that are worthy of an expensive, professional video generator.

Making Noise

In addition to those plentiful audio tracks, Adobe has also whipped into shape its editing support for digital audio by increasing markers, improving the editing display, and adding full support for Apple's Sound Manager.

Up to 1000 markers can be accurately placed within audio clips to provide video sync reference points. When positioning video in the tracks of the Construction Window, you can "snap" the clip to these audio markers.

There's no need to guess where a particular part of a sound sample begins. The upgraded sample-editing display lets you view samples in displays as large as half a screen and at a variety of zoom levels. From within Premiere you can get right down to individual audio cycles for those delicate cut-and-paste operations.

Like its audio abilities, Premiere's Titling capability gets significant attention in version 3.0. Several new effects are available, including gradient fills that can be applied to all objects from simple titles to shadows. You can even add a gradient to an alpha channel mask; this allows you to superimpose one image on top of another with varying levels of transparency across the image surface.

Other new effects include title drop shadows, optional antialiased "soft" shadows, and polygons. When designing titles, you can now drag a visual clip into the Title window to see how your creation looks against its intended background. Title development also benefits from an increased refinement in transparency settings and expanded "key" capabilities, including a traveling matte for generating moving keys.

Fine-Tuning the Interface

A bundle of features have been put into version 3.0 to ease the inevitable strain of juggling cutting-edge multimedia technology. Throughout the product, large and small refinements to interface and function make Premiere easier to use.

When you are using a computer-controlled deck and SMPTE time codes to digitize video clips, Premiere has a batch digitizing mode. Just identify your clips by their SMPTE time codes, and Premiere will digitize and save the lot while you duck out for a quick, or not-so-quick, beverage break.

In past versions of Premiere, you could get lost in the morass of preferences and variables. With 3.0, you can create presets for all program settings and save them to disk. For example, you can use one preset when you're developing for CD-ROM, load another for digitizing, and apply still another when creating multimedia presentations. And you won't have to guess whether you covered all the bases: Set it up right once, save the preset to disk, and your preferences will always be correct.

Thumbnail images of clips are viewable in all windows in a range of user-selectable sizes and configurations. Similarly, click-and-drag operations are more convenient because you can now select multiple items and drag them together. More important, however, the Preview function has been accelerated and expanded. You'll find yourself spending less time staring unproductively at the Mac while waiting to see the test results from your latest digital edit.

If you are working on only one segment of a movie, you can update the portion of the preview that has been altered without touching the rest of the sequence. Previews can also be played from disk at full frame rates.

When you ultimately get around to the Make Movie process, the system creates the final product without unnecessarily reprocessing the effects and transitions. Movies that contain no digital transitions or effects can be processed almost immediately.

While these convenience features may not be as attention-getting as some of the other improvements in 3.0, the time-saving improvements are like manna from heaven for Premiere users with short deadlines and a tendency toward impatience. This new version will get you to the final product quicker than ever.

About the Product

Adobe Premiere 3.0
Floppy disk version $695
Upgrade $179
CD-ROM deluxe version $795
Upgrade $249
Adobe Systems, Inc.
1585 Charleston Rd.
P.O. Box 7900
Mountain View, CA 94039
(800) 833-6687
(415) 961-4400
fax: (415) 961-3769
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Premiere Screening

So how does it work? Premiere performed superlatively using video clips that I captured with New Video's high-end Eye-Q system, a full-screen, full-motion audio/video capture and compression setup. Furthermore, it used Eye-Q's QuickTime acceleration and video display features transparently.

My one warning: You need a very powerful hardware configuration to make the most of Premiere. Don't take the 4-MB RAM requirement or even the 6-MB recommendation seriously. When I took my system down to 8 MB, I experienced frequent program errors when previewing brief video creations. Worse, I also experienced several system crashes, including one that corrupted the hard drive—all apparently due to memory shortages.

Premiere was otherwise bullet-proof, performing like a trooper even when I threw multiple audio and video tracks at it. I was especially impressed with its speed and quality when mixing down 10 or more audio tracks. Just be sure to have plenty of RAM. I'd recommend at least 16 MB.

Another point that can't be overstated is the need for lots of hard drive storage. The Eye-Q board can compress video down to 9 MB per minute, but even at that, it's not going to take long to fill a disk. Trust me—after spending a few hours with Premiere, those 1-GB hard drives will start to look very tempting.

Finally, generating a few seconds of video, mixing several audio tracks, and calculating a couple of digital transitions took 3 to 4 minutes on my Centris 650. If time is an issue (and time is *always* an issue), you'll want the fastest Mac you can get when running Premiere.

But if you have the hardware and storage space to back up its remarkable power, Adobe Premiere 3.0 is a masterpiece at the cutting edge of multimedia technology. There is enough functionality, flexibility, and sheer fun here to keep even a hypercharged creative mind going for years. ■

Bob Lindstrom (Eugene, OR) is a nationally syndicated columnist and composer. He is a former creative director for Dynamix. He can be reached on BIX c/o "editors."

Digital-Media Power

Silicon Graphics' new Indy workstation is low on price but high on graphics performance, and it works with both Macs and PCs

BEN SMITH

I usually avoid spending words on ease of installation. After all, you install a workstation once; you run it every day. I'm making an exception for the Indy, however. In taking a second look at Silicon Graphics, Inc.'s new low-cost workstation, I found the Indy exceptionally easy to set up and use, as well as entertaining. In a month of hands-on use and testing, I also found it as fast and capable with graphics, sound, and video as I'd expected. (For hardware details on how the Indy achieves its performance, see "Apple, SGI Blaze Video Trail," September 1993 BYTE.)

The fun begins as soon as you open the Indy's shipping box. Next to the keyboard and mouse, you'll find red, blue, and yellow rubber balls—for juggling—and a colorful poster that shows how to assemble your system. If you resist an attempt at juggling, you can easily have the system up and running in under 15 minutes.

Serious Fun

The system comes with software loaded. Press the power button on the front of the compact system, and you'll soon find yourself on an introductory musical-video tour of what SGI and the Indy can do. The theme is "serious fun," and the three juggling balls show up as video icons that lead you through a pleasing collage of graphics, video, sound, and voice, all forms of data that can be used seriously in what SGI terms *digital-media communications*.

The IRIX log-in screen has icons for each user. Beside `root`, `guest`, and `tutor` are two accounts that will attract your attention: EasySetup and OutOfBox. You click on EasySetup to give your system a name and network address and to set up the account for the major user. OutOfBox restarts the colorful introductory tour. The `guest` account holds all the demo applications; the `tutor` account gets you up to speed with SGI's new Indigo Magic user interface and its associated work spaces, buttons, windows, and icons.

The Indy is a new system with a significant amount of new hardware and an entirely new design of the operating-system interface. In fact, the operating system is different right down to its core. IRIX 5.1 is an SGI-enhanced release of Unix System V release 4.1 with all of its capabilities for memory-mapped files, dynamic shared libraries, and run-time linking, plus more facilities for real-time event handling.

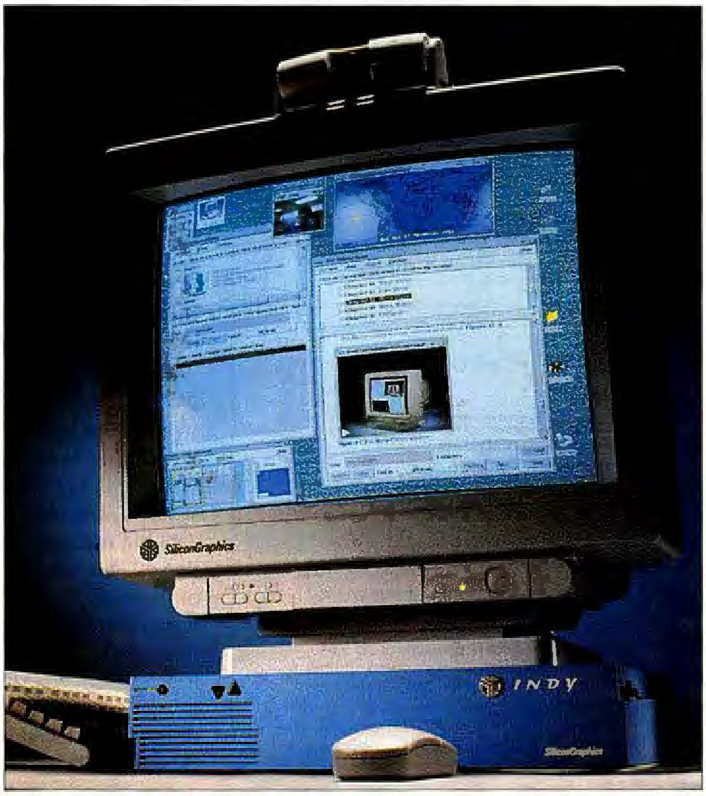
More for Less

Compared to the Indigo, SGI's original venture into the general-purpose computing market, the Indy is visually less cute and more practical. From an ergonomical point of view, the Indy is even quieter than the quiet Indigo, and its compact workstation form factor fits the desktop better than the Indigo's mini-tower. More important, the Indy is faster at general computing operations while costing substantially less than the Indigo it replaces in SGI's workstation line.

Even more so than with the Indigo, SGI has priced the Indy for commonplace computing—desktop publishing, computer-based communications, database access, and graphical image manipulation. Prices start at $4995 for a diskless workstation with 32 MB of RAM, 8-bit video, and a 15-inch monitor. The hardware emphasis is on 2-D graphics, rather than the 3-D graphics performance that SGI built its reputation on.

The Indy's main memory expands to 256 MB, and there are two bays for mass storage devices. Drive options include hard drives of up to 1 GB in capacity and a 21-MB floptical drive that can read and write MS-DOS and Mac 3½-inch high-density disks. The base model comes with an 8-bit color display system and a 15-inch monitor (1024 by 768 pixels), but you can upgrade to 24-bit color and larger monitors (up to 19 inches diagonally).

Besides a keyboard and mouse, a digital color camera (IndyCam) and a microphone also come standard with the Indy. Other standard capabilities include built-in Ethernet ports, four-channel stereo, several types of video port, and an ISDN connection. The system that I evaluated came with the 24-bit color graphics option, 64 MB of RAM, a 1-GB hard drive, and the floptical drive, as well as an external CD-ROM drive for loading sound, images, and software updates and other licenses. The total hardware list price for this configuration is $23,695.



SGI's new Indy *workstation features a $4995 base price, strong 2-D graphics, hardware support for audio and video data, and built-in Ethernet.*

The Indy gets its performance from a Mips R4000 CPU. The R4000 RISC chip uses superpipelining and runs internally at 100 MHz. I ran BYTE's Unix benchmarks as well as our new portable low-

PERFORMANCE RESULTS

BYTE's benchmark results are indexed. On the Unix benchmarks, a Sun SparcStation 1 running SunSoft 4.3 = 1. The results below show SGI's Indy to be roughly 6.5 times faster overall than the SparcStation. For individual low-level portable benchmark tests, a 60-MHz Pentium with a 256-KB cache, a 64-bit data path, and 24 MB of RAM running MS-DOS with a 32-bit DOS extender = 1. The results put the Indy at roughly 1.5 times faster than the Pentium.

TEST	INDY
UNIX Benchmarks	
Arithmetic test (double)	8.7
Dhrystone 2 (w/o register variables)	4.5
Execl throughput	5.2
File copy (30 seconds)	16.2
Pipe-based context switching	2.2
Shell scripts (eight concurrent)	2.9
Portable Benchmarks	
Numeric sort	0.89
String sort	0.43
Bitfield operations	1.48
Emulated floating-point	2.20
Simple math	2.15
Transcendental math	1.25

level benchmarks. The Unix benchmarks show the Indy to be 6.5 times faster than a Sun SparcStation 1 running SunSoft 4.3. The low-level benchmarks show the Indy to be roughly 1.5 times faster than a 60-MHz Pentium with a 256-KB cache, a 64-bit data path, and 24 MB of RAM.

All SGI systems are source code compatible. Models like the Indy that come without high-end graphics processors use their CPUs to create effects done in hardware on the graphics boards of other SGI systems. The Indy is not a Reality Engine–capable machine (see "Damn the Torpedoes!," November 1993 BYTE), so many of these effects are done with system software rather than in the hardware. But with its R4000 CPU running at 100 MHz, even these advanced effects are in reach.

Beyond the Macintosh

Despite the hoopla about the advanced digital-media communications features of the Indy (and Apple's AV Macs), networks that support videoconferencing and the conferencing software are just emerging. It will be a year or two before those capabilities will be an important consideration.

The current need for a system like the Indy is in digital-image manipulation, as in prepress image computing, where traditional machines have been either very expensive or computationally inadequate. (If you want time to juggle, try manipulating 100-MB images on even the most fully configured Mac Quadra.) Adobe has ported both Illustrator and Photoshop to SGI's hardware using Quorum's Latitude porting tools. Even without taking advantage of the pixel manipulation–specific operations of the SGI, they have achieved at least twice the performance as on a Quadra.

Coupling the Indy's relatively low price for high-powered pixel operations with its abilities to communicate with DOS and Mac machines over Ethernet ports (and read DOS and Mac media), Indy is a perfect match for Photoshop, with its tens of thousands of graphics and prepress professionals. Optimize Photoshop and its associated third-party tools for the Indy, bundle the two, and you should end up with heaven for graphics professionals.

Users moving onto the Indy from the Mac will find the Indy's user interface not only similar but superior to the Mac's. Of course, you will now be working on a Unix workstation, but you'll seldom be aware of it, since Unix is so attractively dressed. The hidden advantage is that you get real multitasking and can connect directly to large Unix servers for managing files and heavy-duty computing.

Grievance List

Playing back video images captured from the Indy's digital camera occasionally caused a core dump and a hung session. I also had problems with some network operations between the Indy (running IRIX 5.1) and an older Indigo (running IRIX 4.03), but none between either machine and other Unix workstations. And I was disappointed that the voice-command software was not yet part of the operating system. By the time you read this, SGI should have resolved these problems and shipped the developer tool kits as well.

The power button is on the front panel, and while it's easily accessible, it's too exposed. Only too often, I accidentally brushed against the button and shut down the system. An intermediary confirmation, like that provided on Next computers, would avert unwanted shutdowns. As it is, one accidental brush of the button and you reboot your system, risking loss of data in open files.

About the Product

Indy (base price) $4995
Silicon Graphics, Inc.
2011 North Shoreline Blvd.
Mountain View, CA 94043
(800) 800-7441
(415) 960-1980
Circle 1078 on Inquiry Card.

Another element of concern is the lack of any S-video or NTSC video-out port. While the Indy provides both composite video and S-video input ports, you will have to purchase an optional GIO-bus (graphics I/O) video expansion card at $3395 for video out.

Digital Media for the Common World

When you buy an Indy, hard copy documentation is an option. You shouldn't miss it, however. While the Indy has the usual Unix `man` pages (and the X Window System application `xman` for reading them), there's also a complete set of SGI-specific documentation in an inviting digital-media format (and available with the Help button in the user environment). In fact, the SGI documentation is the finest example of electronic publishing I've seen.

SGI Insight documents start as FrameMaker files. An SGI-developed program takes FrameMaker's MIFF files and produces SGML (Standard Generalized Markup Language) files. Among the SGML markup instructions are hypertext jumps, external references to image files, sound, and animation. A second program takes the SGML files and compiles them into InSight files. SGI's InSight documentation viewer interprets the links and pointers, turning text into sophisticated hypertext. You end up with a documentation set that not only is easy to search and navigate but also includes images, video, sound clips, and buttons that launch associated elements of the documented applications.

According to Jim Clark, founder of SGI, the future of 3-D computing and digital media is the general consumer market (see "Roots and Branches of 3-D," May 1992 BYTE). With low-cost systems like the Indy, that prediction can become a fact. Before the time a data superhighway is in place, we have a chance to develop a great repository of valuable interactive digital material. We have tools to import existing text and develop it into sensually rich interactive documents.

The 500 cable channels of the near future need not be wasted on interactive versions of the Mickey Mouse Club. By generating images and animation, we now have real opportunities to enrich the world with high-bandwidth consumer communications. And because the Indy is so affordable, you can be part of the process. ■

Ben Smith is a testing editor for the BYTE Lab and the author of Unix Step-by-Step *(Hayden Books, 1990). You can reach him on the Internet at ben@bytepb.byte.com.*

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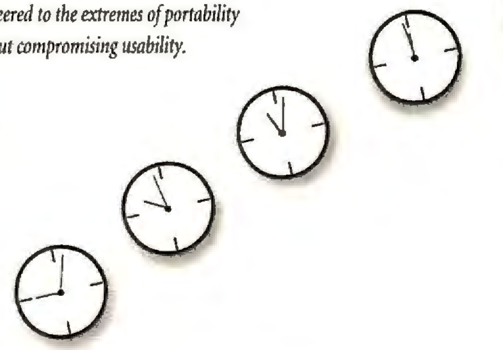

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NT Programming's Early Leader

Along with some flaws, Microsoft's Visual C++ 32-bit Edition delivers effective programming tools and ways to port 16-bit Windows applications

OLIVER SHARP

Programmers currently using Microsoft's Visual C++ will find the new version for NT familiar: The tools and libraries are almost identical. They will also find that Microsoft Visual C++ development system 32-bit Edition for Windows and Windows NT isn't flawless, but it does provide an abundance of tools and on-line documentation that help programmers take advantage of Windows NT's capabilities.

Distributed on a CD-ROM, VC++/NT comes with two complete compilation environments, one that runs under NT and one that runs under Windows 3.1. However, the latter can create only executable files that use the Win32s subsystem, so you can't build Win16 executables. The full NT development environment is over 70 MB, although you can cut down on the space needed by leaving out some features or by running the compiler from the CD-ROM. In addition, the CD-ROM includes over 70 MB of documentation.

Like its 16-bit cousin, the NT version uses Visual Workbench to integrate tools by providing access to the compiler, debugger, profiler, code browser, and programming aids called application wizards. But VC++/NT improves on its predecessor by including all the tools and API documentation formerly available only in the Windows NT SDK (Software Development Kit).

The Programming Environment

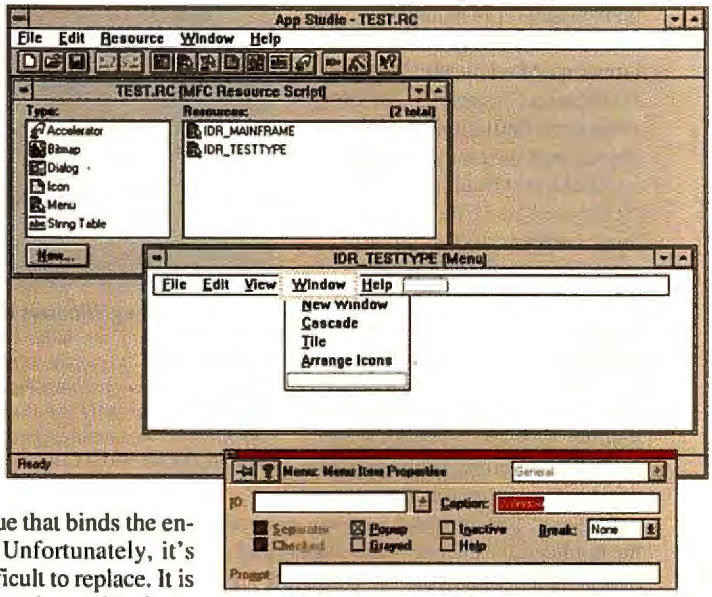
To test the Windows NT programming capabilities, I built a Win32-based telephone database manager that uses the Windows interface. The program allows access to multiple databases, performs various searches, and can output formatted reports. It takes advantage of the new features of the Win32 API by using multiple threads: A thread is spawned to format the database, and each document has a background thread that keeps an index up to date. Whenever you modify the database, the thread wakes up and updates its information in the background.

The Visual Workbench allows easy access to the definitions of functions and variables, documentation for the operating-system calls, and the debugging and applications development tools. With practice, you'll be able to navigate through the system comfortably.

The Workbench's editor is flawed, however. In any environment, an editor is one of the most important programming tools, and in VC++/NT the editor serves as the glue that binds the entire system together. Unfortunately, it's underpowered and difficult to replace. It is not programmable, doesn't provide flexible control of key bindings, and has a fixed strategy for syntax highlighting. If you're a programmer who spends a long time customizing your favorite editor to make it an efficient tool, you will probably not be satisfied with these shortcomings, and the environment doesn't provide much support for using an alternative.

You can add your own editor to the tools menu and use it on files. But once you begin debugging, browsing, and navigating through your application to look up definitions, you must switch to the built-in editor, because there is no interface for sending status messages to an alternative one. Windows programming generally requires you to spend most of your time making incremental modifications in the midst of debugging and testing, so you will spend a lot of time in the built-in editor or lose the convenient interaction of the various tools. I hope Microsoft improves the editor in future releases or provides better support for integrating third-party offerings.

Nevertheless, the Visual Workbench has some good features. One is the high degree of control it gives you when you build programs. Menus provide easy access to the different options available in the compiler and linker. In addition, the dialog boxes show the list of corresponding arguments that will be sent to the tools.



App Studio, a programming tool *that edits resources associated with an application, here is modifying a menu structure (top). You can change menu properties in the dialog box shown in the bottom foreground.*

The Wizards

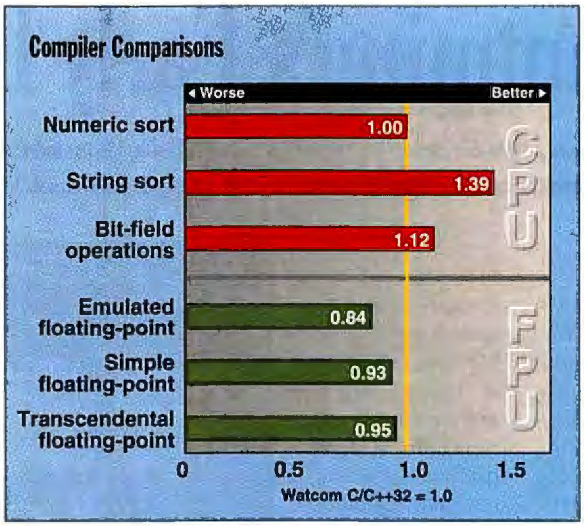
A distinguishing feature of VC++/NT is the set of wizards—programming tools that generate code you can use as a start toward an application. With practice, you can construct simple applications quickly using wizards. I used them to produce the interface to my multithreaded database browser.

To build an application using the wizards, you first open the AppWizard. It produces a generic application framework by displaying a window with a list of possible menu options for you to invoke or delete, depending on your application. Next, you design dialog boxes, menus, and other graphical resources in the App Studio. Then the ClassWizard allows you to tie these pieces to your code: It produces the appropriate procedure stubs for you to fill in. In the case of the database browser, I used App Studio and the ClassWizard to add dialog boxes (to ask the user for such things as search criteria and output formatting preferences), as well as to set various menu options and do some on-screen formatting.

When you write code to handle various

events, you interact with the internal state of the application. The world is divided up into documents containing objects, and the user can see any number of views of the document. You can modify objects based on system or user events; periodically, the objects will be asked to refresh their visual representation.

The wizards assume various idioms supported by MFC (Microsoft Foundation Classes) 2.0, which provides class definitions for Windows objects and the connections needed for Windows event handling. If you create your own data structures, you must conform to the wizards' assumptions about idioms. For example, documents are saved by passing a *serialize object* to every object in the document. Each object in the document is responsible for saving or restoring itself by writing to or reading from the serialize object.



When generating Windows NT *executable files, the compiler in Microsoft Visual C++ 32-bit Edition performed equivalently to Watcom C/C++'s compiler, the fastest one we've tested. Microsoft scores are indexed against Watcom results, which equal 1. The tests consisted of BYTE's portable C benchmarks, with both compilers set to generate speed-optimized 486 code. Tests run on a 50-MHz Everex 486DX2 with 256 KB of cache and 16 MB of RAM.*

Unlike in some other programming environments, the wizards don't keep the interface and the guts of the application separate. After the wizards produce their code, you live within the application and are not shielded from it in any way. Whether you like that strategy is something of a personal preference; some programmers prefer to have more abstraction, while others like to see all the code together. Given the path VC++/NT has chosen, I found that the code it produced was easy to work with. It is well structured and well commented, and modifying the code is straightforward.

A more curmudgeonly lot of programmers object to having tools build their applications at all. These programmers may accept visual-resource editors, but they want to be in control of all the code. Thus, many of the tools in VC++/NT won't interest them much, but they will find the abundance of source code to be a real help. They can work with or modify it to their liking, using it as a model when they forge their own path. Although the wizards rely on MFC extensively, MFC can still be useful to programmers who choose to perform their own sorcery. The classes, which come with full source code, provide a variety of useful data structures and access to complicated subsystems like OLE.

Multithreaded Applications

Adding threads to programs that use MFC can be a problem, because the classes are not reentrant; that is, they cannot be used by different threads at the same time. There is a reentrant C library, however, so threads are free to use the standard C functions when that version of the library is linked in. If you want to use threads in a program relying on MFC, you first need to recompile the MFC library itself to use the reentrant C library. Then the threads can use the C library functions and walk over internal data structures, as long as they stay away from the MFC. (Microsoft plans a reentrant version of MFC in the next release of VC++/NT.)

In my case, the restriction wasn't too onerous because I was using threads to handle time-consuming operations on basic data structures. In my application, some of the menu choices invoke handlers that spawn a thread; they immediately return, leaving the thread to continue working in the background. One separate thread is invoked when each document is opened. The thread hovers in the background until the document is closed, waiting on a semaphore. When it wakes, the thread checks to see if it was awakened in order to terminate; if not, it knows that the database has been modified and the index must be updated. If you have a more ambitious use of threads in mind, such as using them to modify different parts of the GUI simultaneously, you'll need to abandon MFC or wait for a subsequent release.

Other Tools

The VC++/NT debugger is also integrated into the Visual Workbench. It has the usual features for stepping through the source code being executed, and a flexible facility for specifying breakpoints. The debugger allows you to examine data structures and expression values in a dialog box called Quick Watch. You can add a value that you examine in Quick Watch to a watchpoint window in Workbench. Expressions in the watchpoint window are updated whenever you suspend an execution. Also, the support for multiple threads is handy. You can suspend and resume them individually and switch the active focus among them.

The on-line documentation in VC++/NT is extensive and very useful, and I found myself spending a lot of time in it. It comes with a browsing utility that is an improved version of the standard help-file browser. The documentation isn't flawless: It's plagued by some unclear language and typos in both text and sample code. Caveats aside, after you have had some experience navigating through the documentation, you'll find it a terrific resource.

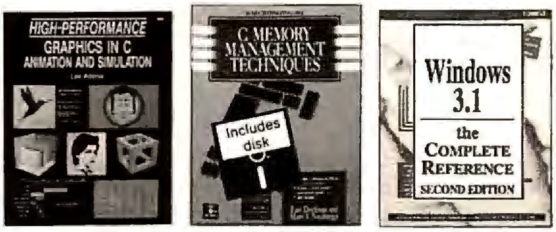
Another tool that was much updated in the move to NT is Spy++, which lets you explore the threads, processes, and windows that are currently active in the system. It's a useful tool for seeing how a multithreaded application is executing.

The Compiler

Although you'll spend most of your time interacting with the programming environment, the heart of the system is the compiler. Microsoft has improved its compiler somewhat by adding support for Pentium optimization, but the main difference is the move to a flat 32-bit address space. As in previous versions of Visual C++, the compiler produces code that is efficient in both space required and execution speed. As the graph shows, compilation speed is on a par with that of Watcom C/C++32, the fastest product in BYTE's recent roundup of C++ compilers (see "C++ Does Windows," September 1993 BYTE). The compiler is also heavily dependent on the amount of memory in the system: I strongly second Microsoft's recommendation of at least 20 MB of RAM.

You also need adequate disk space. The compiler takes up 60 MB to 80 MB, and each application you're working in takes its share. Just the basic application framework, when compiled in debugging mode, chews up 6 MB with all its subsidiary files.

continued



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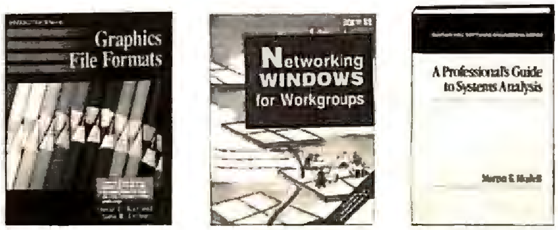

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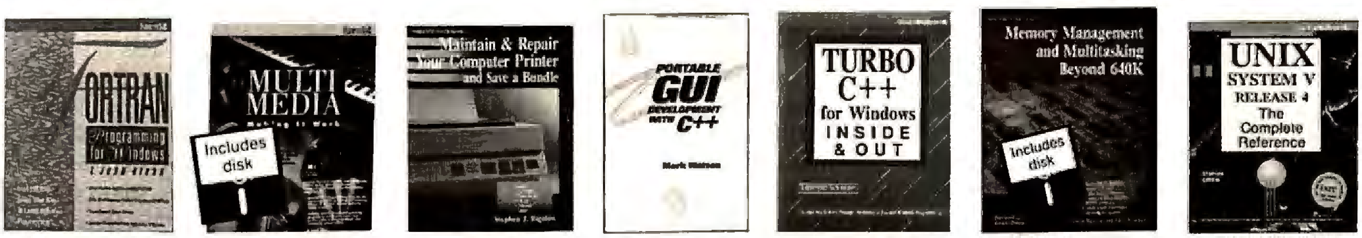

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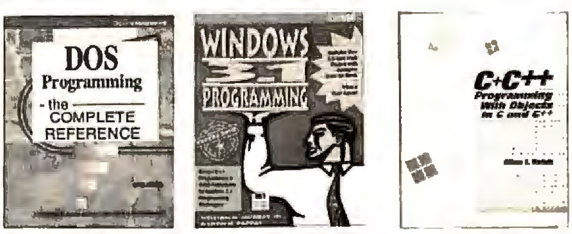

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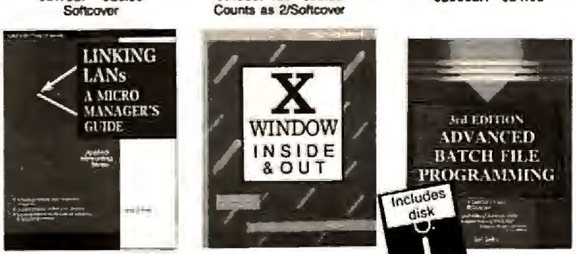

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BY194

Reviews NT Programming's Early Leader

When you compile for distribution, the executable file shrinks below 150 KB, but if you have several projects in progress at once, you'll use a lot of hard disk acreage.

Microsoft has added some new features to the compiler to better support the NT environment. In particular, it has added direct language support to allow the C/C++ programmer to deal with threads more easily. There is a direct call for creating a new thread (`_beginthread`) and passing arguments to it; the construct is mapped to the appropriate API calls by the compiler. You can specify that static or global data is to be thread-specific by using the C++ extended declaration facility: Specifying the declaration `_declspec(thread) int foo` tells the compiler that each thread is to have a private instance of the variable. Local variables do not need special treatment because each thread has its own stack.

About the Product

Microsoft Visual C++ 32-bit Edition for Windows and Windows NT..........$599
Microsoft Corp.
1 Microsoft Way
Redmond, WA 98052
(800) 426-9400
(206) 936-8661
fax: (206) 936-7329
Circle 1079 on Inquiry Card.

One significant problem with the compiler is that it does not support strict ANSI compatibility. Microsoft chose to support only the functionality of cfront 2.1, adding exception handling via preprocessor macros and the compiler. The C++ exception-handling mechanism in cfront 3.0 and the use of templates are not supported. This decision has unfortunate consequences for the C++ programmer who is familiar with the ANSI dialect or who wishes to use sample code that relies on it. Templates are such a useful mechanism that C++ programmers are increasingly encouraged to use them; it's a pity that they're not available in VC++/NT. Microsoft says that an updated version of VC++/NT, due later this year, will support both cfront 3.0 exception handling and templates.

32-bit Changes

In moving from the 16-bit to the 32-bit version, programmers face a variety of changes. Some are caused by the switch to a new API, and some by the updated programming environment.

The Win32 API has a lot of new features, ranging from Bézier curves and security to support for multiple threads. An application that uses threads effectively performs time-consuming operations in the background and lets you carry on with your programming. But these benefits don't come free: You'll often need to recast the structure of your application to take advantage of threads. The compiler can't do much to help you with that.

The Visual C++ environment has also been upgraded with new features in the NT version. A major improvement is that the package now includes tools and documentation formerly available only in the Windows NT SDK. One of the tools is the help compiler, which converts annotated RTF files that you can produce with Microsoft Word or other tools into the HLP files that the NT help system understands. In addition to the SDK additions, new monitoring tools let you watch the interactions between threads and DDE communication. The profiler has also been improved with a better interface.

Since the Win32 API is the only one supported, you need to recode applications relying on Win16 API features. For example, the Win16 communication API has been replaced; NT programs communicate through a serial port with the same calls that handle file I/O. All support for DOS has been dropped, and applications can no longer access INI files directly. Most other changes in the API are to functions that formerly returned 16-bit values packed into a 32-bit word. The on-line documentation summarizes the various changes.

Microsoft also dropped the QuickWin environment that supported DOS programmers with a simple Windows API. You must either use the Console API or move entirely into the Windows environment. VBX custom controls are gone, too.

Is the 32-bit Version for You?

Should you switch to the 32-bit version? It depends on what environment you're moving from and whether you plan to take advantage of the Windows interface.

If you currently write programs using simple-stream I/O or full-screen text I/O, the NT version will let you either take the plunge into Windows programming or settle for the Console API's more limited functionality. To test the latter, I ported Unix and Win16 applications. The Unix programs consisted of two-stream I/O filters that manipulated a phone database, performing lookups and converting the database into a formatted form for printing. The Win16 application was a text browser.

.I found the consoles fairly simple to manage: The API consists of a few dozen functions that let you create a console, control the cursor, do simple I/O, and catch some kinds of events, like mouse-clicks. Consoles are also handy for debugging GUI applications, because the program can output status messages and accept debugging input even when the primary graphical interface is not working or is incomplete. While it's simple to port applications to the Console API, programmers who don't need more than that from their development environment will have little reason to favor VC++/NT over its competitors. And if strict ANSI compatibility is important to you now, you would be well advised to look elsewhere.

On the other hand, the audience Microsoft is really aiming at is the current body of Windows 3.1 programmers. They will find much to like about VC++/NT, particularly if they've been using its predecessor. One of the highest priorities in designing NT was making it easy for programmers to port their 16-bit Windows applications quickly and easily. By following the Win16 API closely and porting MFC 2.0 to NT, Microsoft has done most of the porting work for you. What remains is to get rid of the segmented memory assumptions, fix some data-structure packing issues, and move to a somewhat changed API.

To ease the transition, Microsoft supplies PortTool. It runs through a Win16 program and identifies places where the API has changed or where there are 16-bit declarations that are no longer valid. PortTool is not integrated into the Visual Workbench. To access it, you have to invoke it manually or add it to the Tools menu. You can use it to go through your program interactively, or it can process files and add comments where it found potential problems. Microsoft supplies source code, so you can tailor the program to your needs if you are planning to use it repeatedly. While it's hardly a panacea, PortTool is a useful tool for finding trouble spots.

The bottom line: VC++/NT is the programming environment to beat—every other NT compiler will inevitably be compared to it. Although there are some flaws and weaknesses, Microsoft has succeeded in delivering an integrated package with the tools and documentation that allow a Windows NT programmer to take full advantage of the operating system. ■

Oliver Sharp is an associate at Heuristicrats Research, Inc., an optimization software developer in Berkeley, California. He is completing his Ph.D. in computer science at the University of California–Berkeley, investigating compilation for parallel architectures. He can be reached on BIX c/o "editors" or on the Internet at oliver@heuristicrat.com.

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New Mac Blazes Technology Trails

The Mac Quadra 840AV packages more speed with new video and voice technologies

TOM THOMPSON

It's easy to become complacent with the incremental speed increases and bits of new technology Apple gives each new Macintosh generation. There's a good technical reason for the slow pace. Drastic hardware and operating-system changes tend to cause software compatibility problems for Mac end users, a bad scene that Apple wants to avoid. Remember the SCSI DMA that didn't quite work, and the serial compatibility problems with the Mac IIfx? Or the more recent troubles with the Express Modem driver for the PowerBook Duo? All involved Mac design improvements that unfortunately got in the way of a lot of existing software. So you can hardly blame the company for keeping big changes to a minimum.

Thus, Apple's new AV Macs caught me off guard. The Quadra 840AV and Centris 660AV sport major improvements in hardware design, including a DSP (digital signal processor). They also offer several significant technologies ready to go: built-in video I/O, voice recognition, and a TTS (text-to-speech) engine. (For more details, see "Apple, SGI Blaze Video Trail," September 1993 BYTE.) The new Mac AV features are neat, capably implemented by Apple's engineers, but they also provide opportunities for a lot of the old stuff to go wrong. With this in mind, I took a serious look at a Quadra 840AV.

