57 HIGH-POWERED SYSTEMS REVIEWED

BYTE

APRIL 1994

Pournelle's Product Awards

Object-Oriented Databases Come of Age

A Nifty Multiprotocol Print Server for Ethernet LANs

THE MAGAZINE OF TECHNOLOGY INTEGRATION

First PowerPCs

Apple's Power Macintosh and IBM's Power Personal Systems

EXCLUSIVE

IBM's PowerPC product plans, plus Power Mac vs. Pentium benchmark results

SPECIAL REPORT

CPU Wars: Should you move from CISC to RISC?

PLUS

Intel pushes the 80x86 envelope

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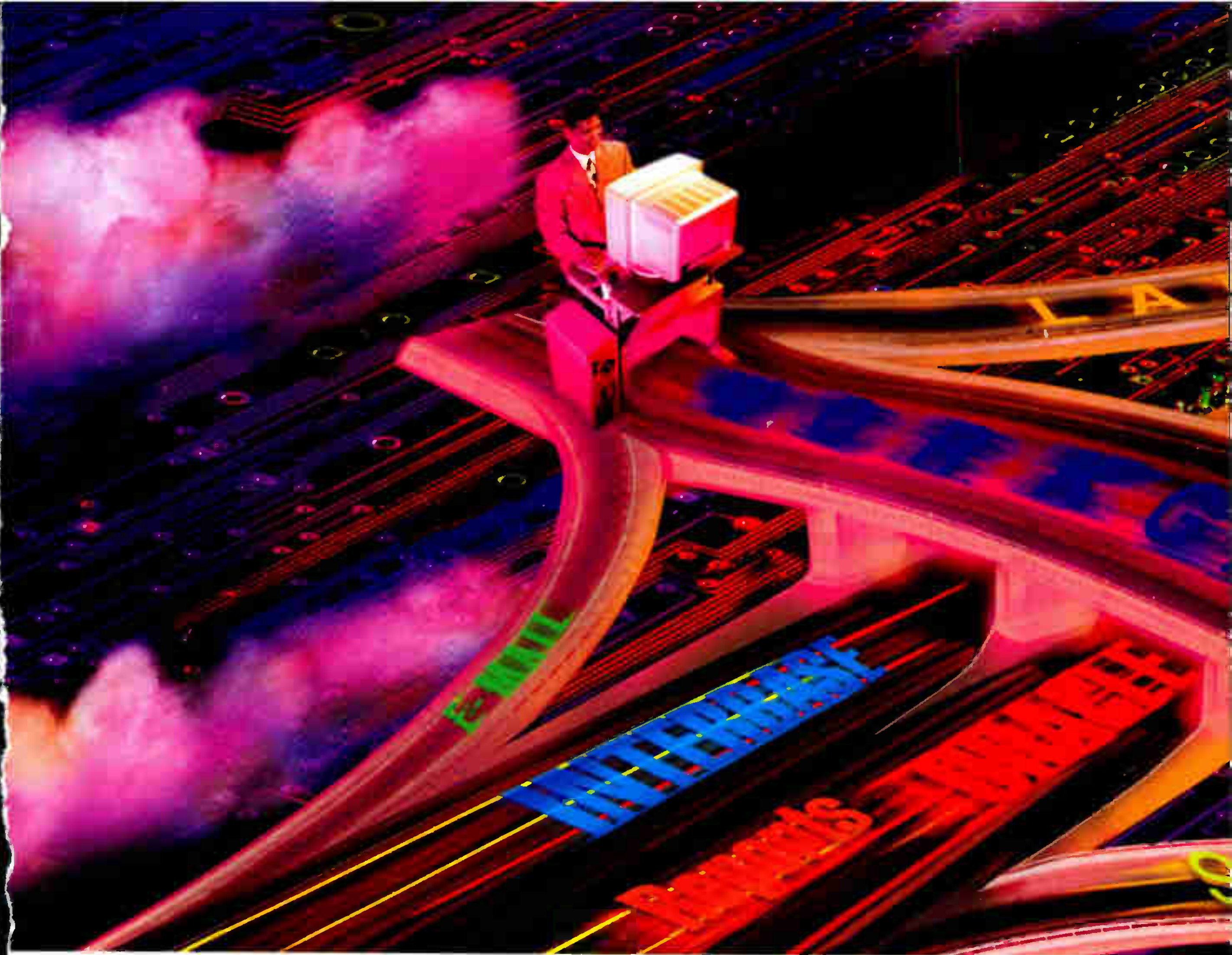

Best Windows database for all skill levels

Of course, Paradox wouldn't be complete without the powerful and easy-to-use features that have made it the #1-rated relational database. Built-in productivity Experts™ guide you at every step, from linking information in tables to building forms and reports. Object Inspector™ menus provide instant access to capabilities without searching through layers of menus.

And Paradox's ease stays with you as you move up the power curve. Even corporate developers find that ObjectPAL,™ the fully integrated programming language, lets you create custom Windows applications that are powerful, graphical, and deliverable *fast*. Plus, 100% compatibility with Paradox DOS means your existing Paradox data will migrate automatically to your new Windows applications.

So when it comes to workgroup database productivity, nothing will get you where you want to go faster or more easily than the new Paradox Workgroup Edition from Borland.

Welcome to life in the fast lane.

Limited-time offer!

$495 *Suggested retail price for new users.*

$149.95 *Upgrade price for Paradox, FoxPro, Access, Superbase, and Approach users. $20 rebate for Paradox DOS or Windows owners.*

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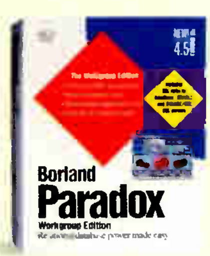


What good is information if you can't get to it. . . or if it can't get to you?

THE #1 WINDOWS DATABASE

New Paradox makes your desk a ramp on the data superhighway