Test Drive

The Quadra 840AV that I tested arrived from Apple equipped with a 230-MB hard drive, a dual-speed CD-ROM drive, and 16 MB of RAM. Apple also threw in a POTS (plain old telephone system) GeoPort adapter. The best compatibility test I can think of is to use the Quadra as my daily work machine. So I connected it to a spare Ethernet drop in my office, switched on File Sharing, and copied to it the contents of my Mac IIci's hard disk. The BYTE Macintosh benchmark suite followed, copied from a Mac file server.

The BYTE benchmark tests show that the Quadra 840AV is one fast Mac. At 40 MHz, it outpaces the 33-MHz Quadra 800 easily on the CPU, FPU, and video tests (see the graph). But the Quadra 840AV trailed the Quadra 800 on the disk tests, and the new SCSI Manager 4.3 is to blame. It handles I/O redirection, implements SCSI DMA, and provides some SCSI-2 command features, but it appears that this new flexibility adds overhead to hard disk I/O. If you use third-party drives, check that the driver software supports the new SCSI Manager; you will eliminate potential compatibility problems and ensure high throughput.

As you'd expect, the slower disk performance affected application benchmark results. The Quadra 800 edged just ahead of the 840AV on several application tests. If you use desktop publishing and scientific applications, though, you will get better performance from the 840AV.

The tests also indicate that the SCSI DMA feature doesn't help performance, for the same reason that it wasn't much use on the Mac IIfx: The single-threaded Mac OS can't use it effectively. SCSI DMA won't help until the Mac OS undergoes a major overhaul, probably with the arrival of the microkernel.

Considering the radically new hardware that Apple has added to the Mac AV design (e.g., nine dedicated DMA channels for SCSI, serial, Ethernet, and sound), I expected to run into a lot of compatibility problems. I was pleasantly surprised to discover that this isn't the case. All my applications, including Claris's MacWrite Pro 1.0v4, Adobe's Illustrator 5.0 and Photoshop 2.5, Telnet 2.5, Lotus's cc:Mail 2.0, Aladdin's StuffIt Deluxe 3.0.6, and Symantec's Think C 6.0, worked just fine. So did my usual herd of indispensable Control Panels and Extensions, including Now Software's Super Boomerang 4.0.1p and WYSIWYG Menus, Adobe Type Manager 3.6, and Berkeley Systems' After Dark 2.0x.

Because of the new DMA serial drivers built into the 2-MB ROMs and the new nine-pin GeoPort connector that replaces the modem connector, I paid special attention to serial communications. On-line sessions using AppleLink 6.1 and America Online through a networked Shiva NetModem and a locally connected Global Village Teleport Gold modem worked fine.

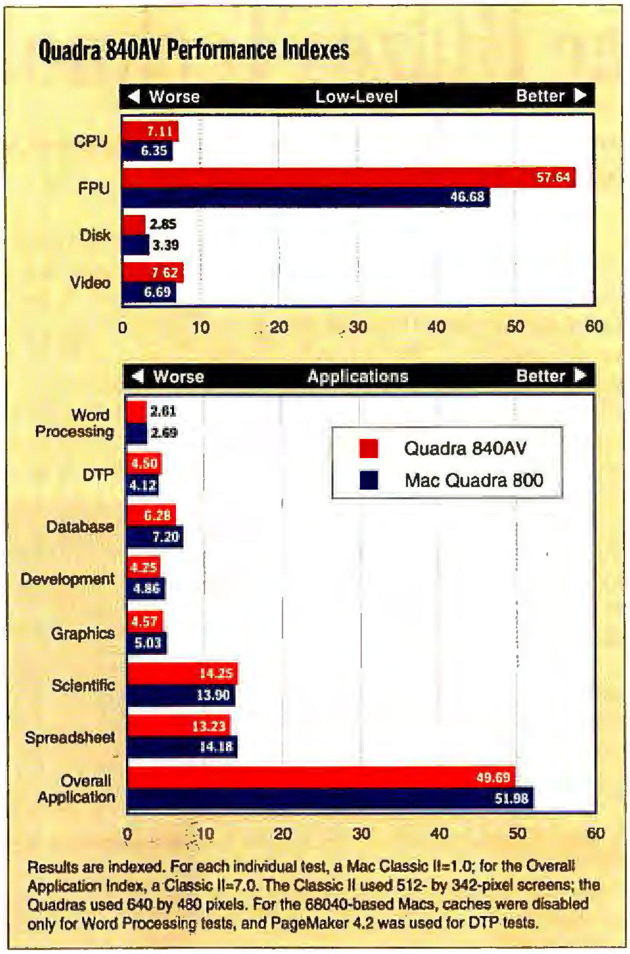
With Apple's AudioVision monitor and a built-in DSP, the Quadra 840AV is ready to handle voice data.

Plain Speaking

PlainTalk is speaker-independent voice-recognition software, and it handled my Southern drawl fairly well. However, nearby conversations and sometimes my own typing made enough racket to confound it. To work reliably, PlainTalk requires a quiet environment—something not available to your average business worker.

In addition to effective speech recognition, PlainTalk's other strength is in providing the means for physically challenged folks to perform useful work. The TTS allows visually impaired people to "read" files, for example. Using TTS, PlainTalk, and the proper scripts, a blind person can

Reviews New Mac Blazes Technology Trails



Running at 40 MHz, the Quadra 840AV is the fastest Mac yet. A new SCSI driver, however, puts hard drive performance slightly behind that of a Quadra 800 that BYTE tested previously. Slower drive performance spills over into some of the application test results.

retrieve, read, and file electronic documents. Articulate Systems (Woburn, MA) is working on PowerSecretary, an application that lets you dictate speech into text on AV Macs or appropriately equipped 68040-based Macs.

You activate PlainTalk through the Speech Setup Control Panel. Switching on voice recognition launches two invisible applications, SR Monitor and SR North American English. The disadvantage to implementing voice recognition this way is that it takes 30 or 40 seconds before the PlainTalk service becomes available. The advantage is that when you switch PlainTalk off, the two applications silently quit and you recover the memory they used.

The memory savings are considerable. Using voice recognition along with the high-quality female voice option consumes nearly 4 MB of system memory. Small wonder that the review unit came with 16 MB of RAM instead of the standard 8 MB. With File Sharing, PlainTalk, System 7.1, and some favorite Control Panel and Extensions loaded, I had only 8 MB of free RAM left. Although you can save memory by using compressed versions of the voices, quality suffers.

A special microphone handles voice input. You place the mike atop your monitor and plug it into the Quadra 840's sound-input port (unless you're using the Apple 14-inch AudioVision monitor, which has the mike built in). The mike's focal point is approximately 30 inches in front of it.

Through the Speech Setup Control Panel, you select a phrase that alerts PlainTalk that you are directing commands at the computer. When PlainTalk recognizes such a command, it consults a command dictionary. If there's a match, it triggers an Apple Event. Otherwise, the computer utters a polite "Pardon me?" The command might launch a single application, or it might start off an AppleScript (the Mac OS's batch command language) that executes a whole cascade of preprogrammed activities. A bundled Speech Macro Editor lets you edit the command dictionary and add your own commands and AppleScripts.

Adding a new application to launch is just a matter of adding an alias file to the Apple Menu Items folder. You invoke the new application with an Open command—"Open Excel," for example. PlainTalk then creates an "open" Apple Event addressed to the Finder, which searches its menus for the stated item. Since the Finder Apple Menu is built from objects in the Apple Menu Items folder, the requested application is there and launches.

If you want to develop more complicated operations, you need AppleScript, UserLand Frontier, or another scripting language. Apple bundles the AppleScript editor with the Quadra 840AV.

Voice-command possibilities also depend on applications that are Apple Event savvy, since the scripting languages use this IAC (Interapplication Communication) protocol. The number of applications supporting Apple Events was initially small but is growing rapidly and now includes Aldus PageMaker 5.0, QuarkXPress 3.2, Microsoft Excel 4.0, WordPerfect 3.0, and Aladdin's StuffIt Deluxe.

To experiment with voice control and scripting, I used a beta version of SITcomm, Aladdin's new terminal emulator application. Since most of SITcomm's interface accepts Apple Events, I could log onto BIX, for example, without any scripting at all. I could just say "Open SITcomm" to launch the application, "BIX" to load the terminal settings and phone number from the internal address book, and "Connect" to actually connect to BIX. However, this isn't a very practical way to control your Mac via voice commands. Instead, I created an AppleScript to painlessly sign me onto BIX with just a single voice command.

With the AppleScript editor, I recorded a BIX log-on session using SITcomm, switched off the editor's recording mode, and then went back to tinker with the resulting AppleScript. Adding the new voice command with the Speech Macro Editor, I could then trigger the finished AppleScript by saying, "Connect to BIX." It would then launch SITcomm, select the service, dial the number, and handle the log-on exchange.

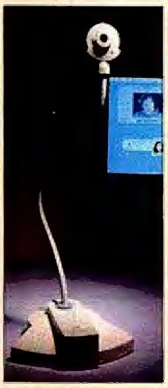
With the Mac OS providing the heavy-duty technology to generate Apple Events from spoken commands, and with vendors writing Apple Event–savvy applications, you play the role of switchboard operator, making the connections between the Mac OS and applications by writing AppleScripts. There's a huge opportunity here for developers to complete these connections by writing scripts for businesses.

Phone, Fax, and Video

The Quadra 840AV's DSP uses a real-time operating system that can perform several signal-processing tasks simultaneously. One such task is the sound preprocessing for PlainTalk. Other programmed functions that the DSP can handle are telephony, modem, and fax operations. A bundled Telephone application lets the Quadra act as a phone, and, with the Apple AudioVision monitor, you can actually use the system as a speakerphone. Telephone can also answer the phone, play a recorded message, and then record a message from the caller—but you'll need lots of hard disk space to record digitized messages.

continued

Live Video on the Mac



In testing the new Mac Quadra 840AV, I used Sony PCS-V2 and VideoLabs Flexcam cameras to obtain live video. Both provide only a composite video signal, and each has its own separate power-supply "brick," with the usual entourage of a power cable and a supply lead to keep track of.

Sony's PCS-V2 is a flat box with a fixed-focus, tiltable video camera, speaker, and microphone. It's designed to sit on top of your monitor, but this assumes the monitor has a flat area several inches wide along the top. Apple's AudioVision monitor has a steeply sloping top, so I had to put the PCS-V2 on the Quadra 840AV's housing instead. I looked at a preproduction version that is actually an inch deeper than the final version will be.

VideoLabs' Flexcam looks like a Martian tripod from H. G. Wells's *War of the Worlds*: A wide base sprouts a long, limber neck that ends in an eyeball contraption. This section contains a focusable video camera and two microphones for stereo sound recording. The PCS-V2's captured images looked better than the Flexcam's, but the Flexcam has the advantage that you can aim it at practically anything, including papers on a desktop (a form of scanning), and you can adjust the focus.

Using Apple's bundled Video Monitor application, I could observe the view behind me through my office door with either camera while I was working. You can observe the view in windows ranging from 160 by 120 pixels, to 320 by 240 pixels, to full screen (640 by 480 pixels), but the image looks grainy on the largest screen. The live video image is 16 bits deep.

Apple manages this feat by splitting VRAM (video RAM) into two frame buffers when live video is in use. The computer-generated screen goes into one buffer, and the live video into another. The video circuitry then melds the two buffers together at the D/A display hardware. To capture the Mac Desktop and live video simultaneously, you need an application, such as the Video Monitor or VideoFusion's FusionRecorder, that understands where the live video resides in the system.

The Express Modem software provided with the POTS GeoPort adapter implements a 9600-bps V.32 modem. (I found this odd. The DSP should have the horsepower to provide 14.4-Kbps modem capabilities—a speed folks using AppleTalk Remote Access need for high-speed connections from the field.) I was able to connect reliably to AppleLink, America Online, and BIX using the GeoPort. The software bundled with the adapter also includes Apple's Fax Sender software, which lets you "print" a document from within any Mac application to a fax. With it, I was able to rapidly dispatch editorial calendars and author proofs at 9600 bps directly from my Mac, rather than queuing up with paper copies at the fax machine.

But the DSP has only so much processing power. I couldn't, for example, fax or connect by modem with PlainTalk active. Fortunately, you get alerts that indicate the problem, and you can switch PlainTalk off during faxing or a communications session. (There's a market here for an Fkey that would toggle these services with a keystroke.) This is a nonissue if you're using an external or networked modem.

The functions provided by the DSP help launch a preemptive strike against Microsoft's proposed API for connecting computers to office equipment. Apple's answer is that the computer becomes your office equipment. Based on the results I've seen so far with faxing, calling, and communicating, Apple's got the better idea.

Besides the usual gaggle of ports (serial, ADB [Apple Desktop Bus], Ethernet, video, and sound I/O), the Quadra 840AV also has four video I/O ports: in and out ports for both composite video and S-video. With the right software, video capture to a QuickTime movie is practically plug-and-play. I connected a portable VCR's output to the Mac's composite video input, fired up a video-capture application from VideoFusion (a demo version of the program comes bundled with the Mac), watched the incoming live video in a screen window, and clicked on the program's record button. The FusionRecorder program captures digital video to memory or hard disk and applies compression to the captured data once you stop recording. If you need editing features, VideoFusion offers an upgrade to the full-blown QuickFlix application for $89.

To test video output, I connected a composite monitor to the output jack. The Monitors Control Panel offers the option of NTSC or PAL video output, and you can also redirect the Desktop to the output port. This way, you can use a VCR to record a demo tape, or set up a large-screen monitor to display work to a classroom or lecture hall. I found the output on the monitor decent and nearly flicker-free, thanks partly to convolution algorithms that minimize the effects of video interlace.

New and Improved

The Mac Quadra 840AV represents Apple's fastest Mac to date. Although the new SCSI driver hurts hard drive performance slightly, it will also support future—and faster—SCSI PDS (Processor Direct Slot) boards and buses. In spite of major hardware changes, software compatibility is excellent. But then, the current Mac OS doesn't fully exploit all the new hardware (e.g., the SCSI DMA), either. Nevertheless, the Quadra 840AV represents a stable platform on which vendors can carefully start using the new features. I also expect to see some of this stuff in PowerPC Macs, so the AV Macs help show developers the way to working with the future RISC-based Macs.

The PlainTalk and video technologies are both well conceived and well implemented. Neither is by any means perfect, but the Quadra 840AV shows a good first effort. More important, they are enabling technologies: Along with the programmable DSP, they will allow developers to push the Mac in new directions, redefining what a Macintosh is and what it can do. It will be interesting to see what appears in the next few months. ■

About the Product

Mac Quadra 840AV
(with 230-MB hard drive and 8 MB of RAM) $4069
Apple Computer, Inc.
20525 Mariani Ave.
Cupertino, CA 95014
(408) 996-1010
Circle 1076 on Inquiry Card.

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70 COLOR MONITORS

We test high-resolution monitors with displays ranging from 15 to 21 inches to find the highest image quality and the best values

ANDREW J. FRONING

The monitor is arguably the most important component in determining how effectively you work, especially if you use a graphical environment that relies on clear displays of text, images, a multitude of data points, or many open windows. Fortunately, today you have more choices than ever for high-resolution monitors, whether you run general business applications or make presentations to packed conference rooms.

To pick the best of today's offerings, we tested 70 color monitors ranging from 15 to 21 inches, with resolutions and refresh rates sharp enough for today's more demanding graphical applications for PCs and Macs. To search for the best image quality, we ran more than 40 tests on each monitor to measure overall quality, sharpness, and distortion. We ranked the monitors for how easy they were to set up, adjust settings for, and use. Finally, we determined how much power each monitor consumed.

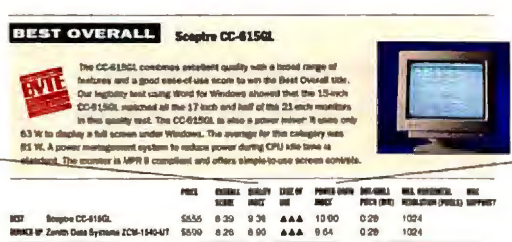
Our test sample consisted of 28 15-inch, two 16-inch, 31 17-inch, one 20-inch, and eight 21-inch color monitors. The average cost of a 15-inch monitor was $610, or half the average price of a 17-inch monitor. Prices more than doubled again for 21-inch monitors, which averaged $2736. The least expensive monitor we tested was the Megatron MegaImage L15MG, a 15-inch display that lists for just $279 (but received the lowest overall score in our quality tests). By contrast, 21-inch monitors from Mitsubishi and Nanao, at $2999, carry the highest price we saw (the Nanao F760iW was a runner-up for Best Overall in its category; the Mitsubishi Diamond Pro 21 FS was not ranked).

To be considered for testing, monitors had to have a display resolution of at least 1024 by 768 pixels. Fifty-nine monitors supported horizontal resolutions high-

How to use this guide

We selected the best color monitors based on quality rankings and evaluations of ease of use, features, and power consumption. Higher numbers mean better performance. Two points or more in the quality index represent obvious differences, a 1-point difference is subtle to the unaided eye, and a 1/2-point difference is difficult to discern visually.

A weighted score for image quality, sharpness, convergence, contrast, distortion, and legibility.



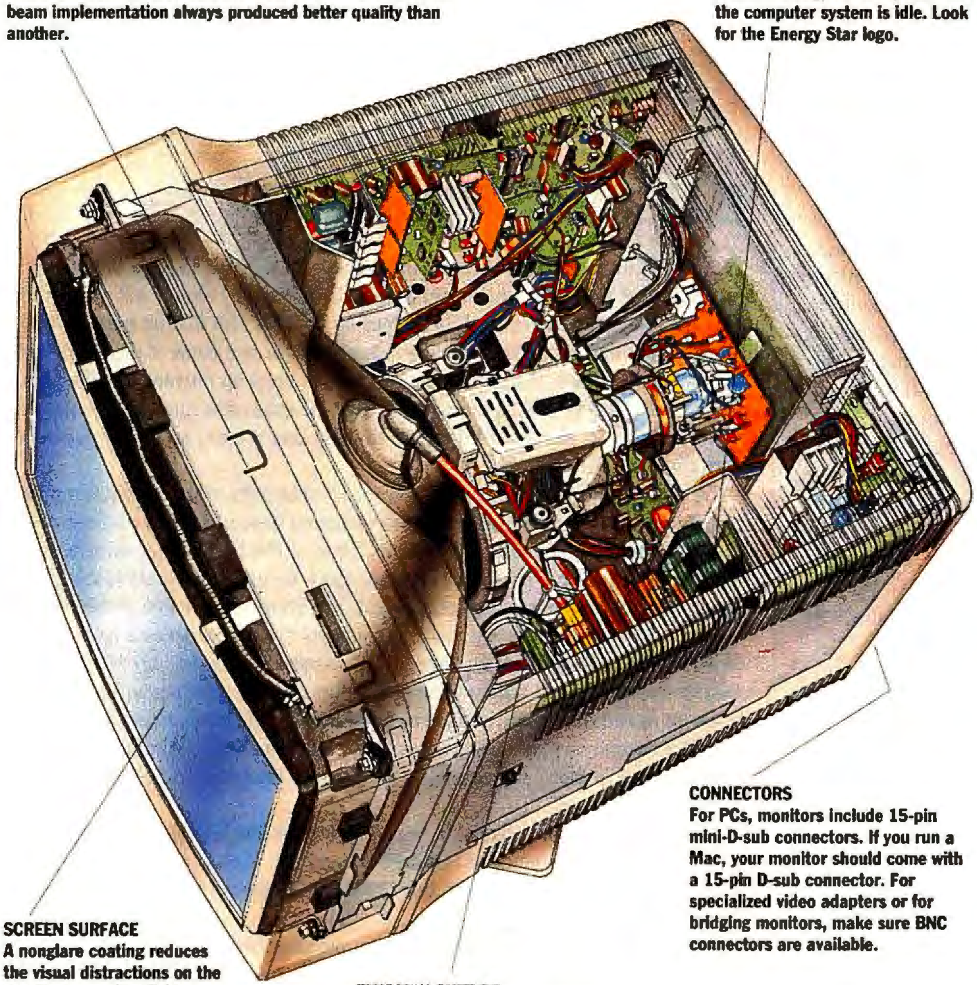
Power scores indicate relative power consumption; higher numbers represent lower power consumption under Windows.

PHOTOGRAPHY: STEVE BELKOWITZ © 1994

What to Look for in a Monitor

PICTURE TUBE
Most monitors use three electron guns to produce color images. In its Trinitron displays, Sony uses a single electron gun shooting three beams. We didn't find that one electron-beam implementation always produced better quality than another.

POWER CONSERVATION
Power management circuitry reduces energy consumption when the computer system is idle. Look for the Energy Star logo.

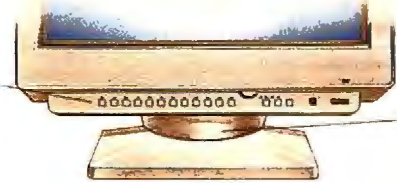


CONNECTORS
For PCs, monitors include 15-pin mini-D-sub connectors. If you run a Mac, your monitor should come with a 15-pin D-sub connector. For specialized video adapters or for bridging monitors, make sure BNC connectors are available.

SCREEN SURFACE
A nonglare coating reduces the visual distractions on the monitor caused by light sources such as windows and overhead lighting. An antistatic surface reduces the accumulation of dust on the screen but shows fingerprints readily.

EMISSION SHIELDS
These shields provide additional protection against VDT emissions. Look for products offering Sweden's MPR II level of protection.

CONTROLS
Look for controls mounted on the front bezel of the monitor with easily identifiable markings.



PEDESTAL
Be sure a monitor can pan and tilt smoothly and offers a good range of movement to make it easier to adjust the display position for comfortable viewing.

er than our minimum requirement: 47 displayed 1280 pixels, one displayed 1152 pixels, and 11 offered 1600 pixels. We required our test monitors to support the VESA (Video Electronics Standards Association) recommended minimum refresh rate of 70 Hz for 1024- by 768-pixel resolution.

We saw only five picture-tube manufacturers represented (Hitachi, Matsushita, Mitsubishi, Toshiba, and Sony). Quality varied according to differences in the individual tubes and the electronics (e.g., the microprocessors that handle the incoming video signals) that each monitor vendor integrated with the tube.

JANUARY 1994 BYTE BEST COLOR MONITOR

BEST

GENERAL BUSINESS

Sceptre CC-615GL

The 15-inch CC-615GL distinguished itself with top-flight screen quality, below-average cost, and the best scores for its monitor class in both the power conservation and distortion tests. The monitor displays excellent corner sharpness, with only a small amount of moiré. Built-in memory holds nine preset resolution modes and 22 user-definable settings. The unit offers a combination of easy-to-use analog and digital controls, including pincushion control and a degauss switch. **PAGE 204**

SPREADSHEETS AND GRAPHICS

Nanao F560iW

Although it ranks close to Nanao's T560i in overall performance, the 17-inch F560iW earned a higher quality rating and costs $500 less. Along with excellent image quality, it complies with both the MPR II emissions standard and the Energy Star power conservation standard.
PAGE 214

COMPLEX GRAPHICS AND PRESENTATIONS

NEC 6FGp

Though not without flaws, the 6FGp scored where it counts: in image quality. This 21-inch monitor received the best score of any monitor in our sample on our image-quality tests, and it achieved the highest combined quality score. The 6FGp provides high-contrast levels and extremely low misconvergence. Offering high video bandwidth and vertical refresh rates, the 6FGp provides 1280- by 1024-pixel resolution at up to 74 Hz noninterlaced. Color controls and power-saving modes are standard.
PAGE 220

THE BEST MONITORS FOR

GENERAL BUSINESS

For general-business PC and Mac applications that don't require the highest resolutions or largest display areas, 15-inch monitors offer a good balance of size and price. On average, 15-inch monitors sell for half the cost of 17-inch monitors and offer approximately 92 square inches of viewing area—about 38 square inches less than a 17-inch display. However, if a 15-inch monitor and a 17-inch monitor operate at the same resolution, you won't see any net difference in "image real estate." That's because larger screens produce larger images, not more image space. So, for example, the two monitors will display the same number of rows and columns in a spreadsheet, but the spreadsheet cells on the 17-inch monitor will be bigger.

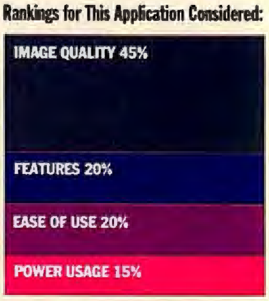
Running a monitor at high resolutions increases space for displaying large spreadsheets and other documents (see "Is Bigger Better?" on page 218). However, there are trade-offs. Using a 15-inch monitor at 1024- by 768-pixel resolution results in substantially smaller characters than using the same monitor at 800 by 600 pixels. Unless the monitor is exceptionally sharp, we don't recommend 15-inch monitors for resolutions exceeding 800 by 600 pixels. (Nevertheless, in making our Best Overall, High Quality, and Low Cost selections, we conducted our image quality and sharpness tests in the 1024- by 768-pixel resolution to provide the toughest tests of these monitors' display capabilities.)

The Sceptre CC-615GL stood out as the winner in the Best Overall and High Quality categories. It scored above average on all but one of the quality tests, the contrast ratio test.

The Sceptre CC-615GL offers a straightforward combination of digital and analog controls. Individual push buttons for vertical and horizontal size and position control the placement of the image. Pressing any three of these buttons simultaneously enables pincushion adjustments.

Zenith Data Systems' ZCM-1540-UT

Rankings for This Application Considered:



ENERGY STARS BURN DIMMER

The EPA (Environmental Protection Agency) awards an Energy Star label to monitors that use 30 W or less of power in their standby mode, and many of the monitors we tested carry the EPA's blessing (see the Roll Call on page 224). So far, no technology can dramatically reduce the current draw of monitors while they are fully active. But a power-down mode can drop current draw from approximately 100 W to less than 30 W. The EPA estimates that people use their monitors only 20 percent of the time the displays are on, so power-down savings could be considerable.

The EPA's guidelines cover only power-level targets, not the ways manufacturers can reach these levels, so manufacturers have created a number of different power management "standards." One of the first monitors with power conservation features came from Nanao. The F series of products feature a microprocessor-controlled system that watches Windows activity. If the monitor senses a blanked Windows screen, the control system initiates a partial shutdown of the high-voltage systems in the monitor, keeping only the CRT and microprocessor warm. When you press a key or move the mouse, the monitor turns on again. If no activity occurs within a user-definable period, the monitor enters a second level of power reduction, called the suspend state, which lowers power consumption to around 4 W. Standby mode refers to the intermediate shut-down level.

There are trade-offs between these states. While the suspend state uses very little power, the monitor requires 8 to 10 seconds to power back up. The standby state uses about 30 W, but the monitor returns to a full image in just a couple of seconds.

But implementations that require the monitor to constantly check on the CPU make it tricky to match monitors and computers. VESA has proposed DPMS (Display Power Management Signaling), a set of power management standards for communication between computers and monitors. DPMS governs the signals used to initiate power reduction in monitors. It relies on Intel and Microsoft's APM (Advanced Power Management) specification to define the names, broad definitions, and recovery times of reduced power levels. The chart below details the APM conventions, along with typical values for the monitors we tested.

APM STATE	ON	STANDBY	SUSPEND	OFF
Power savings	None	Minimal (to under 40 W)	Substantial (to under 4 W)	Maximum
Recovery time	Not applicable	Short recovery (2 to 4 seconds)	Longer recovery (8 to 12 seconds)	System-dependent

DPMS uses the presence or absence of sync and video signals to control power levels. Using these rules as the common starting point, manufacturers of computers and monitors can use whatever technology is available to regulate the power consumption.

If you are considering purchasing a new monitor, an energy-saving display can offer real operational cost savings. Make sure that the monitor will function with your "green" PC or with an external software package such as Windows screen blankers. Our tests also showed that simply using the standard Windows utility to blank the screen (totally blank—no flying appliances) reduces power consumption by an average of 23 percent, even for monitors not equipped with power management systems.

finished as a runner-up to the Sceptre in both the Best Overall and High Quality scorings. It boasted the third-lowest power consumption in its category at just 66 W (the average was 81 W). On both the screen contrast ratio and misconvergence tests, however, this monitor scored in the lower half of all 15-inch monitors. Contrast ratio is useful in determining which monitors can work well in high ambient-light environments. The misconvergence test may indicate a problem in correctly aligning the electron beams. High levels of misconvergence may result in discolored characters or lines.

Mitsubishi's Diamond Scan 15FS also rates runner-up status for both Best Overall and High Quality. This monitor uses multiple-function digital controls. You select a function using a pair of up/down push buttons; an LED indicates the function selected.

Controls for vertical and horizontal size and position also serve as pincushion adjustment controls. Separate sets of up/down push buttons set brightness and contrast. A status indicator lights when limits on these controls are reached.

Other products deserving attention come from KFC and CTX. The KFC CA1507 offers controls that let you adjust image size and position, correct image tilt and pincushioning, recall factory mode settings, and set the power-down delay interval.

However, the KFC CA1507 suffers from noticeable moiré patterns when displaying full-color screens. It also shows local regulation effects—a shifting of the border outward when displaying bright blocks of graphics, like the status lines under Windows. On the other hand, its image-quality score was well above average.

We rated the CTX 1560LR excellent in image quality and scored it well above average in virtually all the quality tests. However, its high power consumption, tested at 96 W, lowers its overall score. Compare its rating to the Sceptre CC-615GL's 63.6 W.

BYTE BEST | GENERAL BUSINESS

For the best balance of quality and features...

BEST OVERALL — Sceptre CC-615GL

JANUARY 1994 BYTE BEST GENERAL BUSINESS COLOR MONITOR

The CC-615GL combines excellent quality with a broad range of features and a good ease-of-use score to win the Best Overall title. Our legibility test using Word for Windows showed that the 15-inch CC-615GL matched all the 17-inch and half of the 21-inch monitors in this quality test. The CC-615GL is also a power miser: It uses only 63.6 W to display a full screen under Windows. The average for this category was 81 W. A power management system to reduce power during CPU idle time is standard. The monitor is MPR II compliant and offers simple-to-use screen controls.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	Sceptre CC-615GL	$555	8.39	9.36	▲▲▲	10.00	0.28	1024	
RUNNER-UP	Zenith Data Systems ZCM-1540-UT	$599	8.26	8.90	▲▲▲	9.64	0.28	1024	
RUNNER-UP	KFC CA1507	$495	8.05	8.33	▲▲▲	9.30	0.28	1280	
RUNNER-UP	ADI Micro Scan 4GP	$539	8.02	8.71	▲▲▲	7.16	0.28	1280	
RUNNER-UP	Mitsubishi Diamond Scan 15FS	$645	7.87	8.79	▲▲▲▲	8.98	0.28	1024	✔

Need the clearest display?

HIGH QUALITY — Sceptre CC-615GL

The flat screen on this 15-inch monitor garnered consistently high scores in our image-quality tests. The CC-615GL had the best score in its class in the legibility test. It exhibited an extremely low amount of misconvergence: 0.054 mm versus the class average of 0.107 mm. This contributed to its excellent results in the sharpness tests. Only its contrast ratio score of 5.4 was below the class average (5.7). The lackluster performance in the contrast ratio test may concern those working where there is a high level of ambient light.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	Sceptre CC-615GL	$555	8.39	9.36	▲▲▲	10.00	0.28	1024	
RUNNER-UP	CTX 1560LR	$639	7.54	8.94	▲▲▲	6.63	0.28	1024	✔
RUNNER-UP	Zenith Data Systems ZCM-1540-UT	$599	8.26	8.90	▲▲▲	9.64	0.28	1024	
RUNNER-UP	Mitsubishi Diamond Scan 15FS	$645	7.87	8.79	▲▲▲▲	8.98	0.28	1024	✔
RUNNER-UP	NEC 4FGe	$755	7.16	8.73	▲	7.91	0.28	1024	✔

Are you cost-conscious?

LOW COST — KFC CA1507

KFC packs quite a lot into this $495 product. The 15-inch CA1507 offers resolutions as high as 1280 by 1024 pixels at 60 Hz noninterlaced. The trade-off for low cost is only average quality scores. The monitor provides a full set of image-adjustment controls, including pincushion, image rotation, and power management. It uses the VESA DPMS power management control signals to meet Energy Star requirements.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	KFC CA1507	$495	8.05	8.33	▲▲▲	9.30	0.28	1280	
RUNNER-UP	Compac Mitac M1564PD	$459	7.36	8.45	▲▲	8.55	0.28	1280	
RUNNER-UP	Fora Addonics C152LR	$479	6.98	8.47	▲	7.16	0.28	1024	✔
RUNNER-UP	MGC 1506D	$499	7.46	8.19	▲▲	7.79	0.28	1280	Option
RUNNER-UP	Zenith Data Systems ZCM-1540-UT	$599	8.26	8.90	▲▲▲	9.64	0.28	1024	

KEY

Ease of Use: Poor ▲ Fair ▲▲ Good ▲▲▲ Excellent ▲▲▲▲

* Higher numbers are better; 10.0 = best score.

How We Tested

We tested monitors with a combination of hardware and software tools that were designed to examine every aspect of screen quality, power consumption, and ease of use. To do this, we conducted more than 40 separate visual inspections on each monitor. All tests were performed at a standard resolution of 1024 by 768 pixels using a VESA-compliant vertical refresh rate of 70 Hz. VESA considers this to be the lowest recommended vertical refresh rate at this resolution to avoid screen flicker. We used #9GXE video adapters by Number Nine in Compaq Deskpro 66M computers for our test bed.

The eye is superb at seeing differences in video quality, but the brain is poor at remembering them, so we used a video splitter to send test-screen images to three sample monitors as well as to the monitor under test. The three control monitors represented the low, middle, and high range of quality in our test sample.

The video splitter took the video signal from the computer, amplified the signal, and split it into four channels. The test monitor received one channel, and the control monitors received the remaining three channels. Because all four monitors showed the same image simultaneously, we could easily compare the test monitor's image quality to that of the best and worst monitors we evaluated.

IMAGE QUALITY

Our overall display quality score was based on a number of screen tests. To gauge image quality, we used 26 different screen images in Sonera Technologies' DisplayMate Professional to help us examine quality characteristics ranging from *blooming* (in which brighter images become larger and more unfocused than darker images) to *local regulation* (i.e., distortion caused by high-intensity images, frequently seen under Windows at the status bar). Each monitor was given a score of from 1 to 10 based on how it displayed each of the 26 screen images. We summed these results and gave each monitor a final score based on that total.

To measure *image sharpness* across the entire display area, we wrote a custom utility using Microsoft Visual Basic. This program produces images of boxes and lines at the selected Windows resolution of 1024 by 768 pixels. The box test produces 1- and 2-pixel-thick red, blue, and green boxes at the outside edges of the screen. We examined each monitor's ability to display these boxes with a black line between the boxes.

Testing team (clockwise from left): Andrew J. Froning, Siva Kumar, Chandrika Krishnamurthy, and Alan Joch.

A second series of images measures the ability of each monitor to display fine vertical and horizontal lines. Again, we tested with red and green lines separated by a black line. We rated each monitor using a set of precise scoring guides that instructed the tester to assign point values based on the screen image. We averaged the scores for the 28 measurement points that made up this test.

DisplayMate Professional also provided a systematic approach to measuring *geometric distortion*. Distortion manifests itself as oddly shaped screen images. The image may appear as a trapezoid or a barrel shape, with the tops or sides of the display area not parallel or at right angles. We measured the length of a series of lines displayed on the monitor, and the program calculated the percentage of distortion. Prior to testing, we used the monitor's controls (if any) to visually correct any existing distortion.

continued

TWO IMPORTANT QUALITY GAUGES

Convergence is the monitor's ability to precisely illuminate specific phosphor dots. To create a white dot, the electron beams must accurately converge on a single color triad. Misconvergence displays itself as white areas or lines that have a tinge of red, blue, or green. We measured misconvergence with an optical gauge manufactured by Klein Optical (Portland, OR). Using red, blue, and green prisms, the instrument reconverged a white line displayed on the test monitor. We calculated the amount of misconvergence from the amount of correction required. Lower amounts of misconvergence received higher scores.

Klein convergence gauge

We measured contrast ratio—in other words, the amount of contrast between the light and dark areas on the display—because this is one of the keys to visual clarity. Contrast differs from brightness as it represents the difference in the luminance levels among objects. While brightness is important for discerning a black cat on the floor of a darkened room, contrast is necessary to find a polar bear in a snowstorm. We used a Tektronix J1823 Narrow Angle Luminance probe to measure the luminance levels between a bright white square in the center of the image and the unilluminated border surrounding the square. A higher ratio provides greater contrast, which makes the monitor more usable in conditions of high ambient light.

How We Tested *(continued)*

The tests just described look at specific quality characteristics. Our *legibility* test, however, provided a real-world measurement of monitor quality. Using Microsoft Word for Windows, we constructed a document featuring six standard typefaces at point sizes from 4 to 14 points. We then determined at what point size the text samples were both readable and legible. We judged text to be readable if it could be discerned without strain from a standard reading distance of 24 inches. We considered text to be legible if it could be discerned from any distance less than 24 inches without the use of aids such as magnifiers.

For consistent results, only one tester conducted this test. In all our subjective tests, each tester conducted one complete set of tests on all the monitors. This system worked to eliminate scoring variances.

In our charts, higher numbers indicate better quality. The highest overall quality score we awarded was 9.64, for the NEC 6FGp, a 21-inch display. The lowest score was 7.54 for Megatron Computer Systems' MegaImage L15-MG, a 15-inch monitor. We found that the difference between a score of 9.5 and 7.5 is apparent to most monitor users. A 1-point difference is harder to discern visually unless you're looking for specific problem areas. Seeing distinctions in monitors whose scores differed by less than 0.5 point requires a sharp eye and some idea of what to look for, unless you're aided by software or hardware that gauges quality.

We did not evaluate color correctness because of the difficulty in accurately measuring this and because people who need exact color reproduction must calibrate monitor color values to other hardware devices, such as printers and scanners. If you need accurate color, we advise you to choose a monitor that allows for color adjustments and to perform your own color tests before making a purchase (see "Color-Matching Monitors" on page 220 and "Do-It-Yourself Monitor Testing" on page 222).

To arrive at our overall quality score, we weighted the image-quality and image-sharpness tests equally; together they accounted for 40 percent of the total quality score. Convergence scores represented 20 percent of the total, followed by legibility at 30 percent and contrast ratio at 10 percent.

Power multimeter

POWER CONSUMPTION

We tested power consumption by measuring each monitor's current draw. Using a digital multimeter connected to the monitor's power system, we took readings when the monitor displayed a full Windows screen and when the screen was blanked. For monitors with power management features, we measured power consumption in the active, standby, and suspend modes. Only the full-screen Windows figures are published and scored.

The Roll Call lists wattage consumption for all the monitors. The summary charts in each of the display-size rankings list power scores based on a 10-point index. Higher numbers indicate that a monitor used less power than another product in that size class.

EASE OF USE

To evaluate how easy it was to set up and use each monitor, we considered the various adjustment controls, cabling, and tilt/swivel bases, as well as the documentation that came with the monitor. We ranked monitors on the placement, range, and ease of adjustment for image controls. Controls typically include adjustments for brightness, contrast, horizontal and vertical size and position, pincushion (distortion), and degaussing. Some products include controls for color matching, phase adjustment, and resetting or saving settings. A greater range of controls combined with front-panel locations earned a higher score.

For making adjustments, most of the products featured digital controls using push buttons instead of analog thumb wheels. We judged that digital controls offer a wider range of adjustments than analog controls. But sometimes the sheer number of controls and their poor design and layout made digital controls more difficult to use.

We also rated monitors for the range of tilt and swivel of their bases (all manufacturers included such bases with their products). In addition, we considered the ease of panning or tilting the monitor.

Products also received higher scores if their video cables were longer than average. We reviewed documentation for clarity and completeness. Finally, products received higher scores if they offered a wider range of technical-support options, such as toll-free phone service and on-line services.

FEATURES

We evaluated monitors for features such as the number of factory-preset and user-definable resolution modes, video connectors, maximum usable screen area, weight, maximum resolution, and compliance with MPR II standards for emissions and EPA's Energy Star standards for power consumption.

Best Overall winners in each size category had the highest scores based on the weighted average of scores in the quality, image-sharpness, usability, features, power consumption, and distortion tests. Quality scores accounted for 45 percent of the total score, while features represented 20 percent, followed by ease of use (20 percent) and power usage (15 percent). We used the scores for quality, sharpness, misconvergence, and distortion to select High Quality winners. Low Cost winners were those monitors priced below the average for the size class and having the highest ratio between overall scores and price.

Contributors

Andrew J. Froning, *Editor/PC Digest, an NSTL publication, spent the last three years testing monitors, systems, and computer peripherals.*

Alan Joch, *Senior Editor/BYTE, coordinates the combined testing between the BYTE Lab and NSTL.*

Chandrika Krishnamurthy, *Technical Analyst/NSTL, evaluates computer peripherals and systems.*

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The Lab Report is an ongoing collaborative project between BYTE Magazine and National Software Testing Laboratories (NSTL). BYTE Magazine and NSTL are both operating units of McGraw-Hill, Inc.

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The Keys to Image Quality

Although the monitor is the most visible part of your display system, it's only one third of the imaging puzzle. The primary piece is the video graphics adapter, which takes the data from the CPU and processes it into the signals that feed the image to the monitor.

VIDEO ADAPTERS

Video adapters are growing in type and number (see next month's Lab Report for a comparison of video adapters). Conventional VGA adapters convert the digital data from the CPU to analog information before sending the data to the monitor. Accelerated video adapters use special chip sets to speed up the processing of GUI operations by off-loading some of these operations from the central CPU. Many high-end adapters also offer 24-bit color rendering, which requires additional on-board RAM for storing processed data.

For highest quality, match a powerful adapter to a monitor capable of receiving the data at high vertical and horizontal frequencies. Carefully review the refresh-rate specifications for both monitors and adapters, even when vendors claim VESA compliance. An adapter may use a standard refresh rate of 70 Hz for 1024- by 768-pixel resolution but use one of a number of different horizontal frequencies. If the horizontal frequency doesn't match that preset by the monitor manufacturer, you'll have to adjust the image for size and placement. In most cases, the problem is temporary, since you can save the adjustment as a user-definable setting. But you'll need to exercise care in matching an adapter and monitor when buying a fixed-frequency monitor. If you find that you can accept the limitations of these monitors, the reward is economic: Often they are the lowest-priced displays.

DISPLAY DRIVER

The final piece in the puzzle is the display driver. In the standard VGA resolution mode of 640 by 480 pixels, all adapters should function without special drivers. At higher resolutions, drivers provide the programming interface between the operating system and the video adapter's hardware.

Most adapters now provide specialized drivers for Windows 3.1. If you use OS/2 or applications that aren't Windows-based, such as CAD/CAM programs, make sure that proper drivers exist before making a purchase. If you have had your adapter for a while, it may pay for you to contact the manufacturer for a driver update. Updated drivers are often available from a vendor's BBS. The time you invest in getting a new driver may pay off. We found significant differences in performance from the same adapter simply by using updated display drivers.

Terms

Aperture grill
In Sony's Trinitron picture tubes, a thin piece of metal with long vertical slots through which electron beams pass before striking the phosphors (see Shadow mask).

Blooming
A monitor image that appears to grow in size or "bloom" when it is brightly illuminated. This occurs most often with bright white characters or objects and causes illegible text, because characters become unfocused as the pixels spread and diffuse.

Degaussing
The realigning of monitor electron beams to reduce screen discoloration. Discoloration occurs when a monitor's electromagnets succumb to interference from the earth's magnetic field after a monitor is tilted or moved. Many monitors automatically degauss at power on; others offer a manual degauss control. Caution: Repeated degaussing within a short time span can damage a monitor's control circuitry.

Dot pitch
The distance between the centers of red, green, and blue phosphor dots that make up the color triad. Smaller distances generally mean greater resolution, since smaller dots produce more dense characters and graphics. In products using the Trinitron aperture grill, the dot pitch refers to the center-to-center distance of the vertical grill openings.

Fixed-frequency
Describes monitors that support video signals at one of a limited number of combinations. These combinations must match frequencies supported by the display adapter used with the monitor.

Flicker
A visual effect that results when an image starts to fade before the monitor's electron beam scans the screen. High refresh rates reduce flicker and keep images sharp and stable. Higher resolutions require high refresh rates to avoid flicker.

Horizontal frequency
The number of lines illuminated on a monitor screen in 1 second. Increasing resolution requires greater horizontal frequency.

Interlaced displays
Interlacing divides the display screen into two fields of odd and even scan lines. In one pass, the electron beams refresh the even lines, and on the next pass, it illuminates odd lines. Interlacing is principally used on devices supporting the 8514A display mode, and the technique can produce noticeable flicker.

Misconvergence
Occurs when the electron beams scan the dots of the wrong red-green-blue triad. The result is colored edges on white objects or characters. Large amounts of misconvergence appear as shifted colors, as when printed four-color images are misaligned.

Multiscanning
A multiscanning monitor supports an unlimited range of horizontal and vertical frequencies within the limits of its controlling electronics. Multiscanning monitors offer the most flexibility in working with a variety of video display adapters. Most manufacturers offer some number of preset modes—that is, combinations of vertical and horizontal frequencies where the image is pretuned to fill the screen and center itself. The more presets offered, the less chance there is that the user will have to adjust the image manually. (See Fixed-frequency.)

Noninterlaced displays
In noninterlaced displays, electron beams scan every line of the display on each vertical sweep. Noninterlaced displays are generally more visually pleasing and are less likely to cause eyestrain than interlaced monitors. (See Interlaced displays.)

Resolution
Image quality based on the size and amount of pixels used to display an image. Increasing resolution requires more and smaller pixels. Standard VGA resolution is 640 pixels horizontally and 480 pixels vertically (we tested monitors capable of resolutions as high as 1600 by 1200 pixels).

Shadow mask
A piece of thin metal with minute holes that allow electron beams to pass through before striking the phosphors (see Aperture grill). These masks help the electron beams to strike the correct phosphor dots. For example, the mask blocks the electron beam for red from illuminating blue phosphors; in other words, it creates a shadow over the blue and green dots when the beam for red passes.

Vertical refresh rate
The speed at which the electron beams scan across the screen from top to bottom.

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MODEL	5468A	1451	1461	1561	1560	1760LR
CRT/Dot Pitch	14"/0.28 mm	14"/0.28 mm	14"/0.28 mm	15"/0.28 mm	15"/0.28 mm	17"/0.28 mm
Scan Frequency	H: 30-38 KHz V: 50-90 Hz	H: 30-50 KHz V: 50-90 Hz	H: 30-60 KHz V: 50-90 Hz	H: 30-60 KHz V: 50-90 Hz	H: 30-60 KHz V: 50-90 Hz	H: 30-65 KHz V: 50-90 Hz
Max. Resolution	1024x768/87Hz	1024x768/60Hz	1024x768/72Hz	1024x768/72Hz	1024x768/72Hz	1280x1024/60Hz
Digital Control	–	–	–	–	Yes	Yes
Full Screen	–	Yes	Yes	Yes	Yes	Yes
Low Radiation	5468LR	1451LR	1461LR	1561LR	1560LR	Yes

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THE BEST MONITORS FOR

SPREADSHEETS AND GRAPHICS

If you need to increase your viewing real estate to see more spreadsheet cells, show an entire CAD drawing, or display multiple windows, consider a 17-inch monitor. We tested 31 products in this size category, as well as two 16-inch products from Mitsubishi and SuperMac.

Like the 15-inch monitors, all the 17-inch monitors support at least 1024- by 768-pixel resolution at 70 Hz. Only the Sony CPD-1730 and the Arche 217AX do not support 1280 by 1024 pixels. However, the newer Sony GDM-17SE1 provides resolution modes of up to 1600 by 1200 pixels, as do products from IBM, Sampo, ViewSonic, and Philips. The 16-inch SuperMac E-Machines T16II supports a maximum of 1152 pixels horizontally.

Do you need the extra resolution? Remember that as the resolution increases, text and objects such as icons get smaller. We believe that a 17-inch monitor provides excellent viewing at 1024 by 768 pixels, but you need to be sharp-eyed to enjoy working at 1280- by 1024-pixel resolution on a screen area roughly 30 percent larger than a 15-inch monitor's.

We conducted our quality tests at 1024- by 768-pixel resolution. Our sharpness tests indicate that at the same resolutions, 17-inch monitors look sharper than 15-inch displays. We found this to be especially true in our Word for Windows legibility test, where the average score was 10 percent to 20 percent higher for the 17-inch products.

One drawback of a larger viewing area is a larger price: The average in this class was $1200, nearly twice that of the 15-inch monitors, although the lowest price for a 17-inch monitor ($799 for the Fora Addonics C172A/LR) is actually a few dollars below the highest 15-inch monitor cost.

Nanao reigned in our rankings for Best Overall, with three products in our top seven picks. We also rated monitors from Sigma, IBM, and NEC highly for Best Overall.

Sophisticated user interfaces also distinguish these products: Virtually all use digital controls to manage image size, shape, and color.

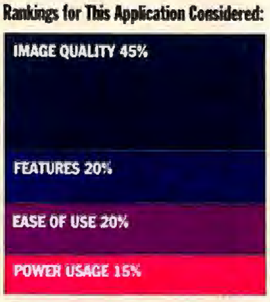
Acer America goes even further with its AcerView 76i by providing an on-screen display. This is an advantage over many monitors with small and hard-to-read icons that we found difficult to identify, especially in the dark.

Other items common in 17-inch displays but not on the smaller monitors are BNC video connectors (for RGB and sync inputs) and dual connectors or cables supporting both Macintosh and PC video.

Our choice for Best Overall winner is the Nanao F560iW. Although it shares virtually identical overall scores with the Nanao T560i, the F560iW had a higher quality rating than its more costly sibling. The third Nanao product, the F550iW, costs less than the other two and had similar quality scores. It uses a 0.28-mm dot-pitch mask, while the F560iW makes use of a 0.26-mm shadow mask and the T560i uses a Trinitron 0.25-mm aperture-grill mask.

Looking only at image quality, however, three products rated higher than the Nanaos. The IBM 17P uses a Sony 0.26-mm-pitch Trinitron tube, which garnered the highest rating in the image component of our quality tests. The Trinitron

Rankings for This Application Considered:



Emissions Overview

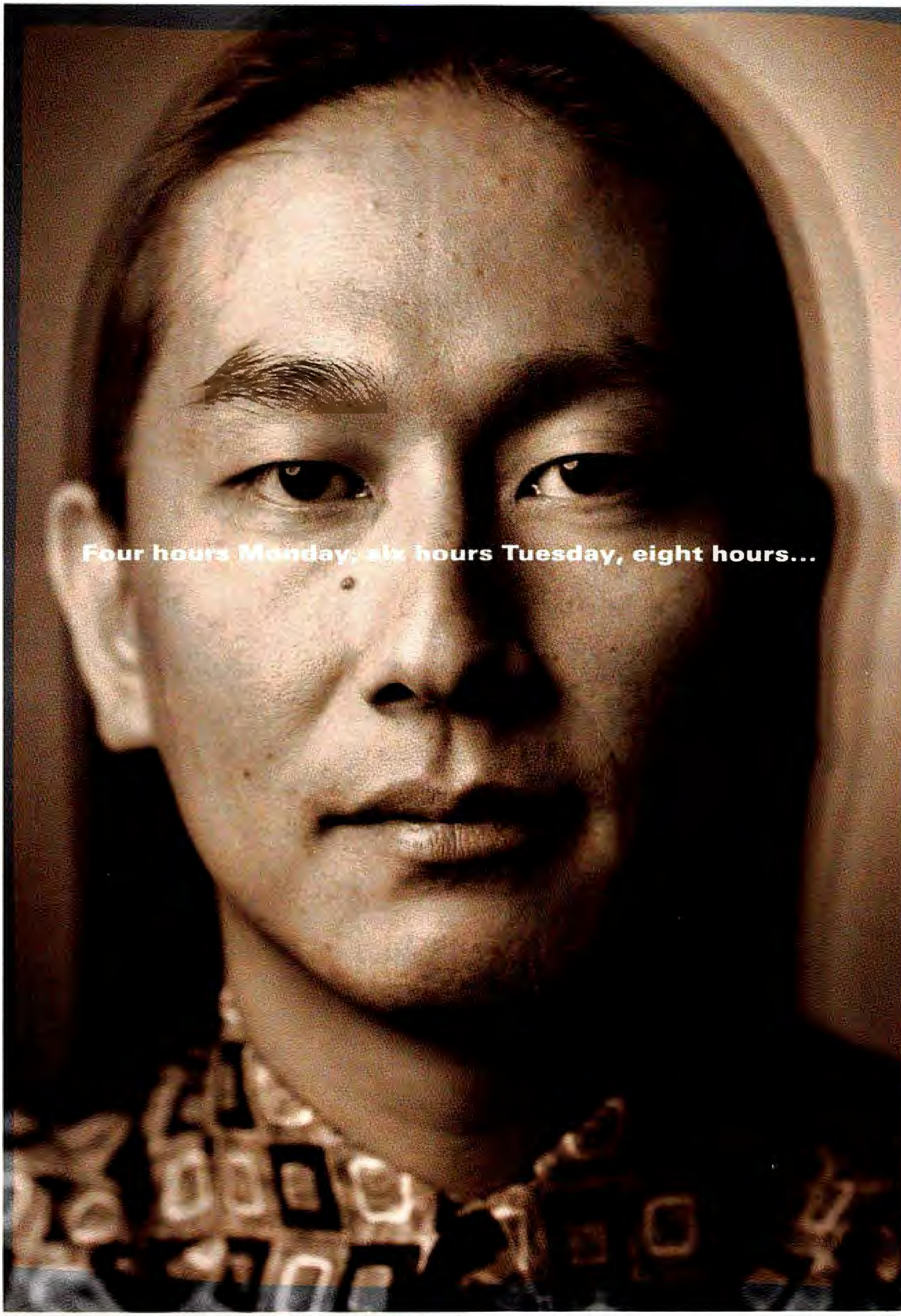
There has been a great deal of discussion in recent years over the possible safety hazards posed by monitors. Some state governments and safety officials are concerned about emissions of VLF (very low frequency) and ELF (extremely low frequency) magnetic and electric fields.

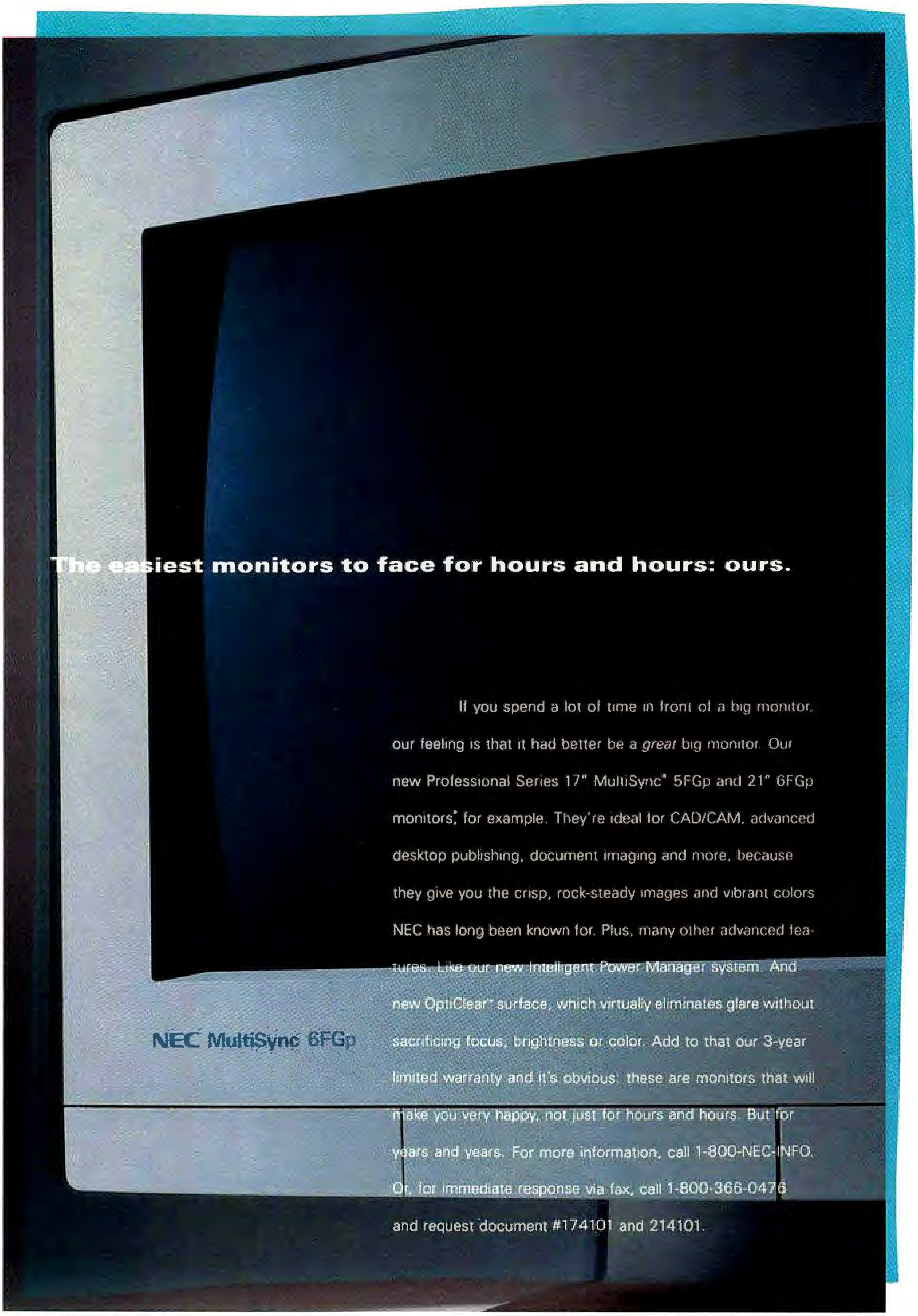
One of the first governing bodies to regulate such emissions from VDTs was the government of Sweden. Through SWEDAC (Swedish Board for Technical Accreditation), the Swedish government has developed a set of guidelines for the allowable strength of such emissions. The newest set is referred to as the MPR II specs.

Efforts in several U.S. jurisdictions to regulate VDTs have run into problems in the legislative and judicial systems. European countries are much more active in their pursuit of low-emission computer peripherals. Thus, companies selling in the worldwide market have been forced to produce low-emission products.

Whether this effort is needed is still a question that puzzles medical researchers. No widely accepted evidence of harm caused to humans by VDT emissions has been published. But clearly, lack of evidence notwithstanding, it pays to be safe rather than sorry. All but seven of the monitors in this report provide MPR II compliance (see the Roll Call on page 224), and the formerly large price gap between compliant and noncompliant products is typically small today.

Additional products tested may meet emission standards, but we did not list them as doing so if we did not receive a specific letter to that effect. Buyers should carefully examine product specifications regarding emission controls. We found that not all products in a single product line met the specifications, and on some monitors, such as the Compac Mitac M1564PD, it is optional.


Four hours Monday, six hours Tuesday, eight hours...



*17" and 21" CRTs yield 15.6" and 19.8" viewable screen areas

Circle 95 on Inquiry Card.

NEC

picture tubes tend to produce strong, vibrant colors. When evaluating Trinitron-equipped products, remember that you are supposed to see two thin lines running through light-colored screens. These are tiny wires inside the tube that support the aperture grill. The IBM monitors that we evaluated are available from IBM's new PC Company as peripherals separate from system bundles.

SuperMac's E-Machines TP16II, a 16-inch monitor, also uses a Trinitron picture tube and is principally sold in the Macintosh market. Its high quality may warrant some consideration from DOS/Windows users as well.

Our Low Cost winners were tougher to judge, since there is a real disparity between low cost and high quality. For example, the winning Fora Addonics C172A/LR had the lowest price of the monitors ranked for low cost, but its quality score ranked third. Two products that retail for around the $1200 average cost and have excellent overall scores are the IBM 17P and the NEC 5FGe. The 5FGe rated high in quality and ease of use, but it received only moderate marks for features and power consumption. One aspect that all our evaluators noted was the high amount of glare on the polished screen surface of the 5FGe. NEC sells a screen that substantially reduces the glare, but it also decreases image brightness. Perhaps as compensation, the 5FGe had the highest contrast ratio among 17-inch monitors.

Two other monitors, the ADI Micro Scan AP and the KFC CA1718, merit consideration for low cost because of their above-average overall performance. The Acer AcerView 76i also made a respectable showing. All three sell for under $1000 and feature power management and MPR II compliance.

We measured the average power consumption of 17-inch monitors at 96 W when running a full-screen Windows image. Compare that to 81 W for 15-inch monitors and 115 W for 21-inch products.

Need the best in performance and ease of use?

BEST OVERALL — Nanao F560iW

Our scoring places two 17-inch Nanao products, the F560iW and the T560i, almost dead even. Although both offer excellent image quality (the T560i uses a Trinitron picture tube from Sony, while the F560iW uses a Toshiba tube), we gave the F560iW the edge for displaying slightly better images at a price that's $500 lower than the T560i's. Each offers support for Macintosh users.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	Nanao F560iW	$1699	8.24	8.95	▲▲▲▲	5.14	0.26	1280	✔
RUNNER-UP	Nanao T560i	$2199	8.23	8.45	▲▲▲▲	7.71	0.25	1280	✔
RUNNER-UP	Sigma ErgoView 17	$1349	8.12	9.08	▲▲▲	6.21	0.25	1280	✔
RUNNER-UP	IBM 17P	$1199	8.09	9.18	▲▲▲	6.51	0.26	1600	✔
RUNNER-UP	NEC 5FGe	$1155	8.08	8.56	▲▲▲▲	7.71	0.28	1280	✔

Want the clear winner for quality?

HIGH QUALITY — IBM 17P

A new product from IBM's new PC Company, the 17P was the clear winner for image quality in this class. We rated it best among 17-inch monitors on the image-quality screen tests, and it proved best at the legibility and sharpness tests. Based on a Sony Trinitron tube, the 17P offers VESA-compliant power management, MPR II compliance, and a complete set of controls for adjusting the screen and color reproduction.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	IBM 17P	$1199	8.09	9.18	▲▲▲	6.51	0.26	1600	✔
RUNNER-UP	Sigma ErgoView 17	$1349	8.12	9.08	▲▲▲	6.21	0.25	1280	✔
RUNNER-UP	SuperMac E-Machines T16II	$1399	7.81	8.97	▲▲▲	6.84	0.26	1152	✔
RUNNER-UP	Nanao F560iW	$1699	8.24	8.95	▲▲▲▲	5.14	0.26	1280	✔
RUNNER-UP	Chenbro DaVinci EZ550	$1000	7.51	8.79	▲	7.11	0.26	1280	✔

When price matters most...

LOW COST — Fora Addonics C172A/LR

This $799 monitor can display resolutions of up to 1280 by 1024 pixels. When operating at 1024 by 768 pixels, this 17-inch monitor can run at an eyestrain-avoiding vertical refresh rate of 76 Hz. The C172A/LR is easy to use, with 16 preset and 15 selectable mode settings. Front-panel controls let you quickly adjust picture size and position, as well as reduce display distortions such as side and barrel pincushion effects. However, the trade-off for the monitor's low price is performance that's only adequate. Its overall score falls below the median for this group, and it received the lowest usability score of the monitors ranked here.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	Fora Addonics C172A/LR	$799	7.16	8.42	▲	6.35	0.28	1280	✔
RUNNER-UP	KFC CA1718	$895	7.85	8.27	▲▲▲	7.94	0.26	1280	
RUNNER-UP	Acer AcerView 76i	$899	7.54	8.45	▲▲	5.51	0.27	1280	
RUNNER-UP	ADI Micro Scan 5A	$949	7.85	8.72	▲▲▲	7.71	0.26	1280	
RUNNER-UP	ADI Micro Scan AP	$949	7.76	8.06	▲▲▲	7.30	0.26	1280	

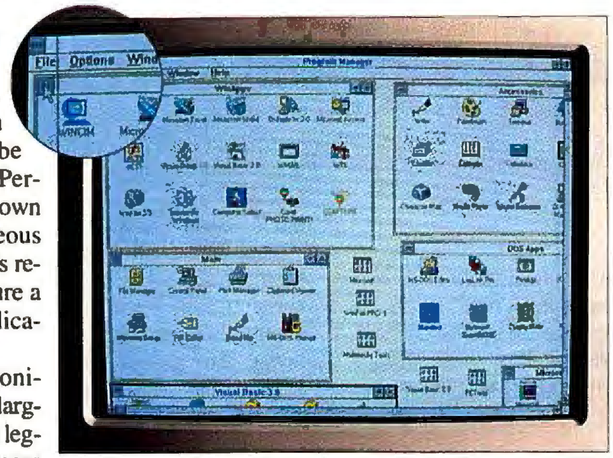
KEY

Ease of Use: Poor ▲ Fair ▲▲ Good ▲▲▲ Excellent ▲▲▲▲

* Higher numbers are better; 10.0 = best score.

Is Bigger Better?

If a 15-inch monitor is better than a 12-inch, and a 17-inch is more fun than a 15-inch, then a 21-inch monitor should be power-user heaven, right? Perhaps, but before you plunk down $3000 for one of the gorgeous monitors reviewed here, let's review some facts to make sure a large monitor fits your applications.


21-inch monitor displaying 800 by 600 pixels.

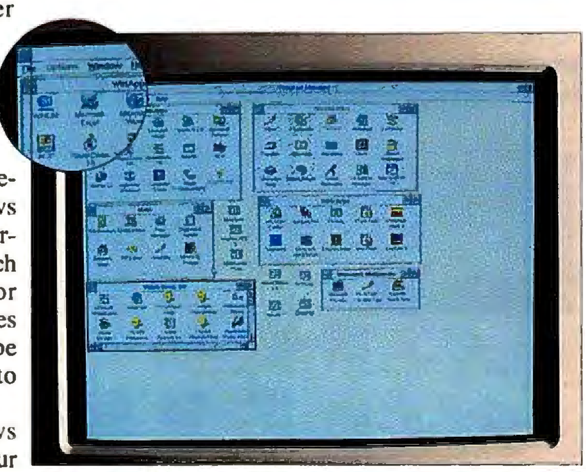
Compared to smaller monitors at the same resolutions, larger monitors do provide more legible characters. Our sharpness and legibility tests showed this to be true: the 21-inch class of monitors had the highest quality scores among all the monitors we tested.

RESOLUTION

Logically, it makes sense that larger monitors provide higher quality. If you use the same number of pixels to make a screen image, a larger screen gives larger characters, making the characters more legible.


21-inch monitor displaying 1024 by 768 pixels.

Under Windows at 1024- by 768-pixel resolution, a 21-inch monitor looks more readable than a 15-inch monitor because of the difference in character size. Increasing Windows resolution to 1280 by 1024 pixels increases the number of characters available but reduces their actual size. Thus, there is always a trade-off between the size of the Windows desktop and the size of the characters. Simply because a 15-inch monitor can handle 1024- or even 1280-pixel resolution does not mean that the text will be large enough to enable you to read what you type.


21-inch monitor displaying 1280 by 1024 pixels.

If you want more Windows desktop real estate, change your resolution mode. For instance, increasing resolution expands the number of rows and columns in your Windows spreadsheet. At 800 by 600 pixels, the default Excel spreadsheet gives you 27 rows and 12 columns. At 1024 by 768 pixels, you jump to 37 rows and 15 columns. Finally, at 1280 by 1024 pixels, Excel provides 49 rows and 19 columns. (Obviously, changing the default row height and column width also increases or decreases the number of visible cells.) Increasing the size of the monitor only makes those characters easier to read. The character size on a 15-inch monitor at 800- by 600-pixel resolution is almost identical to that on a 21-inch monitor at 1280 by 1024 pixels.

VIEWING DISTANCE

Remember that the larger the monitor, the greater the viewing distance it requires. Ideally, you should sit at a distance that allows you to see the entire screen without excessive head or eye movement.

For a 15-inch monitor, that distance seems to be about 18 inches; for 17-inch products, about 24 inches; and for the 21-inch displays, more than 32 inches. Of course, the farther you move back from the monitor, the smaller things appear, so again, character legibility becomes an issue.

SIZE

Another consideration in deciding on monitor size is space. Large monitors are just that—large. Think of placing your 20-inch color TV on top of your desktop computer. In addition to the weight factor (would your desk support an additional 70 or 80 pounds?), these monitors occupy a huge amount of space. They also use more energy and thus produce more heat and other emissions.

Large monitors are good for doing group presentations, detail work like CAD/CAM, or color imaging. For more typical Windows applications, 17-inch monitors let you make use of higher resolutions and more real estate at much less cost. Where money and space are considerations, a high-quality 15-inch monitor will provide excellent service at the cost of some additional spreadsheet scrolling. Our best advice is to experiment with different resolutions on several sizes of monitors, running the applications you use most, before you buy. Hands-on experience is the best way to find the monitor that's most comfortable for you.

WHY Is Brutus*, the King of Monitors, So Impressed by the 15" SCEPTRE?

Among the finest 15-inch High Resolution Color Monitors you can get, the Microprocessor based Low Radiation (MPR II compliant) **SCEPTRE CC-615L** offers:

1024 x 768 VESA 72Hz Flicker-free
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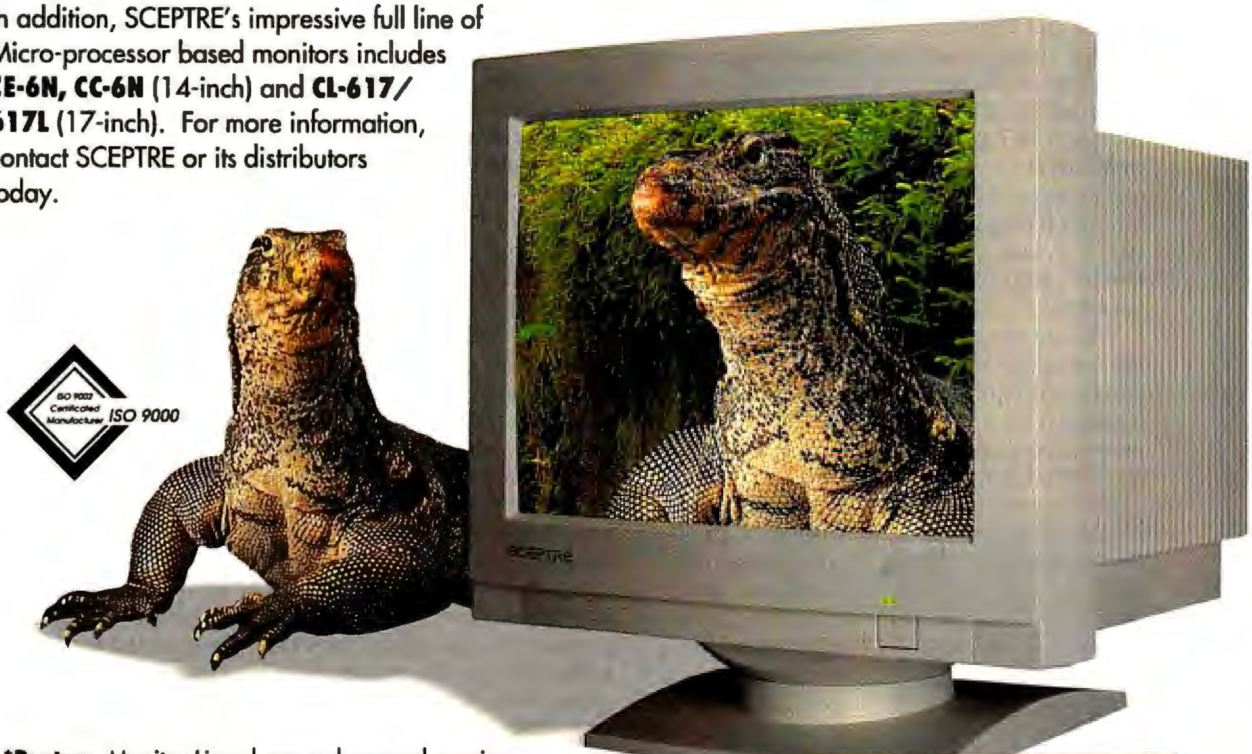
INVAR Shadow Mask Tube, FS II Flat Screen
31 Memory Settings
(5 Factory Preset, 26 User Adjustable)
Anti-static Screen
Universal Power 90-260 VAC 50/60Hz Auto-sensing
Advanced Dynamic Focusing
Manual and Auto-Degaussing
Front Access Push-button User Controls

*PLUS: Energy Saving Option (**CC-615G**), SCEPTRE's Two Year Limited Warranty, and many more.*

In addition, SCEPTRE's impressive full line of Micro-processor based monitors includes **CE-6N, CC-6N** (14-inch) and **CL-617/617L** (17-inch). For more information, contact SCEPTRE or its distributors today.



***Brutus**: Monitor Lizard, an endangered species, recently seen in the film "The Freshman" with Marlon Brando and Matthew Broderick

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THE BEST MONITORS FOR

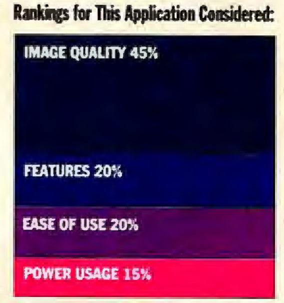
COMPLEX GRAPHICS & PRESENTATIONS

If you conduct group presentations, design large and complex CAD drawings, run desktop publishing applications, or edit color graphics, consider a 21-inch monitor. At 800- by 600-pixel resolution, your presentation will be clear even from the back of a hotel conference room. Many of the products also feature BNC video connectors, allowing you to chain several of these monitors together. The large scale of these displays benefits CAD work by showing details that might require zooming or panning with smaller monitors. Desktop publishers can display a two-page spread. And if your work involves color-image manipulation, the color balance controls and high resolution of these monitors make the meticulous nature of this work easier.

But 21-inch monitors weigh upwards of 70 pounds and dominate any desk surface. They cost big bucks as well: The average suggested retail price of the nine products we tested was more than $2700. These devices are also power-hungry. We measured average power consumption at 115 W; by contrast, 15-inch monitors averaged 81 W (power management was offered on only five of the nine we tested: the IBM 21P, Idek VisionMaster MF-8521, Nanao F760iW, NEC 6FGp, and Nissei Sangyo Super Scan Elite 21).

What do you get in return? A screen area of approximately 185 square inches and high resolution. Six of the nine large monitors we tested support 1600 by 1200 pixels, and the other three support 1280 by 1024 pixels. In addition, all the products come with sophisticated controls, such as pincushion control. All except the Mitsubishi Diamond Pro 21 FS offer some onscreen color control (see "Color-Matching Monitors," at right).

Rankings for This Application Considered:



Nevertheless, these large monitors are probably not suitable for most PC and Mac users. Besides the expense, a 21-inch display is just too big for most activities. Although 1600- by 1200-pixel resolution displays quite a bit of real estate, you'll need to sit close to the screen to discern individual characters.

Still, when these products were considered for the right applications, we found few faults. As a class, the 21-inch monitors had higher average scores for all the criteria than the 15- and 17-inch products. The NEC 6FGp had the highest quality scores of all 70 products reviewed.

To be sure, some of the sharpness tests lend themselves to larger monitors, as the larger object size on a 21-inch monitor makes it easier to discern test patterns. Yet the NEC 6FGp also had the highest scores when compared only to other 21-inch

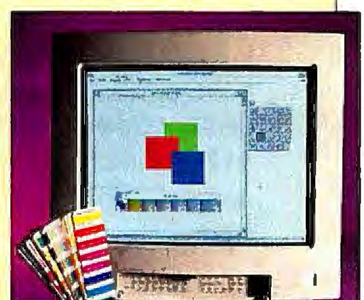
continued

COLOR-MATCHING MONITORS

When it comes to color, the human eye is a marvelous judge. Most of us can distinguish about 7 million colors out of the palette of 16.7 million colors that the most capable computer systems deliver. The trick to working with color on personal computers has been matching colors throughout the process, from image capture to hard-copy output.

Since the color gamut (i.e., the universe of colors) of scanners, monitors, and printers is different for each device, matching colors is difficult. A number of monitor manufacturers now include some sort of color controls for adjusting the color on the monitor to match either the input or output device.

In the 25 monitors we received that support color controls, two types prevail. Most monitors, such as the Epson T1189U, give you a simple control that switches the white balance between 9300 degrees Kelvin and 6550 K. This operation provides a uniform change across all the colors displayed and is perhaps more useful for accommodating the visual taste of users than matching colors on other devices.



More sophisticated color controls are found on monitors such as the Nanao F550iW and F760iW and the NEC FG products. On the NEC 6FGp, you can change the gain or intensity of the three primary colors (red, green, and blue) using individual controls for each color. A color-setting memory lets you store two sets of color adjustments.

Nanao goes a step further. Besides a standard factory white-balance setting, it provides two user-definable memories for color changes. The Nanao monitors offer two sets of RGB adjustment, gain and cut-off. *Gain* refers to the intensity of the color—the amount of energy that illuminates the dots of red, green, and blue phosphor on the screen. *Cut-off* is the point at which the dots fail to illuminate. Changing the gain controls adjusts the white balance at the high end of the gray scale. Adjusting cut-off changes the white balance throughout the gray-scale range.

Note that making a change in any color affects any on-screen color that has that color as a component. Monitors use the additive color process, so adding more red to make an orange more appealing means that all the apples, strawberries, and eggplants change color as well.

How valuable are color-matching systems? To please your sense of color, perhaps the simple white-balance changes offered by a number of manufacturers will satisfy you. However, making useful gain and cut-off adjustments to match the on-screen color of a monitor to a color printer's output requires a thorough understanding of color theory and many trial-and-error adjustments. That is probably why all these systems offer an easy method to restore the factory default settings. If you are a color specialist needing a great deal of control over the color process, a large monitor with color gain and cut-off adjustments may be worth the expense.

products. The 6FGp comes with a dual-headed video cable for either Macs or DOS/Windows PCs. If you have a Mac, you attach the 15-pin D-sub connector end of the cable to your computer and the other end to a 15-pin mini-D-sub connector at the rear of the monitor. You reverse the cable to connect to a standard VGA PC. NEC also provides RGB gain controls that let the user change the content of the image by increasing or decreasing the amount of red, blue, or green in the image. With a suggested retail price of $2535, the 6FGp even falls below the average price ($2736) in this category.

At $2695, the Nissei Sangyo Super Scan Elite 21 fell near the middle in price for monitors in this size group. Nissei Sangyo is a marketing arm of Hitachi of Japan. We also received a 21-inch monitor from Hitachi of America, but the products do not resemble each other; the Nissei Sangyo display scored significantly higher in our quality scoring and cost about $300 less than the Hitachi display. The two monitors compete against each other in the American market.

Interestingly, the ViewSonic 21 tied with the NEC 6FGp for the best score in the image-quality tests. But the ViewSonic displayed considerable misconvergence in that series of tests, and this lowered its otherwise-excellent sharpness test scores. In addition to the standard controls for image size, position, and pincushion adjustment, the ViewSonic 21 offers two other useful adjustments: white balance and moiré reduction. We liked the ViewSonic's drop-down control tray because the control buttons are easy to see and identify.

The Idek VisionMaster MF-8521 has a unique power conservation feature, a sensor that registers your presence when you sit in front of the monitor. If the sensor registers nothing for an hour, the monitor automatically shuts down into a suspended power state, where it draws merely 6 W.

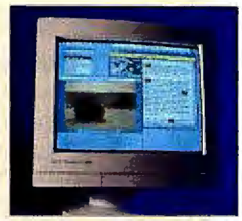
The price leader is the IBM 21P, which lists for $2249. The 21P features VESA-compliant power management systems, and it exhibited the lowest power consumption of all the large monitors. However, this product also suffers worse-than-average misconvergence, which brought down its overall quality score.

Also in this group was the Sony GDM-2038, which the company classifies as a 20-inch display. Its maximum viewing dimensions, however, are only about 2 cm smaller than most 21-inch products. The Sony falls in the middle of the pack in quality and overall scores.

BYTE BEST | COMPLEX GRAPHICS AND PRESENTATIONS

Want the best of the biggest?

BEST OVERALL **NEC 6FGp**

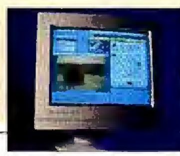


A competitive $2535 price and the highest quality score of any monitor we tested combine to make this 21-inch monitor the winner in this category. With color adjustment, a dual-headed cable for Macs and PCs, and virtual resolution software for Macs with built-in video, this monitor is a solution for almost any application under any operating system.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	NEC 6FGp	$2535	8.80	9.64	▲▲▲▲	18.65	0.28	1280	✔
RUNNER-UP	Nissei Sangyo Super Scan Elite 21	$2695	8.69	9.26	▲▲▲	9.47	0.28	1600	
RUNNER-UP	Nanao F760IW	$2999	8.61	8.73	▲▲▲▲	9.09	0.31	1280	✔
RUNNER-UP	IBM 21P	$2245	8.35	8.54	▲▲▲▲	10.00	0.31	1600	✔
RUNNER-UP	Hitachi Accuvue PS-21AM	$2995	8.19	8.71	▲▲▲	9.68	0.28	1600	✔

For unsurpassed picture quality...

HIGH QUALITY **NEC 6FGp**



Here again, the 6FGp shines. Rated best on the image-quality screen tests, this monitor showed practically no geometric distortion. We would like to see less glare from the polished glass surface. In the dark, however, this monitor showed great contrast and virtually no misconvergence.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	NEC 6FGp	$2535	8.80	9.64	▲▲▲▲	8.65	0.28	1280	✔
RUNNER-UP	Nissei Sangyo Super Scan Elite 21	$2695	8.69	9.26	▲▲▲	9.47	0.28	1600	
RUNNER-UP	ViewSonic 21	$2399	8.12	8.82	▲▲▲	9.00	0.25	1600	✔
RUNNER-UP	Idek VisionMaster MF-8521	$2895	8.15	8.79	▲▲▲	8.04	0.28	1600	✔
RUNNER-UP	Sony GDM-2038	$2859	8.13	8.75	▲▲▲▲	8.65	0.30	1600	✔

Need a large screen at the right price?

LOW COST **IBM 21P**

The IBM 21P provides above-average overall performance and carries the lowest price of any of the large-display monitors we evaluated. This monitor received the lowest image-quality score in the 21-inch class; however, its quality is far from poor. Without a standard of comparison, it is doubtful that you could find fault with the 21P's quality. All the 21-inch products display images clearly and sharply.

		PRICE	OVERALL SCORE	QUALITY INDEX*	EASE OF USE	POWER-DRAW INDEX*	DOT/GRILL PITCH (MM)	MAX. HORIZONTAL RESOLUTION (PIXELS)	MAC SUPPORT?
BEST	IBM 21P	$2245	8.35	8.54	▲▲▲▲	10.00	0.31	1600	✔
RUNNER-UP	NEC 6FGp	$2535	8.80	9.64	▲▲▲▲	8.65	0.28	1280	✔
RUNNER-UP	ViewSonic 21	$2399	8.12	8.82	▲▲▲	9.00	0.25	1600	✔
RUNNER-UP	Nissei Sangyo Super Scan Elite 21	$2695	8.69	9.26	▲▲▲	9.47	0.28	1600	
RUNNER-UP	Nanao F760IW	$2999	8.61	8.73	▲▲▲▲	9.09	0.31	1280	✔

KEY

Ease of Use: Poor ▲ Fair ▲▲ Good ▲▲▲ Excellent ▲▲▲▲

* Higher numbers are better; 10.0 = best score.

Do-It-Yourself Monitor Testing

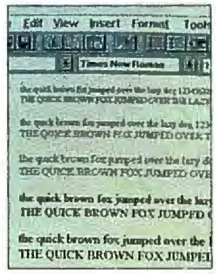
Users without access to sophisticated test instruments can still make informed judgments about a particular monitor's performance. The "homemade" tests that follow will help you evaluate individual products before purchase.

Before you examine a product, let it warm up for 10 or 20 minutes. Set the brightness level so that the illuminated part of the screen has the same background level as the unilluminated portion. Set the contrast level to its highest setting. Position the monitor to reduce glare as much as possible.

Pincushioning effect

An easy test is for pincushioning, in which edges of the display bulge. Place a straightedge along the edges of the screen image. If the image's edge bows in or out, the monitor is exhibiting pincushioning. Excessive pincushioning causes distortion and detracts from legibility. Not all the products we tested had pincushioning controls.

To check for color registration, or convergence, examine thin white lines on a black background and check for colors showing along the edges of the line. Noticeable amounts of color along a white line indicate poor convergence. High levels of misconvergence denote poor monitor adjustment and make viewing graphics displays difficult. You can check for geometric distortion by comparing the dimensions of same-size blocks in the corners and center of the screen. If the blocks vary considerably in size, the monitor will distort graphics and shapes; this is especially problematic for CAD and desktop publishing applications.



Legibility test

To test legibility, run a WYSIWYG program such as Word for Windows. Vary typefaces and font sizes, and check the monitor's ability to resolve images clearly. You should be able to read 8-point type comfortably on most monitors at resolutions of up to 1280 by 1024 pixels.

To check local regulation (i.e., how the monitor handles a block of very bright screen image), open a full-size Windows screen. In the Control Panel, select Color and set the status line to white. Select a dark color, but not black, for the background screen color. If the status bar appears to jut out to the left, the monitor is not doing a good job of regulation.

Look for screen-color consistency. Under Windows, change the background color to pure red, blue, or green. Check for even colors without splotches or shadows. If colors are mottled, try degaussing the monitor. Correcting convergence and pincushioning is possible if the monitor has the appropriate controls; splotchy color and geometric distortion are generally not user adjustable.

HONORABLE MENTIONS

The AcerView 76i displays settings on the screen, which makes adjusting images for brightness, contrast, or distortion easy. It can display the settings in five languages and gives the user a numerical setting for each control. ◁

A tray-mounted control panel on the Idek VisionMaster MF-8521 has easy-to-see adjustment controls, making changes much easier. It also has a unique sensor that monitors for the presence of someone in front of it and induces a low power state when no one's there. ▽

Manuals for the NEC family of products cleverly break out sections under the titles "I can't wait," "I want to know more," and "I want to be an expert," which help you quickly find the information you need. The manuals include indexes, glossaries, and a list of addresses for organizations such as VESA and SWEDAC.

A Perfect Image Under Your Command

The irresistible features on the new KFC monitors are so innovative that capturing a true "What you want is what you get" image is no longer an imagination.

Pin-Cushion Control: No more geometric distortion

Rotation Control: No more tilted screen

Trapezoid Control: No more weird picture

KFC Saves Energy, You $ave Money!

KFC's new green monitors consume less than 1.5 Watts when inactive, and less than 20 Watts when on stand-by. Compared to the average of 85~100 Watts for an ordinary monitor, each KFC monitor contributes substantially to a greener environment. And you're not just sharing the contribution, you're also saving money.

Product Line

CA1718	CA1507	CM1428D	CT1428A	CK1428A
17" Flat Screen	15" Flat Screen	14" MultiScan	14" SVGA NI	14" SVGA
1280 x 1024 NI	1280 x 1024 NI	1280 x 1024	1024 x 768 NI	1024 x 768
New features	New features	72Hz refresh	Energy Savings*	Energy Savings*
Energy Savings	Energy Savings	Energy Savings		
Microprocessor controlled	Microprocessor controlled	Microprocessor controlled		

**Power Saving Features Optional*

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ROLL CALL OF COLOR MONITORS

	MODEL	OVERALL SCORE	QUALITY INDEX[1]	EASE OF USE[2]	POWER-DRAW INDEX[1]	PRICE	DOT/GRILL PITCH (MM)	MASK TYPE	MAX. HORIZONTAL RESOLUTION (PIXELS)	VIDEO BANDWIDTH (MHZ)	FACTORY-PRESET MODES
15-INCH											
Aamazing Technologies, Inc.	CM-1528	7.13	8.12	5.49	9.81	$650	0.28	Dot	1280	85	10
ADI Systems, Inc.	Micro Scan 4GP	8.02	8.71	8.36	7.16	$539	0.28	Dot	1280	75	10
ADI Systems, Inc.	Micro Scan 4GLR	7.55	8.31	8.25	7.36	$579	0.28	Dot	1280	75	10
Amax Engineering Corp.	Impression 5528N	6.25	8.34	6.63	8.28	$399	0.28	Dot	1280	100	None
AOC International	Spectrum 5S	6.92	8.12	6.22	8.57	$699	0.28	Dot	1280	100	14
Arche Technologies, Inc.	215XL	6.47	8.19	4.42	9.64	$499	0.28	Dot	1280	100	INP
Compac Microelectronics, Inc.	Mitac M1564PD	7.36	8.45	6.59	8.55	$459	0.28	Dot	1280	100	10
CTX International, Inc.	1561LR	7.15	8.08	7.25	7.26	$599	0.28	Dot	1024	85	0
CTX International, Inc.	1560LR	7.54	8.94	7.50	6.63	$639	0.28	Dot	1024	85	15
Delta Products Corp.	DCM 1588	7.32	7.95	7.16	8.55	$370	0.28	Dot	1280	110	12
Delta Products Corp.	DCM 1588VA	7.50	7.95	7.04	8.55	$385	0.28	Dot	1280	110	12
Epson America, Inc.	T1189U	7.80	7.86	8.55	10.00	$529	0.28	Dot	1024	38	7
Fora Addonics, Inc.	C152LR	6.98	8.47	6.39	7.16	$479	0.28	Dot	1024	80	16
IBM Corp.	IBM 15P	7.47	8.04	8.81	7.38	$807	0.28	Dot	1280	86	15
KFC USA, Inc.	CA1507	8.05	8.33	7.72	9.30	$495	0.28	Dot	1280	80	8
MAG Innovision, Inc.	MX15F	7.68	8.67	7.45	7.36	$749	0.28	Dot	1280	120	9
Megatron Computer Systems, Inc.	MegaImage L15MG	6.81	7.54	5.74	8.98	$279	0.28	Dot	1280	85	13
MGC Technologies	1506D	7.46	8.19	6.97	7.79	$499	0.28	Dot	1280	65	15
Mitsubishi Electronics	Diamond Scan 15FS	7.87	8.79	8.79	8.98	$645	0.28	Dot	1024	80	6
Mitsubishi Electronics	Diamond Scan 16*	7.48	8.26	8.54	7.83	$1169	0.28	Dot	1280	100	6
NEC Technologies, Inc.	4FGe	7.16	8.73	6.07	7.91	$755	0.28	Dot	1024	80	14
Optiquest, Inc.	2000DX	7.55	8.21	8.16	7.91	$469	0.28	Dot	1024	80	16
Orchestra Multisystems, Inc.	French Horn	7.33	8.35	7.20	8.28	$545	0.28	Dot	1280	110	13
Proton Corp.	FM-1561A	7.27	8.15	7.19	6.88	$799	0.28	Dot	1280	100	10
Qume Peripherals, Inc.	QM865E	7.24	8.28	5.98	9.14	$579	0.28	Dot	1280	85	10
Sampo America	KDM 1566Bi	7.46	8.71	7.16	8.41	$695	0.28	Dot	1280	80	10
Sceptre Technologies, Inc.	**CC-615GL**	**8.39**	**9.36**	**7.53**	**10.00**	**$555**	**0.28**	**Dot**	**1024**	**80**	**9**
SuperMac Technology, Inc.	E-Machines T16II*	7.81	8.97	7.94	6.84	$1399	0.26	Slot	1152	110	7
ViewSonic	ViewSonic 15	7.55	7.92	9.36	6.63	$549	0.27	Dot	1280	86	13
Zenith Data Systems Corp.	ZCM-1540-UT	8.26	8.90	7.67	9.64	$599	0.28	Dot	1024	80	7
17-INCH											
Aamazing Technologies, Inc.	CM-1726X	7.46	8.12	7.09	7.50	$1499	0.26	Dot	1280	110	12
Acer America, Inc.	AcerView 76i	7.54	8.45	7.28	5.51	$899	0.27	Dot	1280	110	16
ADI Systems, Inc.	Micro Scan AP	7.76	8.06	8.02	7.30	$949	0.26	Dot	1280	85	10
ADI Systems, Inc.	Micro Scan 5A	7.85	8.72	8.14	7.71	$949	0.26	Dot	1280	85	10
Altima Systems, Inc.	VScan 70	7.68	8.55	7.94	6.67	$999	0.26	Dot	1280	110	11
Amax Engineering Corp.	Impression 1726N	6.34	8.74	6.85	7.30	$845	0.26	Dot	1280	120	8
AOC International	Spectrum 747H	7.17	8.64	5.30	6.35	$999	0.28	Dot	1280	135	16
Arche Technologies, Inc.	217AX	6.46	8.04	4.88	9.31	$899	0.26	Dot	1024	100	16
Chenbro Micom Co. Ltd	DaVinci EZ550	7.51	8.79	6.51	7.11	$1000	0.26	Dot	1280	135	14
CTX International, Inc.	1760LR	7.39	8.52	7.72	5.93	$1099	0.28	Dot	1280	100	15
ETC Computer, Inc.	Viewmagic 1765C	7.61	8.53	7.54	7.83	$1199	0.26	Dot	1280	75	13
Fora Addonics, Inc.	C172A/LR	7.16	8.42	5.93	6.35	$799	0.28	Dot	1280	110	16
IBM Corp.	IBM 17P	8.09	9.18	8.27	6.51	$1199	0.26	Slot	1600	139	14
KFC USA, Inc.	CA1718	7.85	8.27	7.49	7.94	$895	0.26	Dot	1280	80	10
Liberty Electronics USA, Inc.	Liberty CL-9117	7.19	8.16	6.77	5.68	$949	0.26	Dot	1280	130	14
MAG Innovision, Inc.	MX17F	7.83	8.63	7.44	6.92	$1299	0.26	Dot	1280	120	16
Mitsubishi Electronics	Diamond Pro 17	7.43	8.11	8.54	6.75	$1499	0.25	Slot	1280	100	6
Nanao USA Corp.	F550iW	7.91	8.37	8.68	5.81	$1599	0.28	Dot	1280	80	9
Nanao USA Corp.	**F560iW**	**8.24**	**8.95**	**8.99**	**5.14**	**$1699**	**0.26**	**Dot**	**1280**	**120**	**9**
Nanao USA Corp.	T560i	8.23	8.45	8.53	7.71	$2199	0.25	Slot	1280	130	9
NEC Technologies, Inc.	5FGe	8.08	8.56	9.20	7.71	$1155	0.28	Dot	1280	80	12
Optiquest, Inc.	4000DC	7.60	8.67	8.06	5.81	$899	0.28	Dot	1280	110	INP
Orchestra Multisystems, Inc.	Tuba	7.15	8.44	5.90	7.30	$945	0.26	Dot	1280	110	15
Panasonic Communications Systems Co.	Pana Sync/Pro C1795E	7.93	8.72	8.28	7.01	$1579	0.28	Dot	1280	130	23
Philips Consumer Electronics Co.	Brilliance 17	7.50	7.78	8.07	7.83	$1399	0.27	Dot	1600	135	12
Sampo America	KDM 1777	7.08	8.34	6.79	6.84	$1295	0.28	Dot	1600	100	10
Sceptre Technologies, Inc.	CL-617GL	7.52	7.91	6.98	7.40	$995	0.26	Dot	1280	110	13
Sigma Designs, Inc.	ErgoView 17	8.12	9.08	8.36	6.21	$1349	0.25	Slot	1280	120	16
Sony Electronics, Inc.	CPD-1730	7.34	8.29	8.36	6.92	$1330	0.25	Slot	1024	60	9
Sony Electronics, Inc.	GDM-17SE1	5.90	8.77	5.42	6.14	$1500	0.25	Slot	1600	100	9
ViewSonic	ViewSonic 17	7.41	8.35	7.95	6.14	$1199	0.27	Dot	1600	135	13
21-INCH											
Hitachi America, Ltd.	Accuvue PS-21AM	8.19	8.71	8.09	9.68	$2995	0.28	Dot	1600	130	7
IBM Corp.	IBM 21P	8.35	8.54	8.77	10.00	$2245	0.31	Slot	1600	139	12
Idek Iiyama North America, Inc.	VisionMaster MF-8521	8.15	8.79	7.90	8.04	$2895	0.28	Dot	1600	135	9
Mitsubishi Electronics	Diamond Pro 21 FS	7.66	8.57	8.58	6.72	$2999	0.28	Dot	1280	130	8
Nanao USA Corp.	F760iW	8.61	8.73	9.05	9.09	$2999	0.31	Dot	1280	120	9
NEC Technologies, Inc.	**6FGp**	**8.80**	**9.64**	**9.57**	**8.65**	**$2535**	**0.28**	**Dot**	**1280**	**135**	**12**
Nissei Sangyo America Ltd.	Super Scan Elite 21	8.69	9.26	7.84	9.47	$2695	0.28	Slot	1600	135	8
Sony Electronics, Inc.	GDM-2038*	8.13	8.75	8.46	8.65	$2859	0.30	Slot	1600	120	9
ViewSonic	ViewSonic 21	8.12	8.82	8.31	9.00	$2399	0.25	Dot	1600	150	13

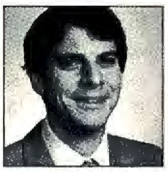
= BYTE Best INP=Information not provided [1] Higher numbers = better performance [2] Below 6.59 = Poor; 6.60-7.49 = Fair; 7.50-8.49 = Good; 8.50 and above = Excellent

USER-SETTABLE MODES	MAC II SUPPORT?	MAX. REFRESH RATE (HZ) AT 1024×768 (NI)[3]	MAX. REFRESH RATE (HZ) AT 1280×1024[3]	ENERGY STAR RECIPIENT?	POWER MANAGEMENT?	WATTAGE USED	FCC CLASS	MPR II	TOLL-FREE PHONE	PHONE NUMBER	INQUIRY NUMBER
INP	No	72	60 NI	No	No	64.8	B	No	None	(714) 255-1688	1105
9	No	72	60 NI	Yes	Yes	86.4	B	Yes	(800) 228-0530	(408) 944-0100	1107
9	No	72	60 NI	No	No	88.8	B	Yes	(800) 228-0530	(408) 944-0100	1108
1	Yes	72	60 NI; 87 I	No	No	76.8	B	No	(800) 800-6328	(510) 651-8886	1109
8	No	70	INP	No	No	75.6	B	No	(800) 343-5777	(408) 956-1070	1110
INP	Yes	70	66 NI	INP	INP	66.0	B	Yes	(800) 437-1688	(510) 623-8100	1111
10	No	72	60 NI	No	Yes	74.4	B	Optional	(800) 888-6482	(510) 656-3333	1112
0	No	72	87 I	No	No	87.6	B	Yes	(800) 888-2012	(909) 595-6146	1113
15	Yes	72	87 I	No	No	96.0	B	Yes	(800) 888-2012	(909) 595-6146	1114
9	Option	70	70 NI	Optional	Optional	74.4	B	Optional	None	(510) 770-0660	1115
9	Option	70	70 NI	Optional	Optional	74.4	B	Yes	None	(510) 770-0660	1116
6	No	70	Unsupported	No	No	84.8	B	Yes	(800) 289-3776	(310) 782-0770	1117
16	Yes	72	Unsupported	No	No	88.8	B	Yes	(800) 336-3962	(408) 944-0393	1106
11	No	75	75 NI	Yes	Yes	86.4	B	Yes	(800) 772-2227	(919) 543-7049	1118
24	No	72	60 NI	Yes	Yes	68.4	B	Yes	(800) 253-2872	(714) 546-0336	1119
8	Yes	70	60 NI	No	No	86.4	B	Yes	(800) 827-3998	(714) 751-2008	1120
0	Yes	72	60 NI	No	Yes	70.8	B	No	None	(714) 777-6166	1121
19	Option	70	60 NI	No	No	81.6	B	Yes	None	(818) 300-8406	1122
4	Yes	76	Unsupported	No	No	160.8	B	Yes	(800) 843-2515	(714) 236-6352	1123
4	Yes	76	60 NI	No	No	70.8	B	Yes	(800) 843-2515	(714) 236-6352	1124
8	Yes	76	Unsupported	No	No	80.4	B	Yes	(800) 632-4636	(508) 264-8759	1125
16	Yes	72	Unsupported	Yes	No	80.4	B	Yes	(800) 843-6784	(909) 468-3750	1126
8	Yes	70	60 NI	No	No	76.8	B	Yes	(800) 257-9988	(714) 708-3400	1127
9	Yes	72	60 NI	No	No	82.4	B	Yes	None	(310) 404-2222	1128
None	No	70	60 NI	No	No	69.6	B	No	(800) 457-4447	(408) 942-4242	1129
10	Yes	72	76 NI	No	No	75.6	B	Yes	INP	(404) 449-6220	1130
22	No	76	60 NI	No	Yes	63.6	B	Yes	(800) 488-2878	(714) 993-9193	1346
8	Yes	75	Unsupported	No	No	94.8	A	No	(800) 541-4787	(408) 541-6150	1347
26	Yes	76	60 NI	Yes	No	96.0	B	Yes	(800) 888-8583	(909) 869-7976	1348
23	No	70	Unsupported	Yes	Yes	66.0	B	Yes	(800) 553-0331	(708) 808-5000	1349
15	No	72	60 NI	No	No	86.4	B	Yes	None	(714) 255-1688	1350
16	No	72	60 NI	Yes	Yes	117.6	B	Yes	(800) 368-2237	(408) 432-6200	1351
9	No	72	60 NI	Yes	Yes	88.8	B	Yes	(800) 228-0530	(408) 944-0100	1353
9	No	72	60 NI	No	No	84.0	B	Yes	(800) 228-0530	(408) 944-0100	1354
9	Yes	70	60 NI	No	No	97.2	B	Yes	(800) 356-9990	(510) 356-5600	1355
13	Yes	72	60 NI	No	No	88.8	B	No	(800) 800-6328	(510) 651-8886	1356
14	Yes	70	INP	No	No	102.0	Pending	Yes	(800) 343-5777	(408) 956-1070	1357
16	Yes	75	75 NI	No	No	69.6	B	No	(800) 437-1688	(510) 623-8100	1358
16	Yes	70	74 NI	No	No	91.2	A	Yes	None	(510) 438-9946	1359
15	Yes	72	60 NI	No	No	109.2	B	Yes	(800) 888-2012	(909) 595-6146	1360
4	Yes	72	60 NI	No	No	82.8	B	Yes	(800) 876-4382	(510) 226-6250	1361
15	Yes	76	60 NI	Yes	Yes	102.0	B	Yes	(800) 336-3962	(408) 944-0393	1352
16	Yes	75	77 NI	Yes	Yes	99.6	B	Yes	(800) 772-2227	(919) 543-7049	1362
24	No	72	60 NI	Yes	Yes	81.6	B	Yes	(800) 253-2872	(714) 546-0336	1363
14	Yes	75	70 NI	No	No	114.0	B	Yes	(800) 745-7011	(510) 623-6000	1364
8	Yes	76	60 NI	No	No	93.6	B	Yes	(800) 827-3998	(714) 751-2008	1365
4	Yes	76	60 NI	No	No	96.0	B	Yes	(800) 843-2515	(714) 236-6352	1366
19	Yes	70	60 NI	Yes	Yes	84.0	B	Yes	(800) 800-5202	(310) 325-5202	1367
19	Yes	70	72 NI	Yes	Yes	111.6	B	Yes	(800) 800-5202	(310) 325-5202	1368
19	Yes	70	72 NI	Yes	Yes	126.0	B	Yes	(800) 800-5202	(310) 325-5202	1369
24	Yes	76	Not supported	Yes	Yes	84.0	B	Yes	(800) 632-4636	(508) 264-8759	1370
INP	Yes	76	60 NI	No	No	111.6	B	Yes	(800) 843-6784	(909) 468-3750	1371
15	Yes	70	60 NI	No	No	88.8	B	Yes	(800) 257-9988	(714) 708-3400	1372
25	Yes	76	74 NI	No	No	92.4	B	Yes	(800) 726-2797	None	1373
15	Yes	70	76 NI	No	No	82.8	B	Yes	(800) 835-3506	(310) 217-1300	1374
10	Yes	72	76 NI	No	No	94.8	B	Yes	None	(404) 449-6220	1375
18	Yes	76	60 NI	No	Yes	87.6	B	Yes	(800) 488-2878	(714) 993-9193	1376
8	Yes	80	64 NI	No	No	104.4	B	Yes	(800) 845-8086	(510) 770-0100	1377
9	Yes	70	Unsupported	No	No	93.6	B	Yes	(800) 352-7669	(408) 955-4136	1378
11	Yes	75	74 NI	Yes	Yes	105.6	B	Yes	(800) 352-7669	(408) 955-4136	1379
21	Yes	70	72 NI	No	No	105.6	B	Yes	(800) 888-8583	(909) 869-7976	1380
13	Yes	70	60 NI	No	No	111.6	B	Yes	(800) 225-1370	(201) 573-0774	1381
10	Yes	75	77 NI	Yes	Yes	108.0	A	Yes	(800) 772-2227	(919) 543-7049	1382
33	Yes	103	79 NI	Yes	Yes	134.4	A	Yes	(800) 394-4335	(215) 957-6543	1383
4	Yes	95	74 NI	No	No	82.8	A	Yes	(800) 843-2515	(714) 236-6352	1384
19	Yes	70	72 NI	Yes	Yes	118.8	B	Yes	(800) 800-5202	(310) 325-5202	1385
24	Yes	76	74 NI	No	Yes	124.8	A	Yes	(800) 632-4636	(508) 264-8759	1386
33	No	70	80 NI	Yes	Yes	114.0	A	Yes	(800) 441-4832	(617) 461-8300	1387
15	Yes	72	76 NI	No	No	124.8	A	Yes	(800) 352-7669	(408) 955-4136	1388
21	Yes	72	72 NI	No	No	120.0	B	Yes	(800) 888-8583	(909) 869-7976	1389

[3] I = interlaced; NI = noninterlaced [4] 16-inch display [5] 20-inch display

Wide-Area Windows Networking

Are NT and Windows for Workgroups truly WAN-savvy?



JON UDELL

The networking that's built into Windows NT and Windows for Workgroups enables machines to share each other's files, printers, and clipboards on a LAN. This set of features, which Microsoft refers to as Windows networking, comes in very handy. (Cynics might prefer the term *Windows and OS/2 networking*, since Microsoft has to date shipped more OS/2-based networks than Windows-based ones.)

A WFW or NT user on BYTE's Ethernet LAN can, for example, browse for and then connect to a shared directory on my Silicon Graphics Mips R4400-based Magnum running NT; a shared printer that's attached to my Everex 486DX2/50, also running NT; or a shared clipboard item on my WFW machine. Windows networks also interoperate with LAN Manager and LAN Server networks.

What Windows networks don't do by default, however, is talk to other Windows networks. Can Windows networks be WANs (wide-area networks)? That's a fascinating question that Microsoft is now trying to answer in several different ways.

Windows networking belongs to a larger family of networking products that use two protocols—NetBIOS and SMB—to enable workstations to communicate with each other and with servers. NetBIOS provides both connection-oriented services (i.e., sessions) and connectionless services (i.e., datagrams or messages); SMB provides a higher level of service that workstations use to, for example, connect to servers, open and read files, lock records, and queue print jobs.

Endless confusion surrounds NetBIOS. You often hear people say that Windows networking, or other SMB-/NetBIOS-based network products, can't run on WANs because NetBIOS "isn't a routable protocol." That's a red herring. NetBIOS is not a transport protocol, so it makes no sense to say that it can or cannot be routed through an internetwork. The NetBIOS protocol instead serves as an interface to a transport protocol, and it's that transport that might or might not be routable.

The default transport for LAN Manager, LAN Server, and Windows networking is NetBEUI, a purely LAN-oriented protocol that is, in fact, unroutable. You can build campus-size NetBEUI networks (like Microsoft's) using bridges, but you can't build global NetBEUI networks using routers.

So how does your Windows client in Canada talk to your Windows server in Sweden? Microsoft took the first step with LAN Manager 2.1. That product provided TCP/IP as an alternate NetBIOS substrate. TCP/IP, which is the foundation of the worldwide Internet, is eminently routable and well supported by vendors of WAN communications gear. It has also been annointed as Microsoft's "strategic" networking protocol. But there's more to NetBIOS-over-TCP than meets the eye.

B-Nodes, P-Nodes, and M-Nodes

A pair of Internet RFCs (requests for comment) numbered 1001 and 1002 propose standards for NetBIOS-over-TCP networking. In the LAN Manager implementation, which carries forward to NT, workstations are *b-nodes* (broadcast nodes). A NetBIOS-over-NetBEUI station calls a session partner by broadcasting to all nodes on the local network. A NetBIOS-over-TCP b-node works the same way, using UDP (User Datagram Protocol) to effect the broadcast.

But TCP/IP broadcasts don't cross routers; if they did, all that extra traffic would bring the Internet to a screeching halt. The RFC 1001/1002 documents therefore define a completely different scheme for wide-area NetBIOS-over-TCP. *P-nodes* (point-to-point nodes) use directed UDP datagrams and TCP sessions to emulate NetBIOS-level multicast and broadcast services. *M-nodes* (mixed nodes), a further refinement, combine the convenience of broadcasting on the local network with the efficiency of point-to-point communication across the WAN.

WARREN GEBERT © 1994

How do p-nodes and m-nodes establish off-LAN connections? They rely on a pair of services called the NetBIOS Name Server, or NBNS, and the NetBIOS Datagram Distribution Server, or NBDD. These agents learn and cache mappings between NetBIOS names and IP addresses, and they intelligently manage naming (i.e., registration, discovery, and defense) and messaging (i.e., multicast and broadcast). A commercial implementation of NBNS/NBDD from Network Telesystems is in use today at some very large NetBIOS-over-TCP sites.

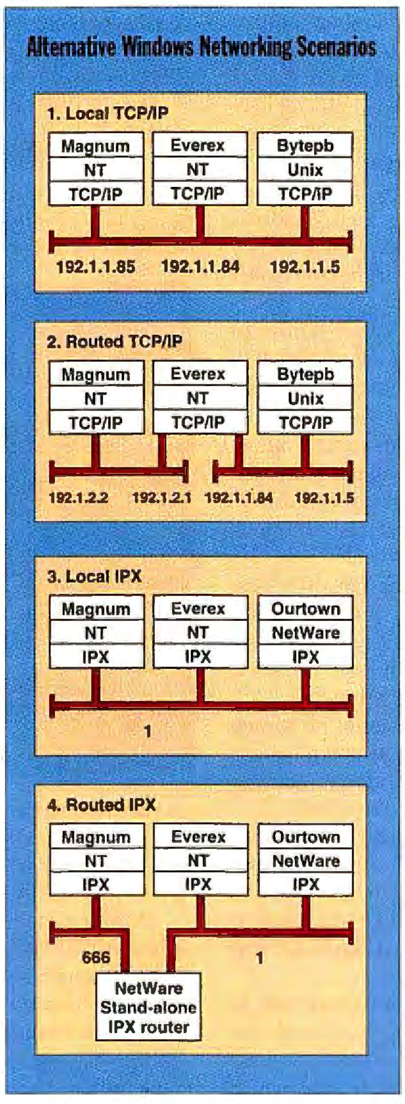
Do the LAN Manager and NT implementations of NetBIOS-over-TCP use p-node and m-node technology coupled with NBNS/NBDD services? No. They rely instead on a table of NetBIOS-name/IP-address mappings (the LMHOSTS file) stored on each participating workstation. Microsoft calls this technique a *modified b-node* approach.

To make things more concrete, see the figure "Alternative Windows Networking Scenarios" below. In the first part, "Local TCP/IP," my two NT machines act as b-nodes, sharing files, printers, and clipboards using TCP/IP alone (there is *no* NetBEUI present); they can also `telnet` to Bytepb, BYTE's UUCP host. In the second part of the figure, "Routed TCP/IP," I've split the network in two. The router is Everex, which uses the basic IP routing capability of NT to join the 192.1.2 and 192.1.1 class-C networks.

Because Everex's Windows networking is configured on the 192.1.1.84 adapter but not the 192.1.2.1 adapter (NT supports Windows networking over just one TCP/IP interface at a time), Magnum and Everex cannot by default share each other's files, printers, and clipboards. NT's internal IP router stands between them. To enable Windows networking across the router, I had to add the line `EVEREX 192.1.1.84` to Magnum's LMHOSTS file and also add the line `MAGNUM 192.1.2.2` to Everex's LMHOSTS file. (I also had to configure Magnum's default IP gateway to be 192.1.2.1.) Then everything worked—except browsing. In the local TCP/IP case, Magnum and Everex could browse each other's shared resources, but in the routed TCP/IP case they couldn't. With an LMHOSTS reference to Everex, Magnum could `NET USE` a known shared drive on Everex but couldn't browse (or `NET VIEW`) Everex to discover what resources it was sharing.

Why not? Workgroup browsing requires broadcasting, which is, as we've seen, strictly local in TCP/IP. According to J. Allard, Microsoft's program manager for TCP/IP technology and the author of a document on NT's TCP/IP (available by `ftp` from rhino.microsoft.com), browsing does work within NT Advanced Server domains that span TCP/IP subnetworks. It works because browse masters on each subnetwork communicate with a domain's primary controller using directed, point-to-point links (which, however, must be described in LMHOSTS files). Workstations, in turn, query local browse masters for share information.

What about TCP/IP support in the new WFW 3.11? Although the product will probably have shipped by the time you read this, its much-anticipated 32-bit NDIS 3.0 TCP/IP stack isn't yet ready. Microsoft says you'll be able to use a (separately available) real-mode NDIS 2.0 TCP/IP stack as the sole substrate for Windows networking on WFW 3.11, but I haven't had a chance to try that yet.



TCP/IP and IPX, with and without routers.

The IPX/SPX Option for NT and WFW

I repeated these experiments using NT's NetBIOS-over-IPX. In the third part of the figure, "Local IPX," Magnum and Everex conduct mutual Windows networking on IPX network 1, which also reaches Ourtown, a NetWare server, and the rest of BYTE's editorial LAN. In the fourth part of the figure, "Routed IPX," Magnum shares IPX network 666 with a stand-alone NetWare router that's also joined to IPX network 1.

Windows networking between Magnum and Everex was instantly and fully functional, requiring no administrative intervention as in the routed TCP/IP scenario. Further, because IPX propagates broadcasts through routers, Magnum and Everex could browse off-LAN to locate each other's shares. The same situation prevailed when I rebooted Everex to DOS and launched the beta version of WFW 3.11. Its IPX transport can substitute for NetBEUI as the sole substrate for Windows networking. Both IPX and NetBEUI can now run as 32-bit VxDs (virtual device drivers) in WFW 3.11, incidentally.

Other new VxD components include a selection of NDIS 3.0 network adapter drivers and a VxD-based FAT (file allocation table) file-system driver. This accumulation of VxD components makes WFW 3.11 an intriguing preview of the forthcoming lightweight 32-bit version of Windows known as Chicago. Of particular note is the fact that the NDIS 3.0 drivers for both WFW 3.11 and NT are built from common sources, according to Microsoft. This sharing of driver code will be a key synergy between Chicago and NT.

Which Strategic Protocol?

Let's recap. TCP/IP, Microsoft's strategic networking protocol, enables wide-area Windows networking, but the current implementation leaves a lot to be desired. Due to the lack of a dynamic NetBIOS Name Server, the mapping of NetBIOS names to IP addresses requires cumbersome manual maintenance of LMHOSTS files. That's the sort of labor-intensive, error-prone activity that network administrators desperately want to avoid. (LAN Manager 2.2 introduced a stopgap measure—TCP/IP extensions that enable broadcast domains to span selected subnetworks—but it doesn't carry forward to NT.)

Even with correct LMHOSTS mappings, workgroup browsing can't cross subnetworks. And while TCP/IP comes with NT, it won't be bundled with the most advanced version of DOS-based Windows, WFW 3.11.

IPX/SPX looks pretty attractive by comparison. It works seamlessly on routed IPX networks, and it is bundled with both NT and WFW 3.11. Moreover, IPX/SPX can simultaneously handle both Windows-to-Windows and Windows-to-NetWare connectivity.

When IPX/SPX appeared late in the development of NT under the name NWLink, the absence of a NetWare redirector for NT (which is now, by the way, available in beta) made NWLink's role unclear to many people. Microsoft's own marketing pitch tended to focus on NWLink's ability to integrate SQL Server into NetWare environments. In reality, it's a fully functional Windows networking protocol. If you operate a routed IPX internetwork, you can do local- and wide-area Windows networking using NWLink.

Given these options, you might wonder which routable protocol complements NetBEUI on Microsoft's own worldwide Windows network. Amazingly, it's a protocol that Microsoft doesn't offer to its customers. The folks in Redmond connect to Microsoft's satellite offices using XNS (Xerox Network Services), an older protocol from which IPX/SPX inherited its routable properties. The annointed wide-area Windows protocol, TCP/IP, can't yet support Microsoft's own mission-critical wide-area networking. If Microsoft doesn't use it, should you?

What's in a Name?

While this all looks mighty suspicious, Microsoft's Allard is candid about the situation. "XNS solved a problem for us years ago and became entrenched here," he says, "but that doesn't mean it's the right solution for us or our customers." Microsoft is now developing an NBNS-like service called WINS (Windows Internet Name Service) that is, as Allard points out, a requirement for efficient use of any routable protocol on WANs.

NetBIOS is a dynamic, distributed name service that works well when bandwidth is essentially free. But LANs and WANs are polar opposites in this regard. Propagating broadcasts through routers can work, but Microsoft pays dearly in tariffs for its extravagant worldwide use of XNS. Users of IPX/SPX WANs can control those tariffs only to the extent that administrators can configure routers to filter the broadcast traffic.

Ultimately, no matter what the protocol, you need efficient management of a distributed namespace that encompasses users, devices, and network services. That's the real problem WINS will tackle. If it works, you'll see Microsoft (and its customers) doing wide-area networking over a choice of protocols.

Will WINS be a full-blown RFC 1001/1002 NBNS/NBDD service? No, says Allard, precisely because it shouldn't be tied to TCP/IP or any other protocol. (WINS will use p-node technology, for example, but it won't depend on it.) TCP/IP—because it's more scalable and robust than IPX/SPX—will often be the preferred choice, but it shouldn't be required. If you have an IPX/SPX infrastructure, you ought be able to leverage it.

Should WINS, or Windows networking in general, be tied to the kind of flat distributed namespace that NetBIOS uses? Again, the answer is no. A structured namespace will likely serve the needs of the distributed enterprise much better.

There's an interesting opportunity for convergence here. Windows wide-area networking requires advanced name support. So do Windows distributed objects in the forthcoming Cairo. Killing these two birds with one stone would make a lot of sense, and that's what I predict will happen. Meanwhile, I'll be watching network developments in Redmond with interest. When Microsoft's wide-area Windows networking over TCP/IP is good enough for those folks to use, it ought to be good enough for us. ■

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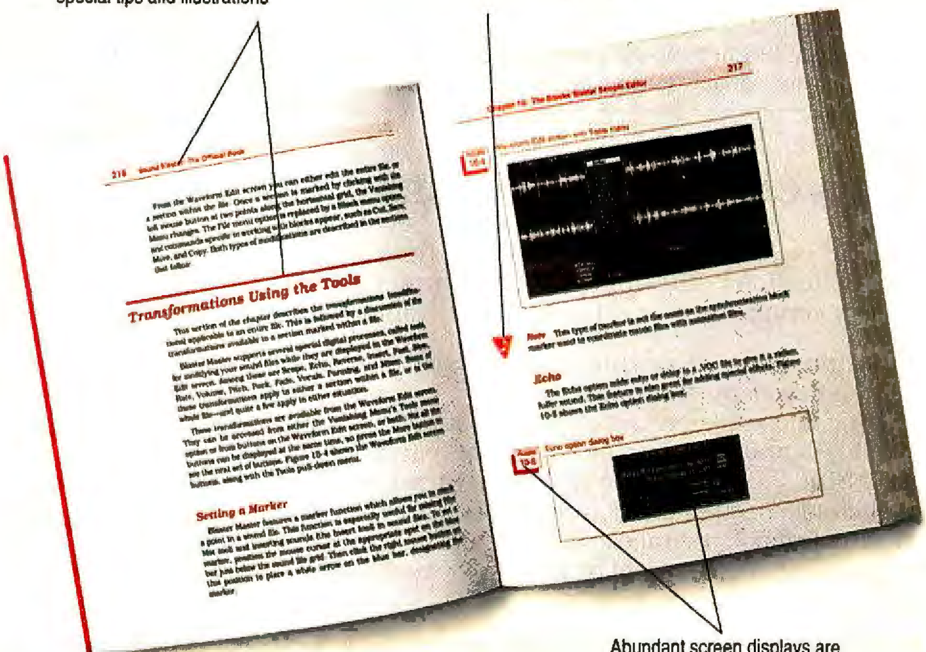

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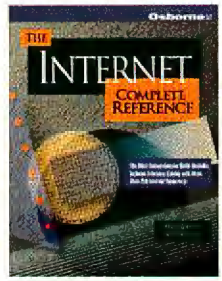

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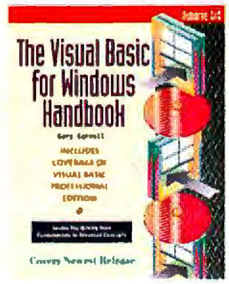

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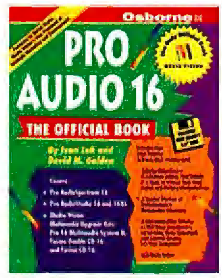

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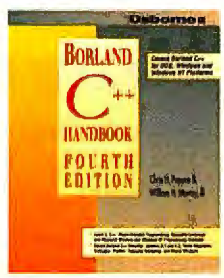

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A Standard for Writing Recordable CDs

The new DIS 13490 standard allows updates to recordable CDs while maintaining cross-platform data exchange

JASON HYON

CD-ROM has fulfilled its promise of becoming a significant data storage and distribution medium of the 1990s. You don't have to look any further than today's desktop computers to confirm this: Most Macintoshes ship with CD-ROM drives, every MPC includes one, and nearly every Unix workstation comes with a CD reader for system software installation.

A key to the success of the CD industry is ISO 9660:88 (hereafter referred to as ISO 9660), the international standard for the CD-ROM logical format. This standard allows the same CD-ROM to be read and interpreted on Mac, MS-DOS, Unix, VAX/VMS, and many other computer platforms.

However, some design problems surface when ISO 9660 drivers are implemented on various operating systems. For example, the information needed to do a Unix directory-listing command is stored not in the directory records, but in the extended attribute records located with the data file. Thus, to do a simple directory command, seeks to the individual data-file locations must be done. Furthermore, a DOS or Mac driver that's not savvy to this type of directory structure can't access the material.

An important feature that's not supported by ISO 9660 is the ability to incrementally add information to recordable media, a feature known as *multisession capability* in CD terminology. This ISO 9660 limitation has become a major problem since the advent of Kodak Photo CDs, which allow you to add a new set of images to an existing platter. Also, low-cost (i.e., under $6000) CD-R (compact disc recordable) mechanisms allow companies to produce limited-run CDs of specialized information. It would be desirable to be able to simply update existing CDs with new information, rather than having to scrap the lot and start over.

CD-WO (compact disc write-once) technology has advanced since the ISO 9660 standard was adopted in 1988. CD-WO is an evolution of CD-ROM to a sequential, write-once medium. It is defined by the Orange Book (developed by N. V. Philips and Sony), which specifies the medium and the basic CD-WO system and supports writability and updatability. Consequently, while the Orange Book standardizes the physical media, a new standard—similar to ISO 9660—is needed to define the logical organization of data on the disc.

The goals in drafting this new standard were as follows: add support for existing CD-WO functions, overcome the deficiencies of ISO 9660, provide support for future extensions (e.g., Windows NT), and maintain compatibility with ISO 9660 within the new framework. Moreover, it had to support additional volume and file-structure standards that are optimized for different media, such as WORM and rewritable CDs.

One difference between the new standard and ISO 9660 is that the former provides logical "visibility" to the tracks and sessions on a CD. This is accomplished through the use of track records in the existing CD-WO standard.

This new standard has followed the same path of acceptance as ISO 9660: When the High Sierra Group drafted a proposal for a CD-ROM volume and file-structure standard, the European Computer Manufacturers Association modified it and accepted it as ECMA 119. It was then accepted as ISO 9660 from DIS 9660. Similarly, the Frankfurt Group (so called because of the location of its first meeting in Frankfurt, Germany) drafted a proposal for a CD-ROM and CD-WO volume and file-structure standard, which ECMA modified and accepted as ECMA 168.

Currently, the logical standard, called DIS 13490, is in

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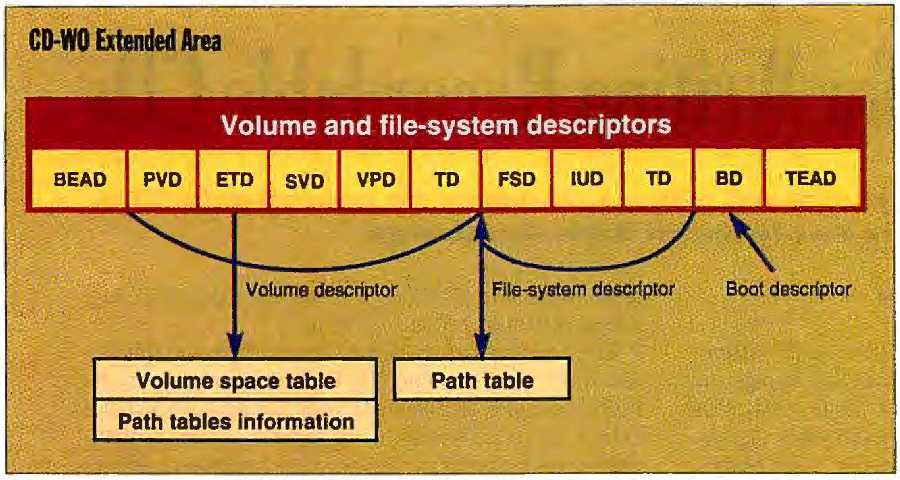
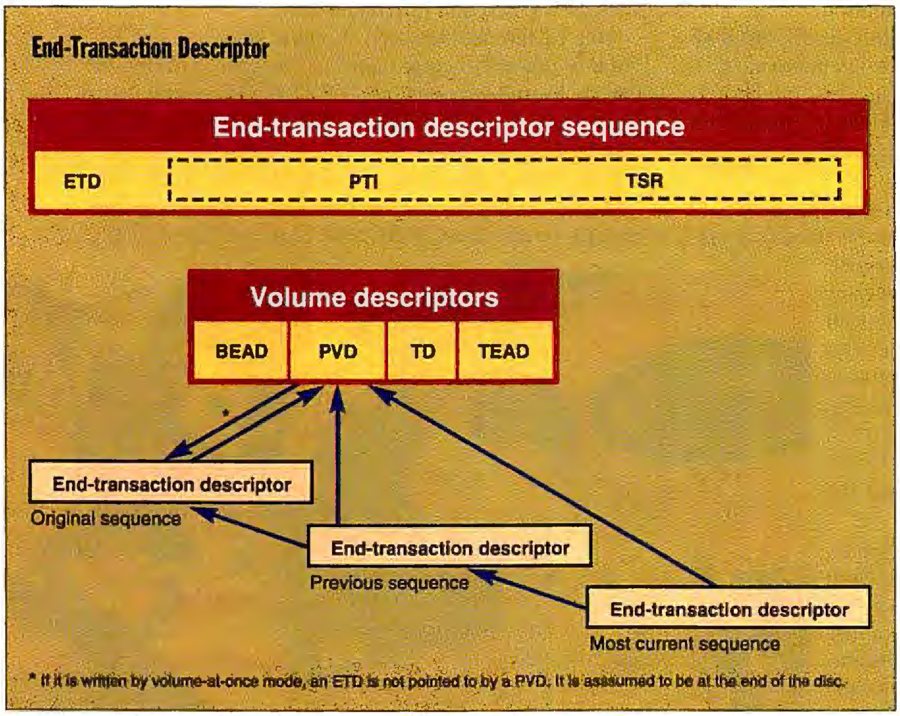


An illustration of the minimum descriptors *required in a CD-WO EA to describe a volume.*



The structure of an ETD *and how ETDs are linked when material on the disc is updated.*

international review. It is very likely to be accepted as ISO 13490 after the review period. To eliminate confusion, it's important to note that in this article CD-WO refers to the physical standard (per the Orange Book), while DIS 13490 refers to the logical structure of data on a CD-WO disc.

CD-ROM Basics

Before I illustrate the CD-WO volume and file-structure standard, it's beneficial to briefly describe ISO 9660, the existing volume and file-structure standard for CD-ROM. ISO 9660 divides a disc into four main areas, called *descriptors*, that describe its data organization. These four areas are called volume descriptors, path tables, directory records, and extended attribute records, or XARs.

In the volume descriptor area, a primary volume descriptor contains the locations of the path tables, the root directory, and other important information on the disc. Unlike CD-WO, since the contents and location of the files are predetermined and do not change, the locations of the path tables and root directory are recorded in the primary volume descriptor.

The *path table* describes the relationship between directories and subdirectories. The *directory records* point to subdirectories or files in a directory.

This mechanism provides two ways of traversing the directory tree of a CD-ROM file system: by chaining through directory records or through the path table. If this same method were used for a CD-WO file system, once a file or directory was updated, every directory record would have to be rewritten to reflect the change. For this reason, the relationship among directories and files for the CD-WO file structure are indicated only in the path table. Thus, directory records for the CD-WO file structure do not contain a pointer to their subdirectory or file.

Finally, ISO 9660's XARs provide the owner ID, group ID, and record structure of a directory or file. However, XARs are recorded on a file or directory basis, and this causes a big performance hit on a CD-ROM drive. This problem has been resolved in the CD-WO file structure, as I will describe later.

The fields used in the internal structure of DIS 13490's descriptors are similar in format and value to the fields used in the internal format of ISO 9660. However, certain fields have been altered so that DIS 13490's structures facilitate the support of Posix. This allows the standard to encompass the dominant operating systems in the market, such as DOS, Mac OS, Unix, and VMS. Included among the participants in the Frankfurt Group were representatives of these operating-system developers.

When you mount a physical volume, the operating system must know what types of data, and in what formats, are recorded on that medium. To do that, DIS 13346 (a volume and file-structure standard for nonsequential write-once media and rewritable media), DIS 13490, and possibly a new tape standard have created a common volume-recognition scheme. These commonly defined volume-recognition sequences enable systems to mount media for the proper volume standard and to boot from the media.

Further, the defined character sets have been expanded from the ISO 9660 standard, and the need for special separator characters has been reduced. The XARs as defined in ISO 9660 have been eliminated, and the functions of XAs (extended attributes) have been expanded through the use of the XA area in the directory and path-table records.

The DIS 13490 standard is organized into four parts, as described below.

- **Part 1:** General. States the notations and definitions used in this standard.
- **Part 2:** Volume and boot-block recognition. Describes volume and boot recognition structures for interchange with other standards.
- **Part 3:** Volume and file structure. Describes volume and file descriptors along with a new, more efficient XA capability.
- **Part 4:** Record structure. Defines the various record types, such as fixed records, variable records, stream records, and so on.

All parts of the standard are independent. The market will determine what parts will be supported. Thus, a vendor can choose to implement only parts 1 and 2 for volume recognition and boot purposes, letting a system recognize what driver to use in mounting the disc's native volume and file system. If a vendor were to implement parts 1, 2, and 3—the volume and file structure without the record-structure support—a transportable volume for data interchange with other operating systems could be created. Part 4 could be implemented for systems that support record structures, such as DEC's VMS. Lots of implementations will probably support only parts 1, 2, and 3, since many microcomputer operating systems (e.g., Mac OS, DOS, and Unix) don't use record structures.

There is currently another CD-ROM standard, called Rock Ridge. Its intent is to use CD-ROM as a complete implementation of X/Open and Posix file systems and directories. The purpose of the Rock Ridge initiative is to create an agreeable common format by utilizing the system area in the directory record of ISO 9660 while maintaining compatibility with the installed base of ISO 9660 hardware and software.

The SUA (system use area) in the directory record includes necessary information such as UID (user ID), GID (group ID), the UID and GID numbers used by receiving X/Open systems, the mode bits, and the major and minor device. Most Unix CD-ROMs already use this standard for file interchange among Unix systems.

While the Rock Ridge standard provides data interchange with Unix systems, DIS 13490 will have to support future operating systems such as Windows NT. Fortunately, DIS 13490 provides many ways to implement future operating-system-specific needs by allowing vendors to embed information in the descriptors and the SUA.

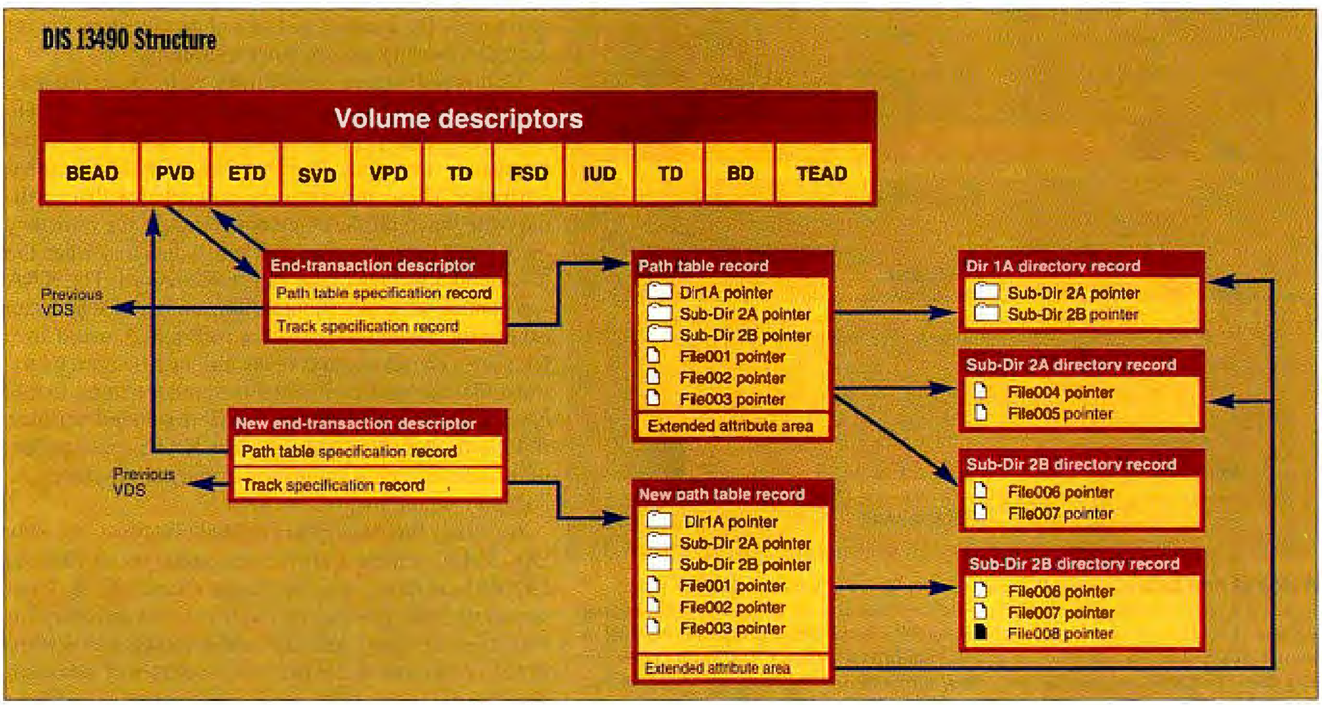
Conforming DIS 13490–receiving systems (i.e., systems that read data on CD-WO) will support a subset of ISO 9660. However, the XAR in ISO 9660 won't be supported by these receiving systems. Thus, it is possible to have a disc that supports both ISO 9660 and DIS 13490 on the same medium.

The Structure of DIS 13490

DIS 13490 starts by using descriptors similar to those used in ISO 9660. These descriptors can be categorized into three main parts: the CD-WO EA (extended area), the ETD (end-transaction descriptor), and path tables.

Volume descriptor sets, or VDSes, are located in the CD-WO EA. The EA is a container for volume and file descriptors (see the figure "CD-WO Extended Area"). The VDS contains at least one PVD (primary volume descriptor) and TD (terminating descriptor), and zero or more SVDs (supplementary volume descriptors), ETDs, and VPDs (volume-partition descriptors).

In a CD-WO EA, different BDs (boot descriptors) can be written. This allows a "generic" boot CD-ROM. At start-up, such a boot ROM would be scanned for BDs for matching system identifications. The system identification encodes the operating-system type and system-dependent options, such as combinations of processor type and memory management. After examining the boot identifier, the boot ROM can present the operator with a



A CD-WO structure, *illustrating the arrangement of a set of directories, subdirectories, and files, with a new file (File008) added.*

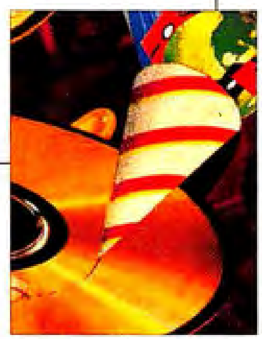
choice of operating systems that can be booted.

A PVD identifies the volume, the volume set to which the volume belongs, the volume's attributes, the character sets used in recording the contents of certain fields within the PVD, and the rule for recording and locating the ETD. An SVD provides an alternate identification of the volume and the volume set to which it belongs. A VPD specifies a volume partition, attributes of the partition, and its identification. The TD identifies the end of a VDS.

Because CD-WO is an updatable medium, the volume information can be revised by writing new VDSes. The standard also specifies how to recognize the most recent or valid VDS. In addition, in a CD-WO EA, or at a location pointed to by the ETD, an FSDS (file-system descriptor set) identifies the file set; the set of characters allowed in certain fields of the descriptors associated with the file set; attributes of the file set; optional application and publisher information; and optional copyright, abstract, and bibliographic information.

An FSDS contains an FSD (file-set descriptor—a concept of a logical volume) and an IUD (implementation use descriptor). The FSD is directly associated with a path table that identifies every directory in the directory hierarchy describing the set of files in the file set. Thus, at least one FSDS should be written over a volume to describe the disc's contents. Also, zero or more IUDs identify an implementation and contain information for that implementation's use. The IUD is one of the descriptors that allow extensions for current and future operating systems' needs that are not yet defined by this standard.

By using descriptors, the new DIS 13490 standard allows the updating of files on CD-WO media.



All VDSes, FSDSes, and BDs are enclosed in a BEAD (beginning extended-area descriptor) and a TEAD (terminating extended-area descriptor). Thus, the CD-WO EA identifies that the CD-WO volume and file-structure standard was used to write that disc. The figure "CD-WO Extended Area" illustrates the minimum required descriptors for a volume or a volume set. The BD is optional.

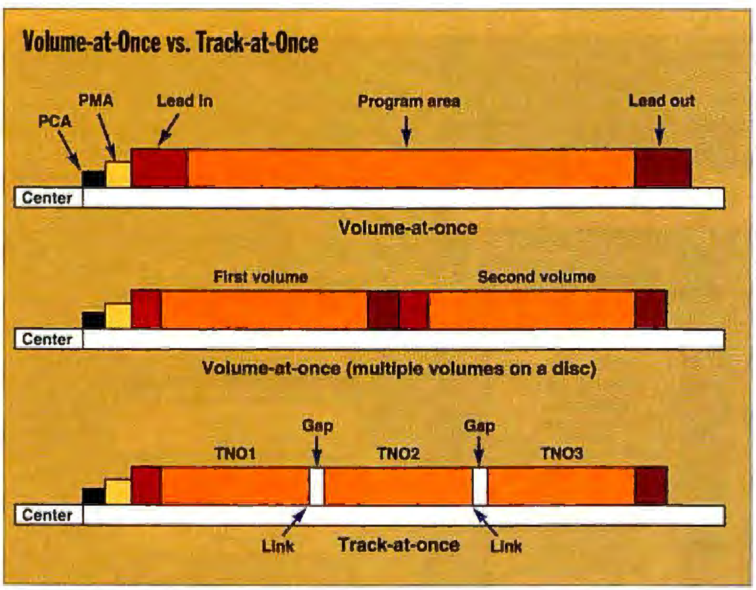
The ETD is one of the most important descriptors in DIS 13490. As the information on a disc changes, VDSes, FSDSes, and ETDs are used to update the volume and file structure. The more a disk is updated, the more complicated these sequences of descriptors are. Thus, this standard suggests several rules for recording ETDs so that they can be searched effectively.

An ETD contains a pointer to the current and previous VDS and FSDS and the previous ETD sequence. ETDs contain information for locating important descriptors. The first is the PTI (path table information); the second is the volume-space table, which contains the TSR (track specification record). The PTI contains records that point to the location of the path table (which is discussed below). The TSR contains a set of records that describe a track, noting such things as its size and recording format. The figure "End-Transaction Descriptor" on page 232 illustrates the ETD and the relationship between a PVD and previous and current ETDs.

Multiple PVDs and PTIs allow multiple directory hierarchies. A path table specifies the root of a directory hierarchy, each directory in this hierarchy, and its relationship (if any) with other directories in the hierarchy. The path tables also supply the location and size of the directory file for each directory in the directory hierarchy.

Volume-structure descriptors, path-table records, and directory records have an XAA (extended attribute area). This area provides extension capabilities to the standard by providing the incorporation of tag-identified attributes. These attributes are associated with an ordinary file when the XAA contains tags in the directory record, and they are associated with a directory when the XAA contains tags in the path-table record. The XAA can contain several attributes, the number of which can exceed the desired directory (or path-table) record size. Or, such a record might contain attributes deemed by the implementation to be located in another extent. In this case, a continuation extent's XAF (extended attribute field) provides this capability. The XAF is used to partition a designated continuation extent into a system-use area and an application-use area.

By using the descriptors described above, the new DIS 13490 standard allows the updating of files on CD-WO media as described in the Orange Book. Consequently, the files can be modified, the directory hierarchy can change, and directories can be added within the constraint that write-once media will retain all previous revisions of recorded information. The figure "DIS 13490 Structure" on page 233 shows a simple set



A look at how data *is physically arranged on a disc using the various CD-WO formats. A* lead in *is a track written for drives to recognize the beginning of the logical volume. A* lead out *designates the end of a logical volume. The PCA (power calibration area) consists of a test pattern on media that calibrates the laser's recording power for this disc. The PMA (program-memory area) stores physical information about the disc, such as the number of tracks. A* link *terminates a block of data, while a* gap *is an indicator for each physical track. TNxx indicates physical track number xx.*

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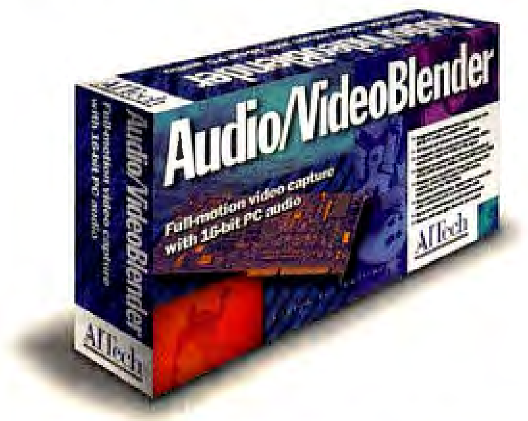

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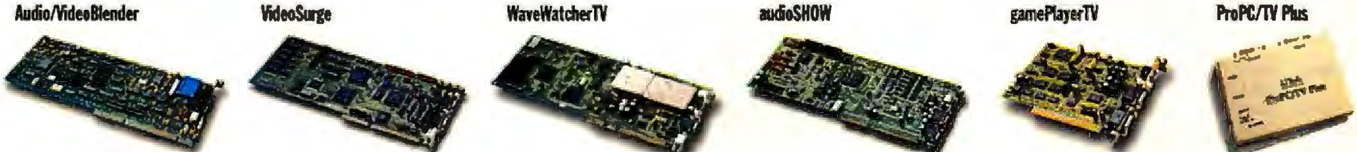

Vision for Multimedia

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of directory hierarchies that can be built with this standard, as well as the updated structure when a file is added to a subdirectory.

Recording Methods

The Standard of Recording (i.e., "Orange Book Part II: CD-WO," N. V. Philips and Sony, November 1990) identifies two methods that specify which tracks on a disc can be recorded. These methods are *track-at-once* and *incremental*, with either fixed- or variable-length packets. Each recording method has a different addressing scheme that has advantages specific to certain applications.

Track-at-once, the only method widely used in the current market, refers to recording one or multiple tracks in one uninterrupted stream. A simpler version of track-at-once is *volume-at-once*, which refers to the recording of a complete CD-WO volume in one uninterrupted stream; this is how CD-ROM is mastered. By using the track-at-once method, you can do stepwise creation of a CD-WO disc, with up to 99 tracks possible (see the figure "Volume-at-Once vs. Track-at-Once" on page 234).

Incremental recording refers to writing within a track with multiple data streams, where they are separated by gaps. The recording of these streams need not be done at once. Streams within a track can be either fixed-length (i.e., they are all the same length) or variable-length. However, this scheme requires that existing players recognize new information that resides among data streams. This embedded information cannot be recognized by existing CD-audio and CD-ROM players.

A *multisession disc* is a special version of a CD-WO disc. A *session* is a sequence of one or more tracks where the track numbers form a continuous, ascending sequence. Each session could be an ISO 9660 volume.

Note that both CD-ROM (Yellow Book) drives and CD-WO/CD-R (Orange Book) drives do not support all types of recording schemes. For example, most CD-ROM drives can read only those discs that are recorded in a single-session, track-at-once format. Also, one brand of CD-WO recorder can record discs only with the track-at-once method. Users need to be aware of these limitations when deciding what type of CD drive to purchase. Although the logical format of a disc conforms to the standard, the disc might not be readable by some drives.

Within a year, most CD-WO drives should be able to record and read all three types of recording schemes. Also, new CD-ROM drives should be able to read all types of CD-WO discs. ■

Editor's note: *DIS 13490, also known as ECMA 168, is available from the European Computer Manufacturers Association, 114 Rue du Rhône, CH-1204, Geneva, Switzerland; phone: +41 22 735 36 34; fax: +41 22 786 52 31. The research described in this article was carried out by the Jet Propulsion Laboratory at the California Institute of Technology, under a contract with NASA. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not constitute or imply its endorsement by the U. S. government or the Jet Propulsion Laboratory.*

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Subclassing in OLE 2.0

It's not just an API anymore: The Component Object Model of OLE 2.0 is the beginning of object-oriented system services

GEN KIYOOKA

Much has been written about OLE 2.0, and a great deal of it smacks of resistance and harsh criticism. Much of the furor over OLE 2.0 seems to arise from its purported complexity and from the apprehension and resistance that accompany a paradigm shift. It seems that software developers, faced with another challenging advance in software interoperability, are not amused.

The problem is one of perception. Many perceive OLE 2.0 as a newfangled cosmetic add-in for Windows 3.1, along with a needlessly complex set of specifications and implementation requirements. In fact, OLE 2.0 marks the delivery of new operating-system software and provides new tools for managing complexity and solving problems. From a marketing perspective, Microsoft has done a great job of packaging this new architecture. Unfortunately, lost amid the ensuing chaos is the greater impact of a fundamental improvement in how objects of "user-level" granularity are distributed and packaged in a GUI environment. Add in a dash of C++ fundamentalism, and you've got the makings of an object holy war.

Interface Rigor

If you get past the OLE rhetoric and market-speak about visual (i.e., in-place) editing, document centricity, automation, and so on, what remains is a fundamentally rigorous and practical architecture for packaging and reusing software objects. In OLE 2.0, this elegant underlying architecture is called the Component Object Model. Understand this architecture, and you've got OLE licked. Fail to grasp its nature, and you're forever mired in a sea of unfamiliar complexity. Fail to appreciate its value, and you're condemned to sit by and watch a software industry reorient itself around a standardized component marketplace.

The pundits raise three major issues: (1) the apparent disparity between OLE's object model and the inheritance-based C++ object model, (2) the amount of overhead involved in implementing an OLE object, and (3) the sacrilege of suggesting the impending disappearance of applications software from the GUI desktop. The first two can be resolved through a better understanding of the problems the Component Object Model was designed to solve. I'll tackle them one at a time. I leave the third issue to be resolved by time itself, and its realization a testament to the foresight of the OLE architects.

OLE and C++: A Match Made in Purgatory

The first issue might be restated as a proposition: "For Windows to be a true object-oriented system, it should be based on an object-oriented language (e.g., C++) featuring encapsulation, inheritance, and polymorphism. The role of the programmer is to refine the functionality of the base system." OLE does not fully subscribe to or endorse this model as the proper solution for system-level (large granularity) software interconnection.

Thus, under OLE 2.0, the use of C++ or inheritance is strictly relegated to an internal component implementation detail. Other languages and software techniques can be used to implement objects. Publishing an object to be employed by people requires that the object expose a standard and rigorous interface.

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OLE's lack of support for a standardized inheritance mechanism merely indicates that inheritance is inappropriate for rigorous, standardized software interconnection between components due to be aggregated into appropriate solutions by the end user. Of the other criteria for object orientation, encapsulation holds the place of honor, with polymorphism—or rather, reuse of interface—playing a secondary role.

continued

INSTANCE.CPP: *A minimal OLE application that instantiates the* `CPoly` *object from the OLE developer's kit.*

```
#include <windows.h>
#include <ole2.h>
//
// This line is stolen from \OLE2\SAMP\DISPDEMO\CLSID.H, and it
// represents the definition of a unique class identifier for
// the CPoly polygon server used in the IDispatch sample.
//
DEFINE_OLEGUID(CLSID_CPoly,  0x00020462, 0, 0);

int PASCAL WinMain (HANDLE hInstance,
  HANDLE hPrevInstance,
  LPSTR lpCmdLine,
  int nCmdShow)
{
BOOL fOk = (OleInitialize(NULL) == NOERROR);
  if (fOk)
    {
   IUnknown FAR* pIUnknown;
   // Creates an instance of the
   // class identified by CLSID_CPoly
   HRESULT hResult = CoCreateInstance( CLSID_CPoly,
     NULL, CLSCTX_LOCAL_SERVER, IID_IUnknown,
     (void FAR* FAR*)&pIUnknown);
     if(hResult == NOERROR)
       {
       MessageBox( NULL,
         "pIUnknown is pointing to an instance of the CPoly class.",
         "Hello World", MB_OK );
       // Release is equivalent to 'destructing' the object
       pIUnknown->Release();
       }
     OleUninitialize();
     }
   return fOk;
}

// Ignore this for now
#include <initguid.h>
DEFINE_OLEGUID(CLSID_CPoly,  0x00020462, 0, 0);
```

OLE Object-Implementation Overhead

The second issue seems to arise when the neophyte OLE programmer is faced with the complex administrative burden of implementing an OLE object or, worse, of implementing a multiplicity of objects and interfaces in a fully OLE-enabled application.

Windows 3.1 introduced a new administrative tool, a version resource, which allowed proper upkeep of shared DLL and EXE packages. OLE 2.0 introduces interface contracts, a system registry for objects, globally unique class and interface identifiers, and a binary standard for exposing interface VTBLs (virtual function tables). The administrative overhead in implementing an OLE object under the Component Object Model is considerable, but it's a fundamental prerequisite to robust interoperability.

Interfaces as Contracts and Objects

Conceptually, an OLE interface (or *protocol*) specifies a contract between two parties (i.e., software components). For instance, to implement drag-and-drop under OLE 2.0, the source and target windows agree to a protocol that involves two interfaces, `IDropSource` and `IDropTarget`. Under the terms of the contract, the window capable of having objects dropped on it implements the functions defined by the `IDropTarget` interface. The window providing the objects that are dragged and dropped onto the target window implements the functions in the `IDropSource` interface. In this case, the protocol involves two separate parties and two separate interfaces. The rigor of this contract ensures that drag-and-drop functionality is implemented uniformly throughout the system.

Unlike an informal grouping of function calls, an OLE interface binds a set of function calls together into a unit as an opaque means for accessing an object. Contrast this with a more informal set of functions in a conventional API. The Component Object Model defines a binary specification of what an interface looks like. More concretely, it specifies a binary description of what an interface is.

This binary specification has these four goals:

1. To provide a function-invocation mechanism that provides a compile-time-type-safe and opaque means for manipulating a software component object
2. To provide polymorphic interfaces for different classes of objects with similar behaviors
3. To provide a limited inheritance from a common shared interface, called `Unknown` (analogous to a base superclass called `Object` in a standard, singly rooted inheritance hierarchy)
4. To allow objects in the local process space and those in remote process spaces to be manipulated in a uniform manner

To achieve these goals, the Component Object Model uses a binary specification of an interface object as a pointer to an opaque chunk of memory whose first 32-bit element is a pointer to an array of function pointers representing the methods that encapsulate the object. This array of function pointers is a VTBL.

Do-It-Yourself Polymorphism

Consider the problems a VTBL interface sets out to solve. Imagine being exposed to Smalltalk in an educational setting and, in your first C programming assignment, being asked to implement an object-oriented, polymorphic class hierarchy with inheritance. The first practical C++ compiler for your operating environment would not be available for several years.

One solution would be a message-passing architecture similar to the one used in the window manager of Microsoft Windows. In this model, polymorphism is achieved through generic parameters whose contents are interpreted according to the message context. Inheritance is achieved by chaining uniformly defined message-handling functions. The message-handling function that first receives the message represents the most specialized subclass in the inheritance hierarchy. It can choose to discard, implement behavior for, or pass a message on to the handler of its immediate superclass. Unfortunately, this method is ill-equipped to handle data definitions at each successive subclass in a hierarchy.

Another solution strikes closer to the heart of the binary interface standard of the OLE Component Object Model: You envision the accretion of both data and functions as proceeding in an orderly fashion down from a general superclass to a specific subclass. Since you're a C programmer fond of `malloc()` and `free()`, you have decided that an object be instantiated by `malloc()` and destroyed by `free()`. To separate the behavior from the private data of these objects, you decide to make the first data element of every object a pointer to an array of function pointers. Each successive specialization in the class hierarchy can add its own new functions to the array of function pointers and its own new data to the private data definition. Only one array of function pointers need be maintained for each class.

This is exactly the binary model used in a single-inheritance C++ class hierarchy. C++ multiple inheritance introduces vulgarities to this otherwise comprehensible and clean model.

Proxy Interfaces for a Uniform Representation

The Component Object Model lets consumers manipulate objects only through the object's interface pointer. Given this opaque definition of an interface, the Component Object Model's final goal can be realized: accessing remote and local objects in a uniform way.

The Component Object Model allows the consumer to manipulate objects only through the object's interface pointer.

Consider a rectangular chart object that has been inserted into a spreadsheet application. The spreadsheet manipulates the chart object's contents by invoking functions on the object's OLE interfaces. But if another application program implements the chart object, the actual implementation is performed in another process space. Therefore, the interface pointer used by the spreadsheet application points not to the chart object itself, but to a proxy representation of the chart object's interface in the local process space. The proxy object forwards the methods invoked on this local interface (through a lightweight RPC, or remote procedure call) to the actual implementation in another process space.

This is the fundamental magic of OLE 2.0. By performing a major behind-the-scenes effort, OLE exposes a uniform and familiar (i.e., function through-pointer invocation) means for manipulating all objects in the system.

A Minimal OLE Program

Rather than jump into a fully capable OLE application with thousands of lines of code, look at the INSTANCE.CPP listing—the OLE equivalent of "Hello World." As you can see, the most basic requirements for an OLE application do not extend much beyond the basic requirements for a standard Windows application. Execution begins at `WinMain`, and two additional calls, `OleInitialize()` and `OleUninitialize()`, are required for a bona fide OLE application start-up and shutdown. The rest of the code involves instantiation, our next topic.

Remember (from OLE 1.0) that the OLE system maintains a system registry—essentially a hierarchical database containing information about each OLE-capable object server on your computer. Each OLE application is required, as part of its setup program, to merge its information with the registration database. Instantiating an OLE object is similar in principle to late binding or dynamic linking. Applications that know nothing of each other can communicate by invoking functions on objects owned by one another. The registration database is a key part of the process, providing a central repository (i.e., catalog) of system parts.

Creating an Instance of an OLE Object

Look at INSTANCE.CPP again. This code shows how to create an instance of an object. To instantiate an object, you need to know its globally unique class identifier. These class identifiers are stored in the registration database (where you'd normally be obtaining it). But for the sake of clarity, I've taken a copy of the definition of the class identifier for `CPoly` from the code to DISPDEMO, included in the OLE developer's kit, and placed it directly in INSTANCE.CPP.

The interface pointer returned by the `CoCreateInstance()` function represents the instantiated object. Having a pointer to the `IUnknown` interface is like having a pointer to `CObject`, the root class, in MFC (Microsoft Foundation Classes). You know nothing specific about the object except how to release your reference to it (`IUnknown::Release()`) and how to ask it for other interfaces it may support (`IUnknown::QueryInterface`).

To run INSTANCE.EXE on your system, your computer has to have the OLE 2.0 developer's library installed. If the `Dispatch` polygon sample programs function correctly, INSTANCE .EXE should, too. This is a large-model program created with Microsoft Visual C++; it links implicitly to the OLE2.LIB (OLE2 .DLL) and COMPOBJ.LIB (COMPOBJ .DLL) import libraries.

The Subtleties of Using Interfaces

Now that you have had a chance to examine the instance application, you should be familiar with the basics of OLE objects:

QUERYINTERFACESOF *is a method of the CBrowseDlg class, which, when given a pointer to the* `IUnknown` *interfaces, invokes the* `QueryInterface` *method to see what interfaces are supported by the object. For each interface that is supported, it adds the name to the listbox.*

```
void CBrowseDlg::QueryInterfacesOf(IUnknown FAR* pIUnknown)
{
POSITION Position = m_RegInterfaces.GetHeadPosition();
COLEInterface *pInterface;
  while ( Position && (pInterface =
    (COLEInterface *)m_RegInterfaces.GetAt(Position))) {
      const char * Name = (const char *)(*pInterface->GetName());
      IID InterfaceId;
      if (NOERROR==IIDFromString( (char*)(const char *)
        (*pInterface->GetIID()), &InterfaceId)) {
          IUnknown FAR* pQueriedInterface;
          if (pIUnknown->QueryInterface(InterfaceId,
            (void **)&pQueriedInterface)==NOERROR) {
              m_InterfaceLB.AddString( Name );
              pQueriedInterface->Release();
          }
      }
      pInterface =
        (COLEInterface *)m_RegInterfaces.GetNext( Position );
    }
    m_InterfaceLB.AddString( "IUnknown" );
}
```

Hands On Some Assembly Required

constructing an instance of a class, invoking functions on the interface pointer (`instance`), and destructing the instance (`Release`). It's time to expand the scope of this discussion.

Obviously, the interface `IUnknown`, with just three members (i.e., `QueryInterface`, `AddRef`, and `Release`), has limited applicability for creating a compound document implementation with in-place editing, OLE automation, and the like. Under OLE 2.0, you generally do object instantiation by requesting a new instance represented by a pointer to the `IUnknown` interface (as in INSTANCE.CPP). The consumer using this object then queries the object about its capabilities by requesting further, more specific, interfaces through the `QueryInterface()` function.

If the object is capable of supporting the functionality implied by the interface, `QueryInterface()` gives the consumer additional and more capable means of manipulating the object. An application developer can begin by implementing a few interfaces and successively add functionality until the complete OLE feature set is realized.

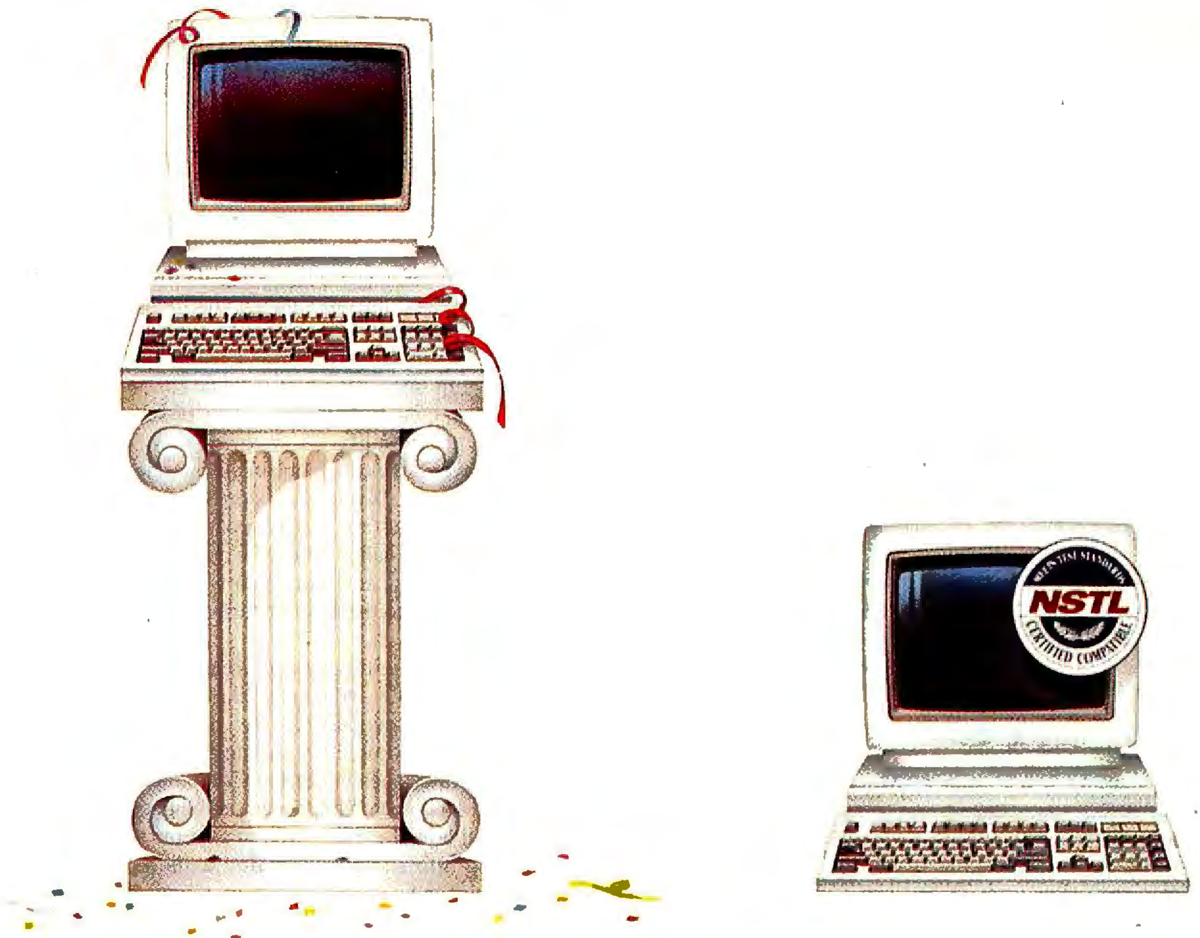
IBROWSE.EXE is a small program that demonstrates the generalized model of locating and instantiating objects by way of the system registry. It also demonstrates the use of `QueryInterface()` as a means of interrogating an object to determine that object's capabilities. The program enumerates all the object classes in the registry. You simply choose a class from the first listbox, and you see a second listbox populated with the names of the interfaces that an object of the selected class is capable of supporting.

IBROWSE.CPP simply instantiates the object requesting the `IUnknown` interface. Once this interface has been obtained, IBROWSE.CPP enumerates all the interfaces listed in the system registry, calling `QueryInterface()` on the `IUnknown` pointer for each interface type. By simultaneously examining this program and exploring the structure of the system registration database, it's easy to understand the role of the registry in OLE 2.0. QUERYINTERFACESOF is from the IBROWSE source code. (You can explore the structure of the system by using the REGEDIT.EXE utility with `/v` on the command line. This utility is distributed with the source code associated with this article.)

Because of the opaque nature of interfaces, and because the implementation and interface of an object can span process and even machine boundaries, managing memory in this object model has some inherent complexity. Unfortunately, the Component Object Model places the burden of managing this complexity squarely on the shoulders of the implementer. Ironically, just as C++ introduced a convenient automatic constructor/destructor model for reducing memory management complexity common in C programs, the Component Object Model introduces a reference-counting system. But unlike in Smalltalk, which provides automatic language (i.e., transparent) support for object reference counting, the C++ or C programmer has to be mindful of a bevy of reference-counting rules. Two steps forward, one step back.

For simple programming examples like the ones accompanying this article, the use of reference counting is trivial. As the implementer creates an instance of an interface pointer for the consumer, the reference count on that interface is bumped by one. This is not evident in the accompanying listings because it takes place in the private code of the application (or DLL). The use of `Release()` (invoked on `IUnknown`) is visible in IBROWSE .CPP: Each interface pointer obtained from `QueryInterface()` is released, as is the initial interface pointer obtained by `CoCreateInstance()`.

continued



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Subclassing and OLE Interfaces

I mentioned earlier that the Component Object Model does not allow subclassing—that is, taking an existing interface and refining the behavior of methods in that interface. However, just as every great musician eventually learns the appropriate time to break rules concerning embouchure, harmony, and form, making maximum use of the OLE architecture smacks of misbehavior.

Subclassing under OLE 2.0 is as simple as providing an intermediary any time a request is made for an interface pointer, through either `QueryInterface()` or standard function calls to the OLE libraries, like `CoCreateInstance()`. The intermediary forwards the call to obtain the interface pointer. However, it also creates a mock interface, stores the actual interface pointer in this mock interface's private data, and passes the mock interface back to the caller. Since the details of the interface methods are well known, any function invoked on the mock interface can be forwarded to the actual interface with any desired pre- or post-processing.

Not surprisingly, this is also an accurate description of the proxy-interface stubs and marshalling used by the OLE system to forward method invocations over process boundaries. Using these techniques completely violates the pure theoretical underpinnings of interfaces under the Component Object Model, so if anyone asks how you happened on the notion, I'd appreciate it if you recall how it came to you in a dream.

Hooking into standard function calls like `CoCreateInstance()` can be messy. However, there's a much easier, flexible, and general method, illustrated by the HANDLER sample in the OLE 2.0 developer's kit. The sample illustrates the use of subclassing in creating a nifty debugging tool.

HANDLER is an example of exposing OLE interfaces from a DLL instead of by a separate EXE. It stands as an intermediary directly between the consumer and the provider of interfaces by rewriting the registration database entries to trick the OLE system into requesting interfaces from the handler instead of from the actual objects (tucking the original entries away for safekeeping).

The Component Object Model affords other conveniences for large-granularity reuse through aggregation. But the number of practical circumstances in which granular objects can be aggregated into new entities is yet to be adequately demonstrated. For some, genetically mutating Excel with PageMaker through aggregation may be the fulfillment of a lifelong dream; for others, decidedly not.

Dispelling any initial impressions of OLE 2.0 that you may have gathered may not always be easy. However, aside from the thorns surrounding reference-counting semantics, the model underlying OLE 2.0 is well thought out, clean, and simple. In fact, the uniformity and simplicity of the model make it possible to attempt such wondrous feats of software as in-place editing.

No software designer committed to object-oriented methods, usability, or the benefits of software systems that can be successfully managed will think twice about employing OLE. Those who do hesitate will one day complain that Microsoft unfairly dominates component software solutions, even though today we all stand as equals on the threshold of this new order. ■

Editor's note: *Both source code and executable files are available electronically; see page 5 for details.*

Gen Kiyooka (San Diego, CA) likes OLE and its implications and, as a tool developer, welcomes any suggestions that will make the construction of OLE software components pleasurable and productive. You can reach him on the Internet or BIX at gen@bix.com.

JERRY POURNELLE

Travels and Travails

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Traveling, lecturing, lobbying, watching the launch of a spaceship, testing modems, setting up a NetWare network, having printing problems, getting a new monitor—Chaos Manor is aptly named

The good news is that we have the Novell NetWare server running. Alex installed NetWare 3.11 on a Gateway 2000 4DX2-50, and all went well. I haven't had a chance to work with it much yet, but at least it's installed. Windows for Workgroups is no bad start on LANs for small businesses, but it does have limits; in particular, it hasn't been reliable with large-capacity optical drives (see below), doesn't have security, and has very limited support for DOS machines. We're looking forward to working with NetWare to link up Windows, OS/2, and Macs.

We're using NetWare 3.11 rather than version 4.x because I'm told that getting 4.x up and running can be more difficult, and since I don't have multiple servers or a complex system, version 3.11 is good enough. I expect I'll know a lot more about that in a month or so; stay tuned.

One reason I didn't get to the network earlier was that the trips haven't stopped. Three this month—I'm writing this crammed into steerage class on a cross-country flight. I was asked to lecture on space operations to the Air War College at Maxwell AFB in Alabama, and the U.S. government not only wants my time for what amounts to no fee, but they will pay only for a tourist-class seat. With all my travel, I have upgrade certificates, but I didn't manage to book an upgraded seat; which gives me an opportunity to test laptops under ghastly conditions.

One trip I did thoroughly enjoy was to White Sands Missile Test Range to watch them launch my spaceship. Actually, DC/X isn't quite a spaceship, and it isn't really mine; it's a one-third scale model of the spaceship that General Graham, Max Hunter, and I sold to the National Space Council in 1989. McDonnell Douglas managed to build it on time and in budget, and it flew precisely as expected, going up, hovering, and landing on a tail of fire.

My present trip combines my lecture at the Air War College with a trip to Washington to talk with members of Congress about how we can revive the X programs, which enabled the U.S. to dominate world aerospace for three decades after World War II. Alas, the only people who remember how the X programs worked are dinosaurs like me.

The X programs were not big operational projects, nor were they prototypes. They were small, tightly managed projects using the best available technology to build the best test vehicles we could make. The output was a practical application of new technologies that could then be used by industry to build operational aircraft. The effect was to reduce technical uncertainties. Firms could concentrate on using that technology to build marketable products. Entrepreneurs will take market risks or technical risks, but faced with both, they'd rather put their money in something less uncertain.

The X programs gave us a long period in which it would have been thought absurd for a major airline to buy airplanes from anyone but U.S. companies. Then McNamara canceled the X programs in the name of arms control. Now, you're as likely to fly on an Airbus as a U.S. plane, and the Brazilians are selling us commuter airplanes. How are the mighty fallen....

continued

ILLUSTRATIONS: STEVE GILLIG © 1994

I'm writing this on the ancient Zenith Mastersport 386SL, which turns out to be endurable even in steerage. The Mastersport has a smaller screen than some of the newer laptops, but that's counterbalanced by that splendid Zenith keyboard and a general feel that just plain works; and perhaps the small screen is an advantage given the cramped working space. I've carried a lot of laptops, and I've liked several of them; but every time, I find myself coming back to this old Mastersport.

I remember when 9600-bps modems were a big deal; now they all come with 14.4 Kbps, and many are even faster. Whether you can use that new speed is another matter. The latest arrival at Chaos Manor is the ATI 14400 ETC. ATI Technologies is no newcomer to the modem game. Many of my friends are very fond of their communications equipment.

The ATI 14400 ETC modem comes with a communications program called Comit and SofNet's FaxWorks 3.0 for Windows. I can't recommend Comit at all, but the modem works all right with Datastorm's Procomm Plus and HyperAccess, which some columnists swear by. FaxWorks isn't my favorite laptop fax program for Windows—I'm more familiar with BitFax, which comes with the AT&T/NCR machines—but it seems to work all right.

Washington, D.C., has lousy telephones, as I discover every time I go there. Whatever modem I carry, I have trouble getting on-line at all, and I almost never manage to connect at 9600 bps. On this last trip, I traveled light: no checked luggage, just a briefcase and my wheeled carryons. After I got my clothes and toothbrush in, there was precious little room for electronics, so I carried Macronix's MaxLite 144 fax modem, which is only slightly larger than a pack of cigarettes. When it came time to connect to Tymnet in Washington, I found that a 9600-bps connection was impossible. It took three tries to get on at 2400 bps with error correction. That worked, but there was so much error correcting, it felt like 300 bps.

When I got home, I decided to experiment. Was my problem with the Mastersport, the MaxLite 144, or Procomm? The first move was to call the Washington 9600-bps number with my standard setup: the Big Cheetah 486, Procomm running as a DOS program under Windows, and a USRobotics Courier HST Dual Standard 14.4-Kbps modem. I've always considered the USRobotics modem the all-around best one available for connecting to noisy lines. (Also, USRobotics updates their firmware for modems in the field; have you registered your modem?)

When that worked on the first try, I tried the 9600-bps number with the Mastersport and the MaxLite 144. No lock in three tries. At 2400 bps, I got a lock, but it was a slow throughput, just like when I was in Washington; so at least the condition was repeatable, and I could run some tests.

I got the same result with the MaxLite 144 and Big Cheetah, so it wasn't likely that the problem was a bad serial port on the Mastersport. To be sure, I tried the USRobotics modem on the Mastersport and got a 9600-bps connection first thing. Then I tried the SupraFaxModem 14400. That locked on at 9600 bps, but it needed two tries. At 9600 bps, the ATI modem locked on first try. No difference between the ATI and the USRobotics modems in several trials; both worked perfectly. Several tries with the SupraFaxModem showed that it

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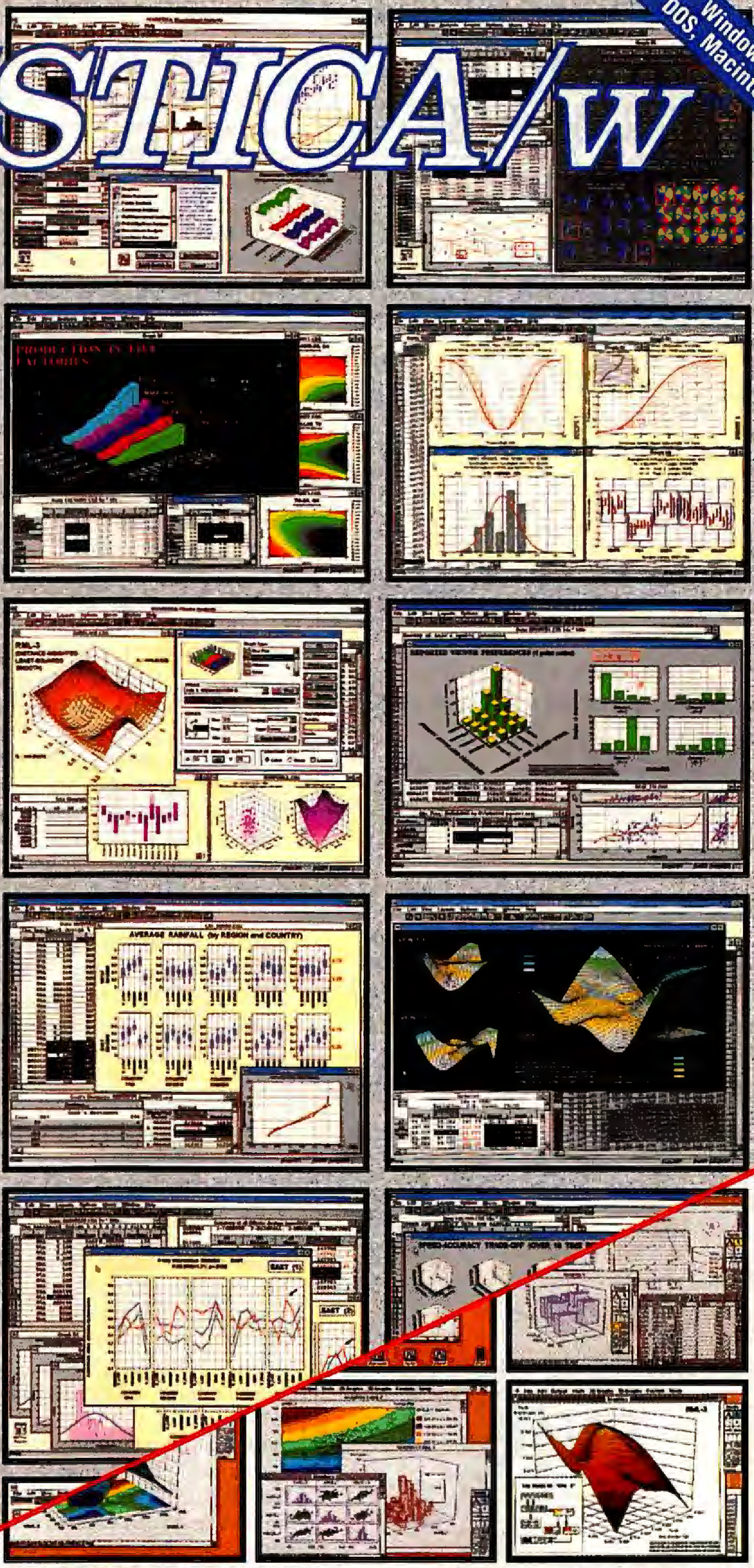

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would always work, but sometimes it did need two tries. I never got a 9600-bps lock with the MaxLite 144.

After that, I tried a particularly noisy path line to an Internet node down toward San Diego. It's a good test; of all my modems, including the ATI, the only one that would work at 9600 bps was the US-Robotics, and it took two tries before it got an error-correcting lock. All the others failed no matter how often I tried, despite experiments with initializations.

The ATI modem comes with good manuals, and it's generally easy to set up, but you may have to try different setup strings. The USRobotics modem generally works with its default settings. I have similar reports from Mike Banks, the coauthor of my communications book. If you deal with lousy communications nodes, you're better off using a USRobotics modem. The ATI 14400 ETC is nearly as reliable.

Of course, both those modems are big. If you're traveling, the SupraFaxModem costs less, is much smaller and lighter, and will generally do the job, but it's still bulky compared to the MaxLite 144. The MaxLite 144 can be battery-powered, but, alas, it won't always connect at 9600 bps. However, it usually will get 9600 bps, and it always seems to work at 2400 bps.

I have found a real glitch in the networking capability of Windows for Workgroups, but I learned to love Maximum Storage's Duette optical drive. My Windows for Workgroups network usually consists of four machines: three 486s of various speeds and one 386. Windows for Workgroups is a peer-to-peer network and doesn't really have servers, but the 386 sort of functions that way. It sits back in the cable room and is loaded down with assets to be used by the other machines. In particular, it has a Pioneer DRM-604X Minichanger CD-ROM drive and a Pioneer read/write optical drive, which I use for archiving programs and book files when I am done with them.

Sometimes, when I use File Manager to move a big chunk of stuff across the network to the Pioneer optical drive, the system will trundle along for a while and then lock up. When it does that, it locks up cold, and I can't access either the sending system or the 386 "server" where the optical drive resides. When that happens, I can generally use Ctrl-Alt-Del on the sending system; to close File Manager, and after a while, something times out over on the 386. I'll then find that some files have been moved and some haven't.

I confess this annoyed me, but it didn't happen often enough that I really worried about it. No data was lost, and nothing was irretrievably locked up. While my general philosophy is that if an error rate is high enough to measure, it's too high, there were so many possibilities—the Pioneer optical drive, the Cheetah 386, one of the network cards, Windows for Workgroups itself—that I just learned to live with it.

Then I got the Duette drive. This thing is the fastest optical drive I've ever seen. I used a Future Domain SCSI card to install it on a Gateway 2000 4DX2-66, and it just screamed. Meanwhile, I did have the problem of storing a whole bunch of installed applications files while I reformatted the PS/2's hard disk. The simplest way was to use LapLink Pro and a parallel port to move the files to the Duette. That's much slower than the slowest network, but it does work.

My first attempt wasn't very successful. Since the Duette seemed to work just fine under Windows—it appeared as drive D on the Gateway 2000—I did the file transfer with the Gateway 2000 running Windows for Workgroups and the PS/2 running OS/2. This had the advantage that I could move files between the PS/2 and any computer on the Windows for Workgroups network. However, when I started moving huge blocks of files from the PS/2 to the Duette, odd things happened, and eventually the system locked up.

The remedy to that was to exit Windows and run LapLink Pro under DOS on the Gateway 2000. That worked fine, and pretty soon I had 400 MB of files transferred from the OS/2 system. When I put the Gateway 2000 back into Windows for Workgroups, I had no problems moving files from the Duette to other machines.

So far, so good; but then I tried to move some files across the network to the Duette. Pretty soon the system locked up, exactly as it had with the Pioneer optical drive, so I had the same problem with two different computers running two different optical drives. Clearly, Windows for Workgroups isn't happy about networking to optical drives.

OK, thought I: I'll move the files to the Gateway 2000's hard drive and then move them again onto the Duette. That way, I won't be writing to the optical drive across the network.

The transfer to the Gateway's hard drive worked fine, but when I moved this big block of stuff onto the Duette—a local move—once again it locked the system. I exited Windows and used Norton Commander to move the files under DOS. That was no problem. I'm told that people running straight Windows don't have problems with file moves, so I concluded that

Windows for Workgroups doesn't really understand large optical drives. There's a new version (3.11) of Windows for Workgroups coming out soon. It's supposed to fix a lot of problems and provide many new features. I'll try that when I get it.

We have Windows NT, both in shrink-wrapped copy and in the Win32 SDK (Software Development Kit). The SDK comes with a CD-ROM chock full of development tools, including NT 3.1, lots of code, Visual C++ for NT, a system guide, and a partridge in a pear tree. Microsoft makes a real effort to get this stuff into the hands of software developers just as soon as they can, and they set their prices as low as possible. Meanwhile, IBM had a low-cost special on their OS/2 development and device driver kits, but that's over: the price is back up to $600 or so.

I recall way back when Texas Instruments' research people produced some really interesting software development tools. They decided to license and sell them at what they thought were fair prices, which were still high for developers who weren't sure they wanted to work with the TI systems anyway. Lo, they sold only a few copies, and not many developers wrote applications for TI systems. Moral: making money by selling SDKs is eating your seed corn.

I haven't installed Windows NT, and I probably won't for a while. Friends assure me that it works, and some people I respect think it's wonderful, particularly as a development environment. I believe this. What I don't believe is that Windows NT is particularly relevant to small systems just now. With regards to PCs, NT is a stalking horse that will be relegated to much larger systems when the new Microsoft "dream" operating systems—code-named Chicago and, more important, Cairo—come out. (At one time at least, there was also a Newark. The slogan at Microsoft is "on to Cairo"; Newark is further than Chicago but not yet to Cairo. Incidentally, I understand that MS-DOS 6 was code-named Yakima, which is closer to Seattle than Chicago.)

NT's real role is to combat IBM's higher-end RISC stuff like AS/400. I'm told that IBM's AS/400-related revenue in 1992 was $14 billion, with a $2 billion profit; no small sums, even for Microsoft.

Thus, working with Windows NT is no waste of time. In addition, Chicago and Cairo will have much in common with NT, and it's much in Microsoft's interest to provide an easy migration from NT to the new RISC-based operating systems we're about to see. As desktop machines become more powerful, there will be more and more integration of software, and NT is likely to serve as a bridge between mainframes, big workstations, and high-end desktop systems.

I also understand that Chicago will incorporate peer-to-peer networking within the operating system. I think Microsoft had hoped to bring Chicago out soon, making any improvements to Windows for Workgroups a waste of time; but they just released a Windows for Workgroups upgrade, which may put a handle on when they expect to ship Chicago.

There's too much software that won't work and won't tell you why. Last night, I found I couldn't print. Chasing that particular problem down took most of the day and was instructive.

The first thing to check is cables. I looked at the printer cable. Just to be sure, I got out an Inmac Blue. Inmac cables are pricey, but they're extremely reliable.

It wasn't the cable. Keyboard next: a faulty keyboard can overload the A20 handler and cause odd addressing errors. Changing keyboards did no good, so the next thing was to define the problem. I found that Windows for Workgroups would print to my Hewlett-Packard LaserJet III using Q&A Write. That uses a font cartridge. However, when I tried printing with Word for Windows (which uses TrueType fonts), I'd get a line of garbage across the top of the first page and dozens of pages of blank paper thereafter. This is not what a novelist on deadline needs.

Next question: Could it be Word? Make a test message in Windows Write and try printing that. Same result.

First things first. I solved the deadline problem by using LapLink to send the entire Word for Windows directory, program and files, over to the PS/2 Model 77. I then let OS/2 "migrate" Word for Windows. That created a Word icon letting me run Word without opening the Windows Program Manager. Printing required that I string a cable from the OS/2 machine to the LaserJet III, open the file in Word for Windows, and tell it to print. Nothing to it, and in truth, OS/2 prints so much faster than Windows, I actually saved time doing it that way.

That got my story draft printed and showed clearly that the problem wasn't with my files, my copy of Word, or the printer. What was left? Corrupted printer drivers in the Cheetah's copy of Windows? A corrupted copy of Windows? I used Palindrome to restore the entire Windows directory from DAT (digital audiotape), which took about 20 minutes. For good measure, I erased the HP driver and reinstalled it from the original floppy disks. No joy: I still got a line of garbage followed by many pages of blank paper.

The next step was to use the Windows for Workgroups network to send the Word directory over to the Gateway 2000 4DX2-66 and connect the printer cable to that machine. It printed fine, meaning that my problem was specific to the Cheetah. Sigh.

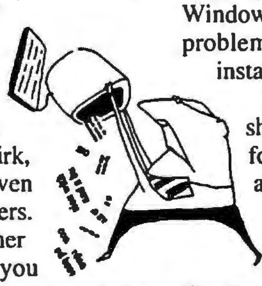
Eventually I figured it out, but first a diversion, which I assure you is relevant. Meanwhile, I confess to being a bit annoyed: Microsoft sells us these highly complex systems, and then when they don't work, they want us to pay for technical support. There has to be a better way.

I have a new Nanao FlexScan T560i 17-inch monitor. Mind you, there was nothing wrong with the old one, which has been in constant use for well over a year; but Nanao is proud of the energy-saving features in the newer models. The Nanao offices are near Los Angeles, so Brian Mast offered to bring out a new model to swap for my old one.

I confessed to some misgivings: I still hadn't figured out why I couldn't print, and this would be yet another change to the system. Still, the computer shouldn't be able to tell the new monitor from the old, so I agreed, and promptly forgot about it until Brian showed up outside Chaos Manor. We lugged the FlexScan upstairs—it's a *heavy* sucker—and connected it up. As promised, it worked perfectly.

If, like me, you sit staring at a computer screen most of your day, you owe it to yourself to get a Nanao monitor. They make really big ones, but the 17-inch FlexScan seems about the right size for me: I put it about 30 inches from my nose, and my text lines are just the right length so that I see the whole line without moving my eyes. Meanwhile, the colors are sharp and crisp, and everything on the screen is as steady as if it were painted. Best of all, I'm in a brightly lit south-facing room, but I don't have a problem with glare. People often ask me how I turn out so many words: the secret is good equipment, and the FlexScan is a big part of that.

Brian had also brought a copy of the newest edition of Berkeley Systems' After Dark screen saver. Of course, screen savers don't do anything you can't accomplish by turning off your monitor, but I confess an attraction for Captain Kirk, Mr. Spock's antics, and even the notorious Flying Toasters. The new edition has another feature: after an interval you can set, Mr. Spock goes away, and the screen is totally blanked out. When the FlexScan detects that condition, it shuts itself down so that it draws only 7 W, as opposed to a couple of hundred when it's active.



The bottom line is I love this Nanao monitor.

When I started to install After Dark, I got a Protection Violation error, and when I reset and tried once more, it happened again. This caused me to wonder if my computer was doing something flaky, so I went into the BIOS Setup program and turned off shadow RAM and caching. When I booted up and tried the After Dark installation again, I got the same error. Brian assured me that most of the people at Nanao use After Dark with Windows for Workgroups, so clearly the problem was something about my own installation.

One nonstandard feature is a shareware program called Plug-In for Program Manager. I've written about this before: it enhances the Windows Program Manager without replacing it. It does such a good job that although I rather like Symantec's Norton Desktop for Windows, I find with Plug-In I don't use Norton. Time to remove that—which did the trick. After Dark installed just fine. Since removing Plug-In solved one problem, maybe it took care of another? I knew darned well I'd been able to print with Plug-In installed—in well over a year, this was the first glitch I could trace to it—but it would do no harm to try printing.

Word printed just fine. I installed Plug-In again. Tried printing. Worked just fine. So did After Dark; it was only the installation program that fought with Plug-In.

I could print again, but, of course, I had the cache and shadow RAM turned off. I turned them back on, tested again—and couldn't print.

Jeff Sloman finally solved the problem for me. Turn on BIOS cache and shadow RAM, get into Windows for Workgroups, open the Printer icon in the control panel, and deselect the box that says "Fast print direct to port." Ignore the dialog box about ports, and Bob's your uncle.

I've been offered an explanation of why this works, and I suppose by next month I'll care; meanwhile, here's another instance of software that can't tell you what's wrong with itself.

Every time I threaten to abandon Windows, I find another valuable program that needs it. VisSim is a simulation program that turns your PC into an analog computer; that is, you can build various analog blocks and connect them up on-screen the way you would connect the physical operational amplifiers and other analog components with wires.

I wrote about a previous edition a year or so ago. There's now a greatly improved version. Alas, the manual isn't much improved. You'll need to know something about model building or have a separate book on analog modeling systems; but assuming you know what you're doing, VisSim is very powerful. There are also new add-on modules, including Analyze, and a real-time interface to many analog/digital boards. You can use VisSim to model a complicated control system and then connect it to the real thing in real time.

VisSim works with matrix operations programs, including MatrixX. There's a C-code generator module you can use to write compilable code that will run models about 10 times faster than the on-screen visual-block models do.

VisSim is a good general-purpose tool for modeling systems, from something simple like an artillery shell to the Jay Forrester World Dynamics models. Until Windows, you had to go to a Mac to find a program as good as this. Recommended.

This year, Microsoft has improved both their desktop and laptop mice. I said last issue that their new large-size "teardrop" desktop mouse is an improvement over the "Dove soap bar" model. Now they have a new Ballpoint mouse, and that, too, is a genuine improvement. Like the previous Ballpoint, this is a thumb trackball mouse that attaches to your laptop keyboard.

You can also attach it to your desktop. If you prefer trackballs to mice, you definitely should look at this. If you're only indifferent, it's still worth a look. The action is smooth, and the mounting is improved over the old Ballpoint mount; while the button placement is nearly ideal, with extremely natural button action.

I got a call from a consultant friend: a client had a system infected with a new virus. I didn't recognize the symptoms, so I gave him the phone number of Alan Solomon's S&S International in England, on the theory that if Dr. Solomon can't fix the problem, no one can. My friend bought a copy of Dr. Solomon's Anti-Virus Toolkit, and that did the trick.

It's not time to panic, but there are a lot of wild viruses out there. I routinely check my system every week now. I boot up from a floppy disk that has *always* been write-protected and run Dr. Solomon's; if you have valuable databases or do important work on your computer, I advise you to do the same.

Software developers who convert DOS applications to Windows should pay a *lot* of attention to installation details. This was brought home to me when I installed the upgrade of WinMortization Pro from Etter Industries. This useful little program calculates loan and mortgage amortizations and prints reports on them. Easy to use, too.

Then last week I got a Windows version. I decided to update, and trouble started. First, it said I had an obsolete \WINDOWS\SYSTEM\GRID.VBX and offered to replace it. Since I use Windows for Workgroups and don't know what GRID.VBX does, it seemed prudent to tell it not to replace that; I figured I could do that later if necessary. The rest of the installation seemed to go all right, but when I tried to run the program, it said "C:\WINDOWS\THREED.VBX is out of date," and died. Thinking I may have done the installation wrong, I tried again. The result was two programs and two readme icons in the WINMORTPRO program group; the installation program doesn't check to see if those are already present.

I deleted the whole mess and talked to Etter Industries. They had meanwhile talked to Microsoft, because this had happened before. Apparently, some unknown third-party application is inserting an ancient copy of THREED.VBX in the Windows subdirectory. The remedy is to delete it, because there's a current copy of THREED.VBX in the WINDOWS\SYSTEM subdirectory (where it belongs).

I deleted the superfluous \WINDOWS\THREED.VBX, deleted all traces of WinMortization Pro, and started over. Again, it offered to replace \WINDOWS\SYSTEM\GRID.VBX. I again declined, and the installation went flawlessly; but attempts to launch the program terminated with the message that I had an obsolete GRID.VBX. I decided to install again, this time letting it replace GRID.VBX, which it appeared to do; but trying to launch the program got the same result as before, and once again I had two copies of the program and readme icons in the WINMORTPRO group box.

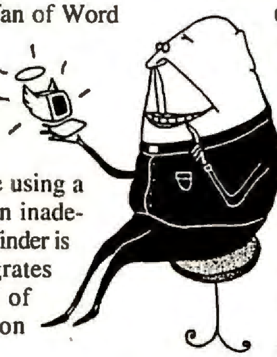
Next, try to delete GRID.VBX. You

can't. GRID.VBX was, according to Windows, in use. OK, exit Windows. Reset the machine. Copy GRID.VBX to GRID.FOO and nuke the original. Scrub all traces of WINMORTPRO, including the Windows program group. Enter Windows with some trepidation. Since I have no idea what GRID.VBX does, I wouldn't have been surprised if Windows couldn't open Windows without that file, but it did. Install WinMortization Pro yet again. This time, unprompted, it decompressed GRID.VBX and copied it into \WINDOWS\SYSTEM; I presume the previous attempt failed but the installation program didn't notice that. Anyway, all went well.

Microlytics has a Windows version of their pioneering Word Finder thesaurus, and it works quite well with Word for Windows and other Windows word processors. To use it, you select (highlight) a word in your text and then leave your word processor for the desktop, invoke Word Finder, wait for its dialog box to pop up (as a small window superimposed over your text), and click on the "import" button. After you have done that the first time, you can return to your word processor by clicking anywhere on your text, and the next time you need to use Word Finder, just highlight a word and do Alt-Escape. Word Finder will appear.

All this works, but no better than doing Shift-F7 within Microsoft Word. The synonyms given are about the same, and, as a bonus, with the thesaurus included in Word, you don't highlight the text, just get the cursor into or next to it.

I have long been a fan of Word Finder, and I use the DOS version (along with Definitions/Plus) in Q&A Write when I'm doing first drafts of text. If you're using a word processor with an inadequate thesaurus, Word Finder is the one to get; it integrates nicely with nearly all of them. The Mac version works just fine, too.



There are a lot of Bible programs now. The latest arrival is Holy Bible from Software Marketing. It's for DOS/VGA and takes 11 MB. It comes on seven 3½-inch floppy disks and features the King James Version, with red highlighting, maps, chronology, art files of sacred masterpieces, a concordance with search capability, and a bunch of other stuff. Useful for Bible scholars, and for that matter, pretty good browsing for anyone interested in the subject.

I have a whole bunch of books this month. The computer book of the month is from the Hayden Development Group Staff, with contributions from a dozen experts. It's called *Everything You Wanted to Know about the Mac* (Hayden, 1992), and it's really complete.

Distributed Systems Management by Alwyn Langsford (Addison-Wesley, 1993) is a specialized book for people who find they have to manage computer systems in many locations. Distributed computing is the wave of the future, but it can create unexpected headaches for management. This is a good place to learn about them.

The book of the month is Joel N. Shurkin's *Terman's Kids: The Groundbreaking Study of How the Gifted Grow Up* (Little, Brown, 1992). Lewis Terman

did a great deal of pioneer work in intelligence testing and did studies of gifted children. One of his groups, more than 1500 California children with genius- and near-genius-level IQs, became known as "the Termites" and were featured in a number of studies. Shurkin is the chief science writer at Stanford University and has a deservedly good reputation for accuracy as well as readability. This book follows the Termites up to the present. If you're interested in gifted children, you'll find this book fascinating.

The game of the month is MicroProse's Master of Orion, which is Reach for the Stars on steroids. It's addicting.

Next month, presentation programs and more on networking, including a test of the new Windows for Workgroups 3.11. As usual, there aren't enough hours in the day. ■

Jerry Pournelle holds a doctorate in psychology and is a science fiction writer who also earns a comfortable living writing about computers present and future. Jerry welcomes readers' comments and opinions. Send a self-addressed, stamped envelope to Jerry Pournelle, c/o BYTE, One Phoenix Mill Lane, Peterborough, NH 03458. Please put your address on the letter as well as on the envelope. Due to the high volume of letters, Jerry cannot guarantee a personal reply. You can also contact him on the Internet or BIX at jerryp@bix.com.

For More Information

After Dark ($49.95) features Captain Kirk and Mr. Spock. Contact **Berkeley Systems, Inc.,** 2095 Rose St., Berkeley, CA 94709, (800) 877-5535 or (510) 540-5535; fax (510) 540-5115. **Circle 1146 on Inquiry Card.**

The **ATI 14400 ETC** modem (ETC I, $249; ETC E, $299) comes with good manuals. It's generally easy to set up. Contact **ATI Technologies, Inc.,**33 Commerce Valley Dr. E, Thornhill, Ontario, Canada L3T 7N6, (905) 882-2600; fax (905) 882-2620. **Circle 1147.**

If you do a lot of mousing around, think seriously about the new Microsoft **Ballpoint** mouse ($125). It really is that good. Microsoft's **Win32 SDK** (call for price) comes with a CD-ROM chock full of development tools. There's a new version (3.11) of Microsoft's **Windows for Workgroups** ($249.95) coming out soon. Contact **Microsoft Corp., 1** Microsoft Way, Redmond, WA 98052, (800) 426-9400 or (206) 882-8080; fax (206) 883-8101. **Circle 1148.**

If you deal with lousy communications, you should use a USRobotics **Courier HST Dual Standard** modem ($1295). Contact **USRobotics, Inc.,** 8100 North McCormick Blvd., Skokie, IL 60076, (800) 342-5877 or (708) 982-5010; fax (708) 982-5235. **Circle 1149.**

If **Dr. Solomon's Anti-Virus Toolkit** can't solve your virus problem, nothing can. DOS version, £99; Windows version, £125; OS/2 version, £149). Contact **S&S International, Ltd.,** Berkley Court, Mill St., Berkhamsted, Hertfordshire HP4 2HB, U.K., +44 442 877877; fax +44 442 877882. **Circle 1150.**

Maximum Storage's **Duette** drive ($2790) is the fastest optical drive I've ever seen. Contact **Maximum Storage, Inc.,** 518 North Nevada Ave., Suite 203, Colorado Springs, CO 80903, (800) 843-6299 or (719) 442-6674; fax (719) 442-6671. **Circle 1151.**

If, like me, you sit staring at a computer screen most of your day, you owe it to yourself to get Nanao's **FlexScan T560i** monitor ($2199). Contact **Nanao USA Corp.,** 23535 Telo Ave., Torrance, CA 90505, (800) 800-5202 or (310) 325-5202; fax (310) 530-1679. **Circle 1152.**

Useful for Bible scholars, **Holy Bible** ($49.95) is also pretty good browsing for anyone interested in the subject. Contact **Software Marketing Corp.,** 9830 South 51st St., Building A-131, Phoenix, AZ 85044, (602) 893-3377; fax (602) 893-2042. **Circle 1153.**

Master of Orion ($59.95), or Reach for the Stars on steroids. Contact **MicroProse,** 180 Lakefront Dr., Hunt Valley, MD 21030, (410) 771-1151; fax (410) 771-1174. **Circle 1154.**

The **MaxLite 144** fax modem ($299) is slightly larger than a pack of cigarettes and can be battery-powered. Contact **Macronix, Inc.,** 1348 Ridder Park Dr., San Jose, CA 95131, (800) 858-5311 or (408) 453-8088; fax (408) 453-8488. **Circle 1155.**

Plug-In for Program Manager ($20) enhances the Windows Program Manager without replacing it. Contact **Plannet Crafters, Inc.,** 2580 Runic Way, Alpharetta, GA 30202, (404) 740-9821; fax (404) 740-1914. **Circle 1156.**

If you're traveling, the **SupraFaxModem 14400** costs less (for IBM PCs, $229.95; for Macs, $249.95). Contact **Supra Corp.,** 7101 Supra Dr. NW, Albany, OR 97321, (800) 727-8417 or (503) 967-2400; fax (503) 967-2401. **Circle 1157.**

VisSim (Personal VisSim, $495; VisSim, $1495) is a good general-purpose tool for modeling systems. Recommended. Contact **Visual Solutions, Inc.,** 487 Groton Rd., Westford, MA 01886, (508) 392-0100; fax (508) 692-3102. **Circle 1158.**

WinMortization Pro for Windows ($99.95) is about the best program around for doing complex loan amortizations. Contact **Etter Industries, Inc.,** 82 Shoreview Dr., Bedford, Nova Scotia, Canada B4A 1V5, (800) 565-2662 or (902) 835-6060; fax (902) 835-5431. **Circle 1159.**

Word Finder Plus ($39.95) is the thesaurus to get. The Mac version works fine, too. Contact **Microlytics, Inc.,** 2 Tobey Village Office Park, Pittsford, NY 14534, (800) 828-6293 or (716) 248-9150; fax (716) 248-3868. **Circle 1160.**

What's New Hardware

UPGRADE YOUR PC TO MULTIMEDIA ▲

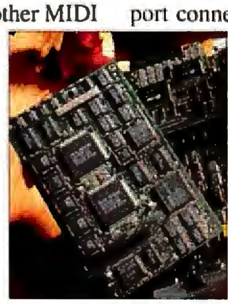
Media Vision's (Fremont, CA) Memphis multimedia upgrade system ($999) gives you the power to create voice or video-annotated presentations on your PC. The MPC- and MPC2-compliant system incorporates Media Vision's Pro Audio 16 sound technology to produce 16-bit stereo sound; built-in MIDI support lets you control other MIDI musical instruments using the on-board MIDI connectors or an external music keyboard. Other features include a 20-voice synthesizer, a software-controllable mixer, and a SCSI CD-ROM controller interface. A double-speed CD-ROM drive can transfer data at 300 KBps with a 350-ms access time. Memphis supports DOS, Windows 3.1 and NT, OS/2 2.1, and NextStep. The system is also backward compatible with Sound Blaster and AdLib.
Phone: (800) 845-5870 or (510) 770-8600.
Circle 1315 on Inquiry Card.

BUBBLES OF COLOR

The BJC-600 ($719) from Canon Computer Systems (Costa Mesa, CA) uses an ink formula that, according to Canon, dries 100 times faster than conventional inks, giving you nonbleeding color on plain paper. The 360-dpi BJC-600 uses four separate ink cartridges to hold the primary output colors of cyan, magenta, yellow, and true black. You can change each color cartridge separately as it runs out, eliminating waste. A 256-nozzle print head has 64 nozzles for each of the four colors. The printer also accepts recycled paper, labels, Bubble Jet transparencies, and back print film.
Phone: (800) 848-4123 or (714) 438-3000.
Circle 1327 on Inquiry Card.

THREE-IN-ONE ETHERNET CARD ▼

A technique called workgroup filtering integrates Ethernet port connectivity, filtering, and on-board SNMP management on the 10BT-FTR card (from $3095). Designed for use with the INX 5000 intelligent wiring hub, the 10BT-FTR filters and forwards all or some of the local and remote network traffic that passes through the filter. Two custom ASICs on the Racal-Datacom (Boxborough, MA) card give the Ethernet interface and filter control for all information that passes through the card, providing packet-forwarding at the full Ethernet speed of 10 Mbps.



Phone: (800) 722-2555 or (508) 263-9929.
Circle 1319 on Inquiry Card.

PEN INPUT FOR YOUR PC

A combination software and hardware pen-input system, Handwriter for Windows ($399) is compatible with standard, off-the-shelf Windows applications. From Communication Intelligence (Redwood Shores, CA), Handwriter for Windows comprises handwriting recognition, Pen Extensions for Windows, signature-verification software, pen utilities, a cordless pen, and a tablet with a 10-foot cable that plugs into your computer's serial port. You can write, edit, point, select, drag, create customized gesture macros, draw, and navigate through menus.
Phone: (800) 888-9242 or (415) 802-7888.
Circle 1318 on Inquiry Card.

MULTIMEDIA UPGRADE

The Mega 535M Multimedia Upgrade Kit ($649) from Megamedia Computer (San Jose, CA) provides you with the necessary equipment to add multimedia capability to your 386- or 486-based computer. The kit is compatible with the MPC Level 2 specifications and includes a Chinon CDS535 internal SCSI-2 CD-ROM drive, a Pro Audio Spectrum 16 sound card with a SCSI connection, amplified magnetically shielded speakers, and SCSI and audio cables.
Phone: (800) 634-2633 or (408) 428-9920.
Circle 1326 on Inquiry Card.

BITWISE COLOR PORTABLE

The BitWise ACP (from $6295) 10-inch active-matrix TFT color flat-screen portable is packed with power for working in multimedia, CAD, and engineering applications. From BitWise Designs (Schenectady, NY), the 486-based computer has 4 MB of RAM (expandable to 32 MB), 128 KB of cache RAM (expandable to 256 KB), and up to 2 GB of internal hard disk capacity. A 5¼-inch drive bay accommodates a CD-ROM, WORM, or read/write optical drive. One half-size and three full-size expansion slots are available. You can run an external Super VGA monitor at up to 1024- by 768-pixel resolution.
Phone: (800) 367-5906 or (518) 356-9740.
Circle 1325 on Inquiry Card.

A FIVE-IN-ONE DESKTOP UNIT

The multifunction Omnifax G5 ($1995) provides the functionality of a 14.4-Kbps plain-paper fax, a PC fax board, a laser-quality printer, a copier, and a scanner with optional OCR capability. The Omnifax can simultaneously scan one document, print another, and send or receive a third. The unit's fax capabilities include a 99-number auto-dialing feature, quick scanning into memory, auto-batching to group documents going to the same destination, broadcasting, and page retransmission. The 300-dpi print function works from any DOS or Windows application. You can use the PC fax board function to send a file from your attached PC or from a PC on a LAN. The unit lets you edit scanned documents and incoming fax messages on your PC. Depending on your application, you can rotate, scale, and clip documents on the PC, export image documents to Windows Paintbrush, or copy files to the Windows Clipboard.

Contact: Omnifax, Los Angeles, CA, (800) 221-8330 or (310) 641-3690.
Circle 1312 on Inquiry Card.

MAC ETHERNET CONNECTORS

The AAUI-2 and AAUI-T transceivers ($89 each) provide Ethernet connection for the Mac Centris 610 and 650 and Quadra 800, 900, and 950 systems. The AAUI-to-10Base-2 AAUI-2 has an auto-terminating BNC connector and supports up to 30 nodes per segment. The AAUI-T provides a single-port AAUI-to-10Base-T connection. From MacNet (San Jose, CA), each transceiver has an LED that provides power-on status.
Phone: (800) 486-2638 or (408) 954-8888.
Circle 1316 on Inquiry Card.

KEYBOARD CALCULATOR

A solar-powered calculator that adheres to your PC keyboard, the MediaMate Keyboard Calculator ($9.99) allows you to do separate calculations while working on your computer. The device, which fits above the keypad, has a battery backup and displays eight figures with a floating decimal. The unit is from Hunt Manufacturing (Philadelphia, PA).
Phone: (800) 765-5669 or (215) 732-7700.
Circle 1321 on Inquiry Card.

PORTABLE SPARC ▼

Based on the MicroSparc processor, the 50-MHz PowerLite portable workstation (from $9995) is configurable with up to 80 MB of memory and more than 1 GB of internal disk space. The RDI Computer (San Diego, CA) system comes with a 640- by 480-pixel Colorplus active-matrix LCD, upgradable to a 1024- by 768-pixel active-matrix color LCD. The system also has a Peripheral Expansion Unit, or PXU ($2950), with a 450-MB hard disk and two open SBus slots that you connect directly to the bottom of the unit. You can configure the PXU to include extra hard drives, SBus slots, and SCSI peripherals.
Phone: (619) 558-6985.
Circle 1317 on Inquiry Card.

VIDEO CARDS FOR TV DISPLAY

VideoOut ($99), from International Computers (Wauwatosa, WI), consists of a plug-in card and software. The card, which gets its power from the PC bus, functions as a pass-through for VGA video signals. The TSR software stays resident until you press the hot key; it then quickly reprograms the registers on your VGA card to convert the video signal to the timing for NTSC, letting your TV receive the signal. VideoOut, which, according to the manufacturer, is compatible with all VGA boards, automatically detects a board's manufacturer and configures itself to fit the particular configuration.
Phone: (414) 764-9000.
Circle 1323 on Inquiry Card.

The Channel One multimedia video card ($459) enables you to display or output computer-generated data and graphical images to any device that supports VGA, S-VHS, and composite NTSC/PAL. From STB Systems (Richardson, TX), the Channel One comes with 1 MB of 60-ns DRAM video memory and a Sony CXA1145 RGB encoder that enables the card to convert VGA signals to NTSC/PAL video formats. The card is based on Cirrus Logic's 5426 video-controller chip.
Phone: (214) 234-8750.
Circle 1324 on Inquiry Card.

IMP COEXISTS WITH YOUR MOUSE

A wireless remote-control input device, Imp ($199) lets you position the cursor, execute common mouse functions, and replicate keyboard functions from as far as 15 feet away from your computer. Windows- and Microsoft Mouse–compatible, Imp consists of a hand-held wireless transmitter and a compact receiver that connects to your PC's serial port. The transmitter has a control disc for cursor control and four auxiliary buttons that act as keyboard keys. Powered by your PC, the receiver has indicator lamps that reflect communication activity and the status of the batteries in the transmitter.
Contact: ArcanaTech, Pittsburgh, PA, (800) 364-4677 or (412) 441-6611.
Circle 1313 on Inquiry Card.

SPEEDY MULTIPORT CONNECTIVITY FOR UNIX

Comtrol's (St. Paul, MN) RocketPort family of controller boards (from $259) replaces major hardware components, such as the processor, serial ports, and bus-interface logic, with two specially designed ASICs. One ASIC includes a 36-MHz processor in place of the conventional multiport board processor. The board is designed to maintain consistent speeds of 230.4 Kbps or 115.2 Kbps at each port. RocketPort supports operating systems such as DOS, Windows, Unix, SCO Xenix, and QNX and is available with four, eight, 16, or 32 ports.
Phone: (800) 926-6876 or (612) 631-7654.
Circle 1328 on Inquiry Card.

A MODEM WITH PARALLEL-PORT CONNECTIONS

A 28,800-bps portable modem with fax, the TravelPorte Fast ($499) has data throughput of up to 115.2 Kbps using V.42bis and MNP 5 data compression. The Windows-compatible modem uses the parallel port interface and drivers to achieve this high throughput rate. From Microcom (Norwood, MA), the TravelPorte Fast supports MNP 10 and communications with non-V.fast modems such as V.42, V.32bis, and V.32, as well as synchronous and asynchronous operation, Group 3 send-and-receive fax, and UUCP. Flash-downloadable memory lets you upgrade the unit. The modem also supports the serial port for compatibility with DOS.
Phone: (800) 822-8224 or (617) 551-1000.
Circle 1330 on Inquiry Card.

PCMCIA SCSI ADAPTER

The FastSCSI PCMCIA host adapter card ($229.95) from QLogic (Costa Mesa, CA) is based on the company's ESP406, a single-chip SCSI processor that automates SCSI operations at hardware speed without host intervention, according to QLogic. The adapter supports DOS, Windows 3.1 and NT, NetWare, SCO Unix, and OS/2. The card connects directly to the internal PCMCIA Type II bus and includes a 50-pin connector for use with external devices.
Phone: (714) 438-2200.
Circle 1331 on Inquiry Card.

What's New Hardware

GRAB A CARD AND SCAN IT ▶

The CardGrabber ($399) is a plug-and-play scanner of business cards that uses the parallel port of notebooks and desktop computers. From Pacific Crest Technologies (Newport Beach, CA), the DOS- and Windows-compatible CardGrabber scans a card and then stores the information in a Windows-based address book. You can use the address book to search, customize, sort, and print your information. You can import and export data to any Windows or DOS database and PIM, as well as ASCII text, word processors, Lotus-compatible spreadsheets, and PDAs. The 15-ounce device has built-in AI and OCR software.
Phone: (800) 870-3391 or (714) 261-6444.
Circle 1339 on Inquiry Card.

CONNECT REMOTE USERS

The OutPost remote messaging system ($299) provides near-real-time E-mail responsiveness for remote locations and eliminates the need to regularly run an MHS session. The combined hardware and software from Calculus (Deerfield Beach, FL) permits you to have nondedicated MHS servers by letting the remote PC power-off without losing connectivity. At the remote location, the OutPost Remote Service Unit receives inbound MHS transactions, stores messages in nonvolatile memory, and provides audio and visual indications of the saved message.

Phone: (305) 481-2334.
Circle 1335 on Inquiry Card.

SPEAK TO YOUR DOCUMENTS

A fully integrated business audio system, SoundXchange Model BX ($169) lets you record and play your voice in OLE-compatible Windows 3.1 documents. From InterActive (Humboldt, SD), the Model BX includes a built-in sound board that records at 2750 to 11,025 Hz. It plays back sound files recorded at frequencies of up to 44,100 Hz. The system attaches to the side of your monitor and plugs directly into your computer's parallel port.
Phone: (605) 363-5117.
Circle 1344 on Inquiry Card.

CARD WITH A MULTIPLE VIEW

The FastMax/MV dual-channel display controller ($399) from VidTech Microsystems (Minneapolis, MN) supports two VGA channels that are totally independent of each other. Each channel can display different resolutions at the same time and can be configured with a 512-KB or 1-MB DRAM frame buffer. Resolution on the DOS- and Windows-compatible controller can go up to 1280 by 1024 pixels with 16 colors; 1 MB of DRAM per channel is required. You can install as many as four cards per system.
Phone: (612) 780-8033.
Circle 1332 on Inquiry Card.

DIGITALLY CONTROLLED MONITOR

The Brilliance 2130 21-inch color auto-scanning monitor ($3499) from Philips Consumer Electronics (Knoxville, TN) gives you digital control of internal signals to fine-tune picture quality. The monitor supports refresh rates of up to 76 Hz at 1280- by 1024-pixel resolution, as well as an extended horizontal scanning frequency range of up to 82 Hz and a 150-MHz video-amplifier bandwidth. The flat-square display has a 0.29-mm dot pitch and an antireflective, antistatic, multilayer coating.
Phone: (212) 532-6300.
Circle 1336 on Inquiry Card.

RAID FOR MACS AND PCS

A series of disk array subsystems for the Mac, the Personal Array (from $1595) supports striping, mirroring, and spanning, with seek times as low as 5 ms and data transfer rates of up to 10 MBps. The subsystem software lets you select and switch among the configurations. From Procom Technology (Irvine, CA), the Personal Array consists of two SCSI drives in a compact, modular case; you snap new modules directly onto the system when you want to expand it.
Phone: (800) 800-8600 or (714) 852-1000.
Circle 1337 on Inquiry Card.

The MicroDFT-1 (from $4495), a hot-swappable RAID storage device from ECCS (Tinton Falls, NJ), provides up to 2 GB of fault-tolerant storage. The subsystem, which slides into 5¼-inch drive bays, can replace your computer's primary hard drive to provide a fault-tolerant boot drive. The hardware-only product is based on RAID-1 technology, which eliminates the need for software mirroring. The MicroDFT-1 reaches a data transfer rate of up to 7 MBps by reading from the drive that is closest to the data. Seek time is as low as 8 ms.
Phone: (800) 322-7462 or (908) 747-6995.
Circle 1338 on Inquiry Card.

PC-PERIPHERAL PORTABLE POWER PROJECTOR

The ergonomic Desktop Projector 2800 ($8995) stands less than 6 inches high and pulls in its lenses and mirrors for transport and storage. The active-matrix projector incorporates a fully integrated digital video processor and accepts all three international video formats and power sources as well as S-VHS.

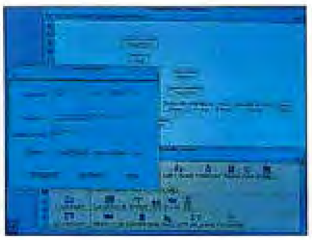
The optical system in the Desktop Projector focuses the available light through the aperture of the LCD panel to provide an image up to four times brighter than one on a standard LCD panel, according to the manufacturer, Proxima. A "folded" optical design and angled panel placement enable the lens to be stored inside the device. You simply move the mirror to adjust the position of the image on the screen. The Active Color Enhancement technology uses processing techniques that provide enhanced color matching from a palette of 16.7 million colors, Proxima says. The 410-W quartz halogen redundant lamp system lets you operate the projector in a lighted room.

Contact: Proxima, San Diego, CA, (619) 457-5500.
Circle 1314 on Inquiry Card.

What's New Software

BUILD APPLICATIONS FROM PICTURES

A visual application builder that relies on moving icons and creating diagrams to develop client/server applications, HarborView (development license, $3900; database drivers, $700 each) has you build the actual application



during the design and prototyping phase. The Harbor Software (Manchester, MA) program enables you to work with pictures rather than traditional programming mechanics. You develop the business logic, and HarborView then automatically builds the forms from the logic. To modify an application, you change the picture, and HarborView automatically rebuilds the application.

Phone: (508) 526-1376.

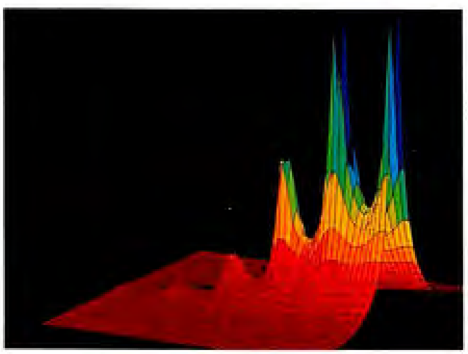
Circle 1281 on Inquiry Card.

NUMBERS AND SYMBOLS ▼

The Symbolic Math Toolbox ($495), from The Mathworks (Natick, MA), provides an extension to Matlab that integrates symbolic computing with numeric computation. Based on an embedded version of Waterloo Maple Software's Maple V, the toolbox provides commands for variable precision arithmetic, direct access to the Maple kernel, and Maple's core math library and linear algebra module, which are included.

Phone: (508) 653-1415.

Circle 1275 on Inquiry Card.



DETECT NT FILE CORRUPTION

File Alert for Windows NT ($99 for each hard disk to be scanned) is file-corruption-detection software that automatically notifies you at the first sign of corruption. From Executive Software (Glendale, CA), File Alert continually checks and verifies data integrity in all types of files. It detects corruption from sources such as hardware or power failures, user error, and software defects and creates and maintains a journal of any corrupted files it finds.

Phone: (800) 829-4357 or (818) 547-2050.

Circle 1276 on Inquiry Card.

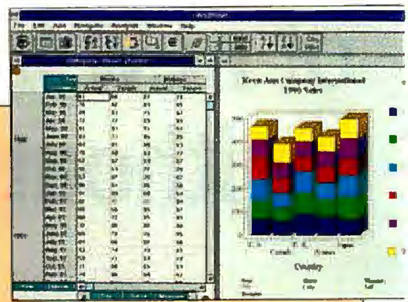
TAME ALL THAT TAX-TIME TENSION

The 1993 updates of AM-Tax Personal ($39) and AM-Tax Professional ($150) include what-if worksheets that enable you to quickly compare different tax scenarios, such as single, married filing jointly, and married filing separately. An audit-alert feature automatically reviews a completed return for more than 100 omissions and inconsistencies. The program from AM Software (Kansas City, MO) issues a warning when various itemized deductions exceed national averages, provides on-line help for operation and forms calculation, and has the ability to print blank copies of any federal or state form that it supports.

Phone: (800) 859-8537 or (816) 426-8361.

Circle 1286 on Inquiry Card.

CROSS-PLATFORM DATA ACCESS AND MANIPULATION



Multiuser client/server-based software, Kenan Technologies' Acumate Enterprise Solution 1.0 lets you access all the data on your company's enterprise-wide system regardless of its format or location. With the software's analysis tools, such as forecasting, business modeling, and exception highlighting, you can extract previously defined information as you need it.

Built around Multiway, the company's multidimensional database and 4GL engine, Acumate ES seamlessly integrates data from sources such as relational databases, spreadsheets, flat files, text reports, and proprietary packages. It then stores the data in a format that permits browsing.

Features include object-oriented programming, a focal-point integrator, data-loading/data-analysis Copilots, and an open API that provides flexible links to front ends such as Excel, Visual Basic, and Improv. Acumate ES is compatible with Windows 3.1 and NT, OS/2 2.0, Unix, and Alpha. Licenses range from $500 to $3000 per seat.

Contact: Kenan Technologies, Cambridge, MA, (617) 225-2224.

Circle 1271 on Inquiry Card.

DATA COMPRESSION AND ARCHIVING

A Windows product that also runs under DOS, Greenleaf ArchiveLib ($279) from Greenleaf Software (Dallas, TX) is an object-oriented data-compression run-time library that lets you compress ASCII or binary data into an archive for storage. C and C++ programmers can compress and archive buffers of data within an application without having to store them as a file. Compressed data can be retrieved into a disk file or a memory buffer. You can code without specifying the type of data to be compressed or the type of location in which the data will be archived.

Phone: (214) 248-2561.

Circle 1277 on Inquiry Card.

AN ATLAS FOR THE MAC

Now available for the Macintosh, Street Atlas USA ($169) provides a complete road map of the U.S. on a single CD-ROM. From DeLorme Mapping (Freeport, ME), Street Atlas USA includes 646 MB of mapping data, delineating urban areas, population centers, block address ranges for large metropolitan areas, and elevation lines. You can print maps from within the program or export them to the Mac Clipboard to use them in other applications.

Phone: (207) 865-1234.

Circle 1279 on Inquiry Card.

DOCUMENTS BY DESIGN

By Design for Microsoft Word for Windows ($99) enables you to create professional-looking documents even if you have no design training. The Streetwise Software (Santa Monica, CA) package supports version 6.0 of Word for Windows and integrates directly into the Icon Bar and Tool Menu. It includes page designs of formats for newsletters, business forms, faxes, memos, and letterheads and has features such as Quick Doc templates, an integrated address book, and a set of design tools.

Phone: (310) 829-7827.

Circle 1280 on Inquiry Card.

MULTIMEDIA IN A PIM

Available in three editions, the Personal Daily PlanIt PIM ($59.95 on CD-ROM or $49.95 on floppy disk) can run under Windows or on the Macintosh. Each edition revolves around a theme: PlanIt Earth has an environmental theme, PlanIt Paradise is a swimsuit edition, and PlanIt Adrenaline features high-intensity pursuits. With each of the titles, you can import and mix and match your own Kodak Photo CD images. Integrated voice annotation and voice recognition let you annotate your to-do lists and appointments with verbal comments. The Media Vision (Fremont, CA) PIM includes an appointment scheduler and alarms that interrupt other programs. You can link contacts and locations with scheduled events and track contact activity with a notes log for everyone in the directory.

Phone: (510) 770-8600.

Circle 1284 on Inquiry Card.

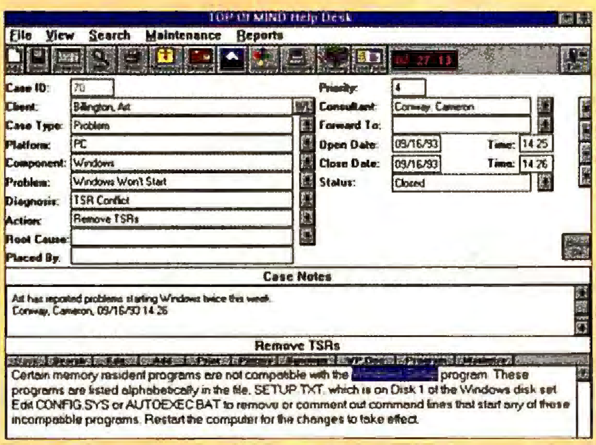
IMPROVE PICTURE QUALITY

By presenting a slide show of screen images similar to test patterns used by TV stations, DisplayMate for Windows ($79) gives you the means to improve monitor-picture quality. From Sonera Technologies (Rumson, NJ), the slide show presents ways to improve sharpness and contrast, reduce some forms of geometric distortion, minimize or eliminate moiré patterns, and improve color and gray-scale accuracy. Test patterns let you evaluate and explore color quality, balance, range, accuracy, and color matching.

Phone: (800) 932-6323 or (908) 747-6886.

Circle 1282 on Inquiry Card.

COGNITIVE SOFTWARE LEARNS FROM EXPERIENCE



Based on cognitive processing, the Top of Mind Help Desk for Windows incorporates principles of fuzzy logic, neural networks, case-based reasoning, expert systems, and text association. Top of Mind's ongoing learned experience forms the basis for its smart pick lists—case information and diagnostics listed by strength. The software forms its own links and associations and processes information the way people do. Faced with a problem, the software provides an answer based on this learned experience, while it gathers and stores precise data about the user's needs in continual expansion of the database for use in solving future problems. From $4500.

Contact: The Molloy Group, Parsippany, NJ, (201) 884-2040.

Circle 1272 on Inquiry Card.

PUT A CLOAK ON YOUR TSR

Developed for Netroom 3.0, Helix Software's (Long Island City, NY) Cloaking technology is now available as the Cloaking Developer's Toolkit ($299) for designing "Cloaked" utilities for memory managers such as DOS, DR DOS, QEMM, and 386Max. Cloaking allows device drivers and TSRs to run in protected mode without using conventional memory.

Phone: (718) 392-3100.

Circle 1278 on Inquiry Card.

DESIGN APPLICATIONS IN ADA

A GUI application designer and Ada GUI source code generator for Windows, Visual Ada for Windows ($595) lets you choose from push buttons, bit maps, text-entry fields, combo boxes, static text fields, radio buttons, and scroll bars to create and modify GUI applications. The Aetech (Carlsbad, CA) code uses the company's Standard Ada Human Computer Interface Library, which consists of an Ada library of data structures and subprograms that work identically on systems that use a standard GUI, such as Motif, Open Look, and Windows.

Phone: (619) 431-7714.

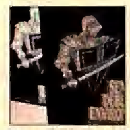
Circle 1283 on Inquiry Card.

Software Update

4PC-Doctor 1.2, WaterGate Software (Emeryville, CA), adds external cache testing, tape drive information, SIMM stress testing, modem setup information, PostScript printer testing, disk-usage information by file type and directory, BIOS data area information, and more. $129.95.

Phone: (510) 596-1770.

Circle 1296 on Inquiry Card.



Sentinel 2.0, AIB Software (Dulles, VA), is fully integrated with Hewlett-Packard's SoftBench development environment and adds a new GUI. From $595.

Phone: (703) 430-9247.

Circle 1301 on Inquiry Card.

MapExpert 2.0, DeLorme Mapping (Freeport, ME), is a completely revised and expanded database of every city, town, and rural area in the U.S., including urban areas, population centers, and elevation lines. $495.

Phone: (207) 865-1234.

Circle 1297 on Inquiry Card.

GX Graphics 3.0, Genus Microprogramming (Houston, TX), features direct support of Super VGA chip sets, high-color and true-color video modes, increased VESA support, mode X resolution support, multiple Super VGA pages, faster drawing primitives, 16-bit protected-mode support, and more. $249.

Phone: (713) 870-0737.

Circle 1298 on Inquiry Card.

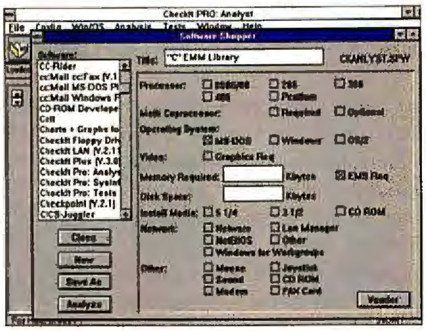
NovaLink Professional 3.1, ResNova Software (Huntington Beach, CA), provides support for Apple Open Collaborative Environment, Novell, UUCP, and FidoNet; multiple file attachments; and enhanced graphics and sound. From $300.

Phone: (714) 379-9000.

Circle 1299 on Inquiry Card.

What's New Software

DIAGNOSTIC UTILITY HAS ANSWERS ▶



Designed specifically for Microsoft Windows, CheckIt Pro: Analyst ($149.95), from TouchStone (Huntington Beach, CA), is a diagnostic utility that provides a comprehensive system analysis. The CKData applet collects all system information needed to troubleshoot your system; you can save the CKData-created data file across the network for interpretation by the utility. The Upgrade Analyst module lets you rate your computer's performance against that of others, compare systems to find configuration differences, analyze system setup, and access a software-compatibility library.
Phone: (714) 969-7746.
Circle 1289 on Inquiry Card.

VIRUS DETECTIVE

A 3-D proactive antivirus program, Virus Detection System Pro 3.0 (from $49) from Z-RAM (Annapolis, MD) combines scanning, integrity verification, and decoy launching to identify and eradicate viruses. The network-compatible program has a detailed set of instructions for system administrators to customize features to fit a particular situation. VDS Pro includes generic cleaning and positive overwrite.
Phone: (410) 266-5221.
Circle 1293 on Inquiry Card.

ADD YOUR VOICE TO VISUAL BASIC

The Visual Voice ($495) custom control and toolkit for Visual Basic and C++ developers lets you build PC-based voice-processing applications such as voice mail, interactive voice response, and fax on demand. From Stylus Innovation (Cambridge, MA), Visual Voice makes the PC the server and the phone the client. Set up to support the Microsoft/Intel Telephone Application Programming Interface, Visual Voice includes a set of visual tools that help you create and revise all voice-processing objects such as voice prompts, menus, and files.
Phone: (617) 621-9545.
Circle 1287 on Inquiry Card.

DOCUMENT IMAGING FOR THE PC

Westbrook Technologies' (Westbrook, CT) PC-based document-imaging File Magic Vision ($199) software supports 200 file formats, including color photos, video, and slides. The OCR software directly integrates documents from scanners and fax cards. Imported images can be from photographs, video-capture boards, film scanners, slides, and transparencies. An advanced viewing feature lets you display, index, retrieve, and store computer-generated, scanned, or faxed text-and-image documents in a single File Magic database.
Phone: (203) 399-7111.
Circle 1280 on Inquiry Card.

INTEGRATION AND LINKING FOR UNIX

Applixware applications and tools provide Unix LAN and WAN information-sharing as well as personal office functions. Based on an information object architecture, Applixware can integrate with external applications to build applications that you define.

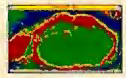
Office applications include Applix Words and Applix Graphics ($695) and Applix Spreadsheets ($495). Applix Data ($995 per seat) lets you access information on Informix, Oracle, Ingres, and Sybase relational databases without any SQL knowledge. Applix Mail ($195) and Applix Open Mail ($295) let you exchange and edit multimedia compound documents, messages, and data files directly from source applications or the Applix Mail facility. You can communicate across disparate hardware platforms, operating systems, and networks.

Contact: Applix, Westborough, MA, (508) 870-0300.
Circle 1273 on Inquiry Card.

Software Update

FAServer 1.1, Network Appliance (Santa Clara, CA), supports FDDI, has increased disk storage (to 27.3 GB), rebuilds replaced RAID disks on-line, and adds a Unix-compatible rdump command for network backup. $16,995.
Phone: (408) 562-1900.
Circle 1300 on Inquiry Card.

Global Lab Image 3.0, Data Translation (Marlborough, MA), supports Add-In Modules, adds image-analysis features, and provides additional particle measurements, enhanced particle counting, new filters, and new frame-grabber support.



Phone: (508) 481-3700.
Circle 1311 on Inquiry Card.

The Norton AntiVirus 3.0, Symantec (Cupertino, CA), can identify and resist known and unknown viruses, incorporates Virus Sensor technology, detects 100 percent of the NCSA libraries, and optimizes the virus scanner and user interface. $129.
Phone: (408) 252-3570.
Circle 1303 on Inquiry Card.

TapeWare/LAN-NLM 4.2, Emeritus Technologies (Fresno, CA), adds full NetWare 4.x Directory Service backup support and Cruise Control for automated backup tape rotation. From $299.
Phone: (209) 292-8888.
Circle 1304 on Inquiry Card.

OS-9 3.0, Microware (Des Moines, IA), adds a preemptible kernel and enhancements such as faster interrupt response and context switching, more efficient interprocess communications mechanisms, improved determinism, enhanced memory management facilities, and greater system-call throughput. From $4000.
Phone: (515) 224-1929.
Circle 1307 on Inquiry Card.

SOLUTIONS

Access Technologies for People Who Are Blind

Olga Espinola and Diane Croft

". . . first-class and strongly recommended. . . . This is the book to keep on the desk always within reach for study and reference . . . ."

—Jeffrey Moyer, access consultant
Journal of Visual Impairment & Blindness

Solutions takes a hard look at adaptive technology through the actual experiences of blind people who use it on the job every day. There is something for everyone—the solo computer novice, the mid-level user, or the "expert" wanting an overview or refresher course.

There are interviews, resources galore, training programs, financial-aid assistance, and much more, including a complete product price list, and current information on every type of adaptive device. No more searching for bits and pieces of information; now it's all in one book.

". . . a whale of a good book. . . edifying, clear, inspiring, and lots of fun to read. My students are in for a great adventure."

— Ted Lennox, access instructor
Eastern Michigan University

". . . you don't need to know much about technology or computers to use this book; it explains everything."

— BOOKLIST, American Library Association

". . . excels in its ability to couple the technical and the practical sides of adaptive issues. . . ."

— National Association of Private
Rehabilitation Professionals

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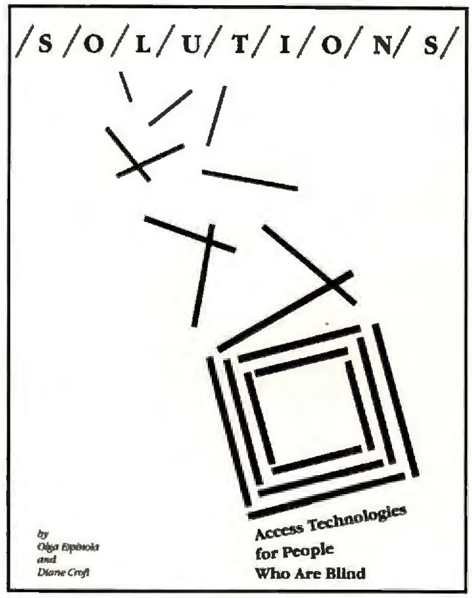
—Jeri Williams, blind computer user



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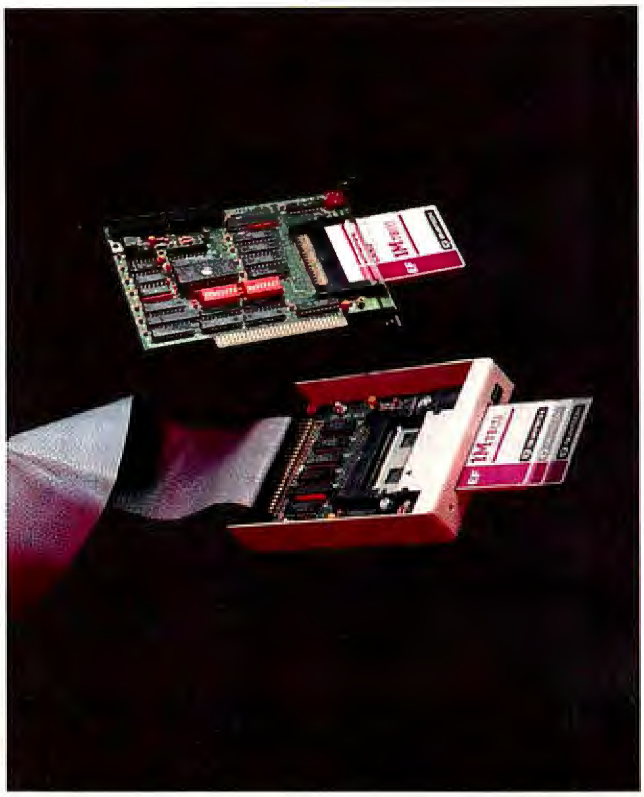

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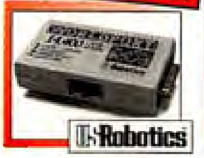

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Cupid Memory Board	0-32Meg	500818-001		169.00

ZENITH MEMORY MODULES

MODEL	AMT. UPGRADED	AST PART #	PRICE
Z386/33, 25, 20, 33E	1Meg	ZA3800ME	59.00
Z386/33, 25, 20, 33E, 486/25E	4Meg	ZA3800MK	195.00
Z386SX	2Meg	Z-605-1 modules	119.00

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286/386SX-16, 386SX-20, 486SX-20 & 386-33 *all are 72PIN SIMM:*
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0-32Meg, Ext.-Expnd. Memory Bd. for P/S2 70, 80, 90, Lim 4.0

0Meg	2Meg	4Meg	8Meg	16Meg	32Meg	64Meg
$179.00	$268.00	$374.00	$569.00	$959.00	$1935.00	$3255.00

PS/2 MCA 0-8MEG EXPANSION BD.

0-8Meg Extended and/or Expanded Memory for all IBM P/S2 Models 50, 50Z, 60, 55SX, 65SX, 16 Bit, 4.0 LIM Compat.
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IBM PS/2 SIMM MODULES

IBM PART NO.	WORKS WITH MODEL NO.	PRICE
30F5348 (512K)	30-286	37.00
30F5360 (2Meg)	30-286, 25-286, 50 MTHR BD.	124.00
6450375 (1Meg)	80-041	79.00
6450379 (2Meg)	80-111, 311-121, 321, 081, 161	89.00
6451060 (4Meg)	80-A21, A-61, 80-A31, 80-111, 80-311	189.00
6450604 (2Meg)	70-061, E61, 121, 50Z, 55SX, 65SX, P-70, 55LS, 65LS, X-Station 120 & 130, 35SX, 35LS, 40SX	89.00
6450608 (2Meg)	70-A21, A-61, B-21, B-61, 35SX, 35LS, 40SX, Val Pt. 325T	80.00
78X8955 (128K)	25	35.00
34F2933 (4Meg)	35SX, 40SX, 55SX, 65SX, 55LS, 65LS	199.00
87F9977 (4Meg)	55SX, 55LS, 65SX, 40SX, 35SX, 35LS	199.00
1057035 (512K)	P/S1-286	49.00
92F9935 (2Meg)	P/S1 & P/S1/386SX-2121	109.00
92F9694 (4Meg)	P/S1 & P/S1/386SX, Mode-2121	209.00
6450902 (2Meg)	56, 57, 57SX, 90, 95, P-75, 57SLC Value Point 77 486DX2, 486SX, SVR 85	95.00
6450128 (4Meg)	57SX, 90, 95, P-75, 57SLC, 56, 56SLC, P/S1, 386SX, Mod-2123, 2133, 2155, Val Pt 77, 486CS2, 486SX, SVR85 Value Point 77 486DX2, 486SX, SVR 85	209.00
6450129 (8Meg)	35SX, 40SX	419.00
6450130 (8Meg)	56, 57, 57SX, 90, 95, P-75, 57SLC Value Point 77 486DX2, 486SX, SVR 85	439.00
79F0999 (2Meg)	LX40, N33SX, PS Note	114.00
79F1000 (4Meg)	LX40, N33SX, PS Note, Thinkpad 350, 350c	209.00
79F1001 (8Meg)	LX40, N33SX, PS Note	399.00
07G1826 (2Meg)	N51 (all)	109.00
07G1827 (4Meg)	N51 (all)	219.00
07G1828 (8Meg)	N51 (all)	449.00
07G1414 (2Meg)	Thinkpad 750, 750c	129.00
07G1415 (4Meg)	Thinkpad 750, 750c	239.00
07G1416 (8Meg)	Thinkpad 750, 750c	449.00
66G0094 (16Meg)	Thinkpad 750, 750c	1029.00
07G1420 (4Meg)	CL57LSX LpTp, Thinkpad 700, 700C, 720, 720C	249.00
07G1421 (8Meg)	CL57LSX LpTp, Thinkpad 700, 700C, 720, 720C	449.00
60G0378 (8Meg)	Thinkpad 350, 350c	285.00
60G0379 (16Meg)	Thinkpad 350, 350c	769.00
92F8804 (2Meg)	N45SL	119.00

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MODEL	AMT. UPGRADED	CMPQ PART #	PRICE
DeskPro 386/33, 386/33L,	2Meg Module	115144-001	109.00
486/25, 486/33L,	8Meg Module	116561-001	459.00
486/50L, System Pro	32Meg Module	116568-001	1499.00
DeskPro 386/33L, 486/33L	(Exp Bd)	116569-001	279.00
DeskPro 386/25, 386/20	1Meg Module	113131-001	79.00
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	4Meg Exp Bd	113634-001	329.00
	1Meg Module	113646-001	79.00
	4Meg Module	112534-001	219.00
DeskPro 386/20E	1Meg Exp Bd	113644-001	149.00
DeskPro 386/25E	4Meg Exp Bd	113645-001	329.00
	1Meg Module	113131-001	79.00
	4Meg Module	113132-001	229.00
DeskPro 286N, 386N,	1Meg Module	118688-001	59.00
386SX/20, 386/25M, 486/33M,	2Meg Module	118689-001	89.00
486S/25M, 486S/16M	4Meg Module	118690-001	195.00
Port. 486C	8Meg Module	128877-001	429.00
M Series Exp Bd	0-64Meg	129160-001	279.00
DeskPro 386/16	1Meg Kit	108071-001	99.00
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T2000/T2000SX	2Meg	PC18-PA8317U	94.00
T2000SX/T1000LE	4Meg	PC-PA8314U	199.00
T2000SX/T1000LE	8Meg	PC14-PA8315U	369.00
T2000SXE/2200SX/T1800, 1850, C	2Meg	PC-PA2000U	94.00
T2000SXE/2200SX/T1800, 1850, C	4Meg	PC-PA2001U	199.00
T2000SXE/2200SX/T1800, 1850, C	8Meg	PC-PA2002U	369.00
T4400SX, SXC T6400	4Meg	PC-PA2004U	231.00
T4400SX, SXC T6400	8Meg	PC-PA2005U	463.00
T4400SX, SXC T6400	16Meg	PC-PA2010U	729.00
T4500, T4500C, T4600, T1900, T1900C (3.3 v)	4Meg	PC-PA2012U	249.00
T4500, T4500C, T4600, T1900, T1900C (3.3 v)	8Meg	PC-PA2013U	489.00
T4500, T4500C, T4600, T1900, T1900C (3.3 v)	16Meg	PC-PA2014U	1349.00
T3300SL	4Meg	PC-PA2007U	234.00
T3300SL	6Meg	PC-PA2008U	349.00
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T3100e	2Meg	PC9-PA8340U	129.00
T3100SX	2Meg	PC15-PA8308U	104.00
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MODEL	AMT. UPGRADED	MANU. PART #	PRICE
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AST Notebook Prem Exec 386SX/20/25/25L	4Meg	500814-003	199.00
AST Power Exec 3/25C, 425EL	4Meg		209.00
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AST Power Exec 425SL	4Meg	501166-001	239.00
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Epson NB3	4Meg	A808511	209.00
Everex Tempo LX, LX20	2Meg	PCA 00053-0001	109.00
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Magnavox Metalis	1Meg, 4Meg	286, 386SX	119.00 219.00
NEC Prospeed 286, 386SX-16	1Meg	PC21-21	79.00
NEC Prospeed 286, 386SX-16	4Meg	PC21-22	209.00
NEC Prospeed 386	2Meg	PC31-21	119.00
NEC Prospeed 386	8Meg	PC31-22	399.00
NEC Prospeed 386SX-20	1Meg	PC43-21	79.00
NEC Prospeed 386SX-20	4Meg	PC43-22	219.00
NEC Ultralite III/20, 20P, 25C	2Meg	PC47-21	119.00
NEC Ultralite III/SL/25C	4Meg	PC47-22	219.00
NEC Ultralite SL/20, 20P	6Meg	PC49-21	319.00
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NEC Ultralite Versa	4 Meg/8Meg/16Meg	OP4104	249/489/899
Packard Bell 386SX, 286	1Meg, 4Meg	286, 386SX	109.00,209.00
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TI Travelmate 3000	2Meg	2568996-1	84.00
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Epson Action Laser II	–	–	89	–	Call	–	–	Call	–	–	–	–
Epson 8000	–	–	89	–	Call	–	–	Call	–	–	–	–
Epson 1000, 1500	–	–	–	Call	–	–	Call	–	Call	–	–	–
HP 2, 2D–	–	–	–	119	–	–	199	–	–	–	–	–
HP 3, 3D, 3P, 2P 2P+	–	–	–	109	–	–	189	–	–	–	–	–
HP 4, 4M, 4SI, 4SIMX	–	–	–	89	–	–	195	–	–	399	–	–
HP 4L	–	–	59	–	–	–	–	–	–	–	–	–
HP 3SI	–	–	69	–	–	–	199	–	–	399	–	–
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HP Deskjet 500, 500C, 550	–	59	–	–	–	–	–	–	–	–	–	–
HP Deskjet 1200C, 1200C/P	–	–	–	89	–	–	199	–	–	399	–	–
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IBM Laser 4019, 4019E	–				–	160					–	
IBM Laser 4029	–	–	–	–	–	–	199	–	–	–	–	–
IBM Laser 4039, 4079	–	–	–	99	–	–	199	–	–	389	–	–
NEC 90, 290	–	–	–	139	–	–	–	–	–	–	–	–
NEC 95	–	–	–	99	–	–	–	–	–	–	–	–
Oki 400	–	–	–	95	–	–	–	–	–	–	–	–
Oki 400 E	–	–	135	189	–	–	–	–	–	–	–	–
Oki 830, 840	–	–	–	109	–	–	–	–	–	–	–	–
Packard Bell PB 9500	–	–	–	124	–	–	209	–	–	–	–	–
Panasonic 4420/4450i	–	–	–	129	–	–	209	–	–	–	–	–
Panasonic 4410/4430	–	–	–	126	–	–	195	–	–	–	–	–
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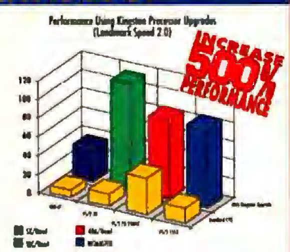

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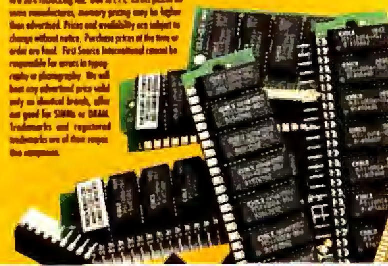

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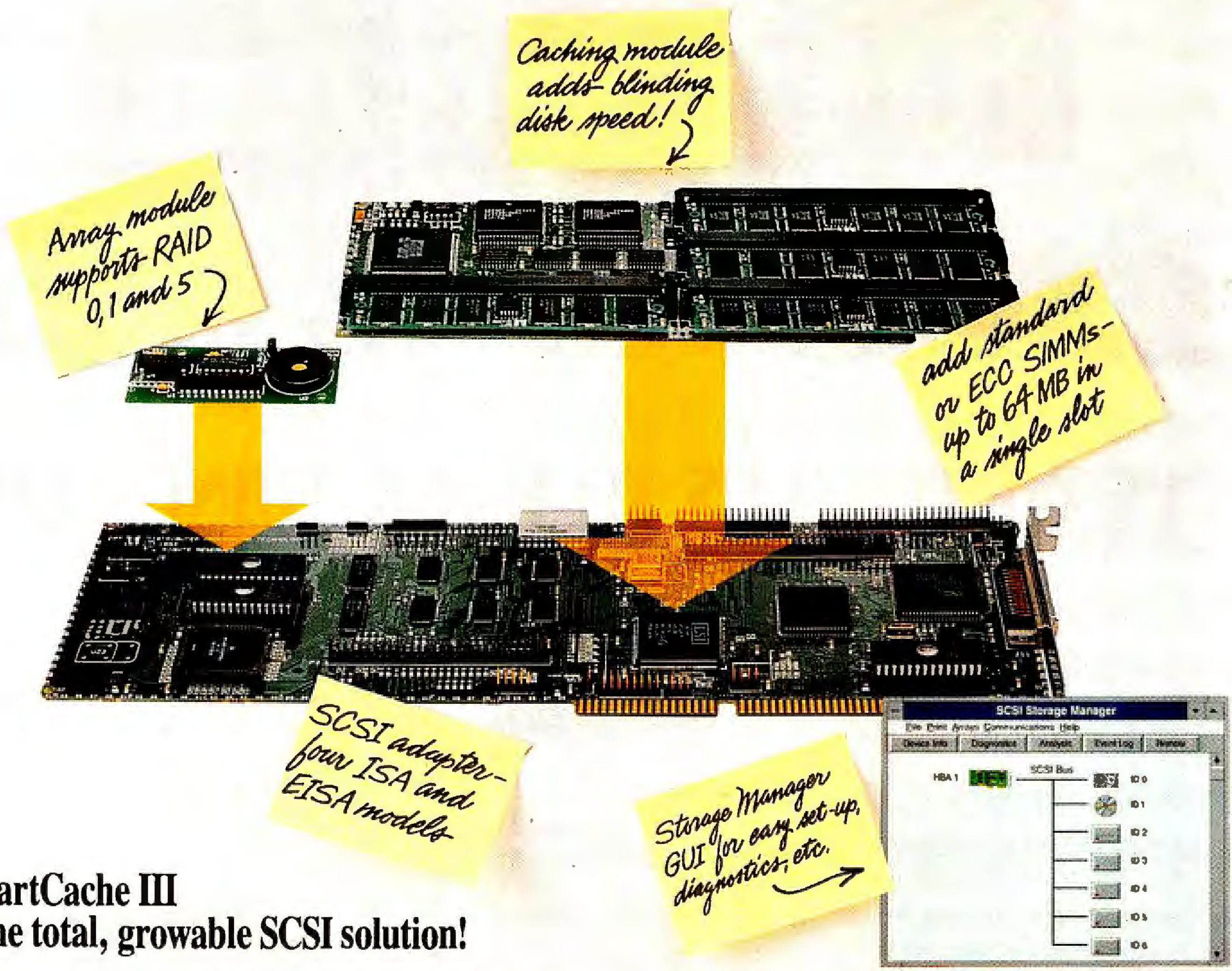

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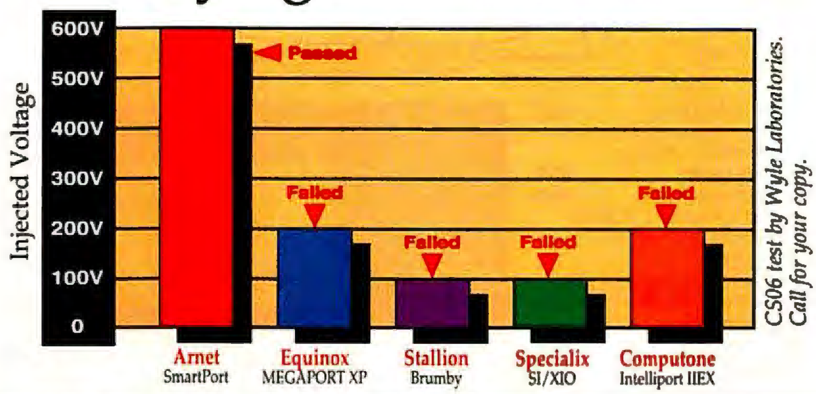

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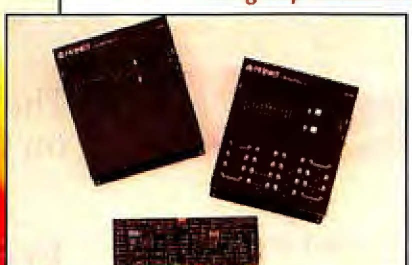

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Build large systems that can support remote users with ClusterPort. A host adapter card with two high-speed synchronous links connects to multiple 16-port Cluster Boxes or to modems for remote locations. Remote users can be connected without using costly multiplexers.

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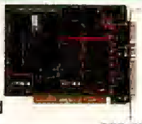

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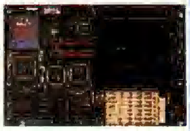

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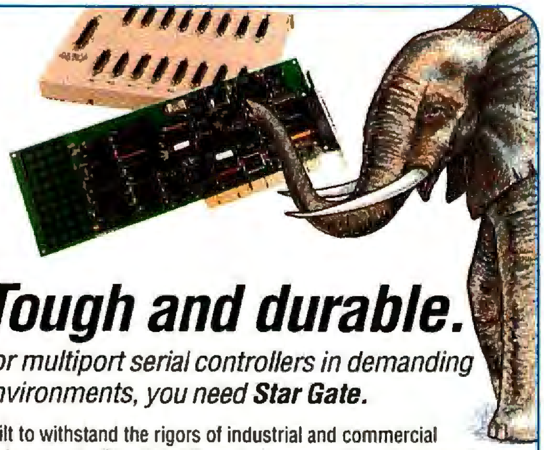

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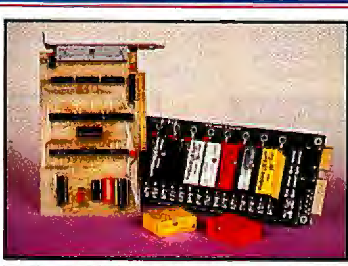

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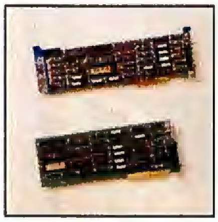

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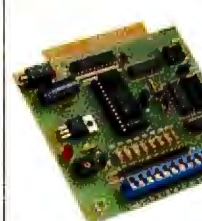

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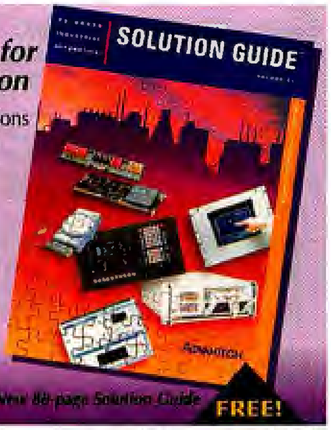

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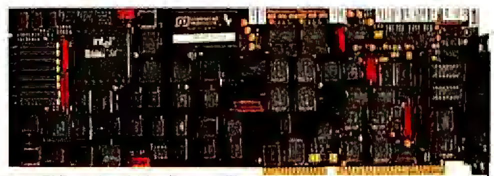

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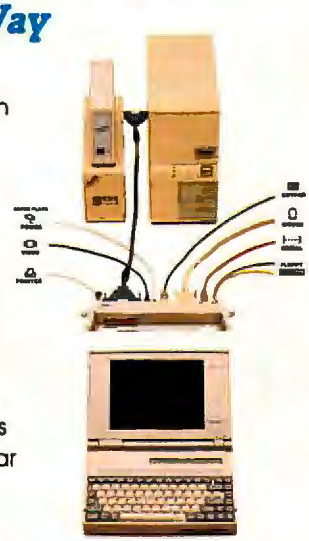

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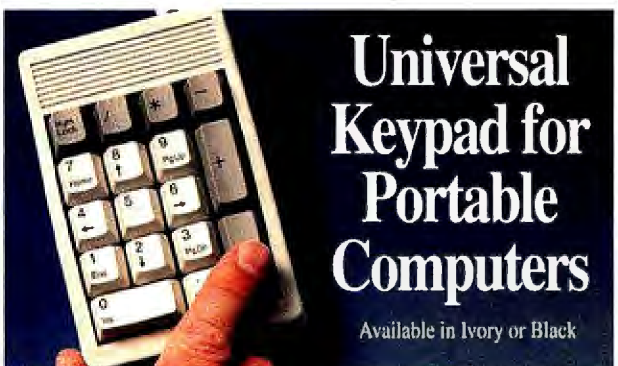

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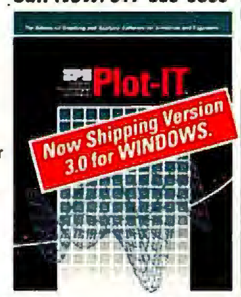

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Commentary **Thornton A. May**

Shakespearean Wisdom

There are many similarities between Richard III and an MIS director

Few information technologists remember Cole Porter's admonition in *Kiss Me Kate* to "brush up your Shakespeare." Fewer still took action on the prolific composer's suggestion. But many contemporary computer technologists share many characteristics with that most infamous of all Shakespeare's characters—Richard III, at least as he appeared in the early pre-tragic parts of the eponymous play.

Professional thespians agree that there is no more sought after and yet no more difficult part to play than Richard III. Indeed, Richard Burbage, the actor who first played Richard III for Shakespeare (ca. 1593–1594), was heard to tell the playwright after opening night, "If you ever do this to me again, I'll kill you."

In a similar vein, the difficulties facing an MIS executive as he or she enacts the role of authoritative technologist in an organization require an ability to:

- Understand how the technology works
- Understand business problems
- Move seamlessly and rapidly between multiple platforms
- Address business problems with technology solutions
- Innovate and manipulate the evolving technological environment
- Prepare the organization for "what's next" technologically

Richard III (unlike all the other Shakespearean tragedies) omits a major fourth act break. To play Richard requires almost supernatural strength, skill, and endurance. An information technologist is also asked to play a bigger-than-life role in his or her organization.

Like Richard, many technologists have turned their uniqueness into a source of power. As organizations emerge from the planning stages of the investment programs that will revitalize their in-place technology infrastructures, the move is away from "stuff you buy cheap" to "stuff you buy smart." The technologist plays a crucial role in the increasingly important "knowledge space," where money and technology combine to create business value.

In *Richard III*, the action revolves almost totally around the title character. In a similar fashion, the decisions to acquire and implement technology revolve around the technologist. The technologist, as the central actor operating in the knowledge space, is responsible for identifying, verifying, and specifying how technology budgets will be allocated. There is now a great deal of activity in the knowledge space around reengineering work processes, retraining the user, and, most important, getting the technology to work as promised. Shakespeare may have written, "The play is the thing." An appropriate information age paraphrase might be, "The technology is the thing."

While Richard and contemporary technologists share many behavior traits, it is important to realize that dissimilarities do exist. For one thing, Richard is a great actor. Technologists tend to be less theatrical in nature, less able to make protean shifts in behavior at a moment's notice. They also tend to be truthful and fact-based—nothing is further from the truth for Richard.

Another dissimilarity is that Richard is malevolent. Information technologists, for the most part, are not. If they have a flaw, it is that they are too self-effacing and too honest to play the political games that constitute such a lamentably large part of today's employment picture.

A key dissimilarity is that Richard is monodimensional. He has one and only one focus: He wants to be king. When he achieves that objective, he loses momentum and initiative. Instead of being the high-energy, bustling protagonist of the play's early acts, he becomes a sedentary responder to initiatives put in play by others. He fears the future.

The contemporary technologist does not stop just with identifying or specifying a technology to buy. He or she maintains responsibility through implementation, maintenance, and return on investment. The technologist not only looks forward to the future but also plays an active role in shaping that future.

Richard manages to alienate (and in many cases execute) all those around him. Quite conversely, successful technologists draw people to them—not so much by the power of personality as by the power of thinking. ■

Thornton A. May is director of research for Tenex Consulting, a Burlington, Massachusetts–based management consulting firm. You can contact him on BIX c/o "editors."

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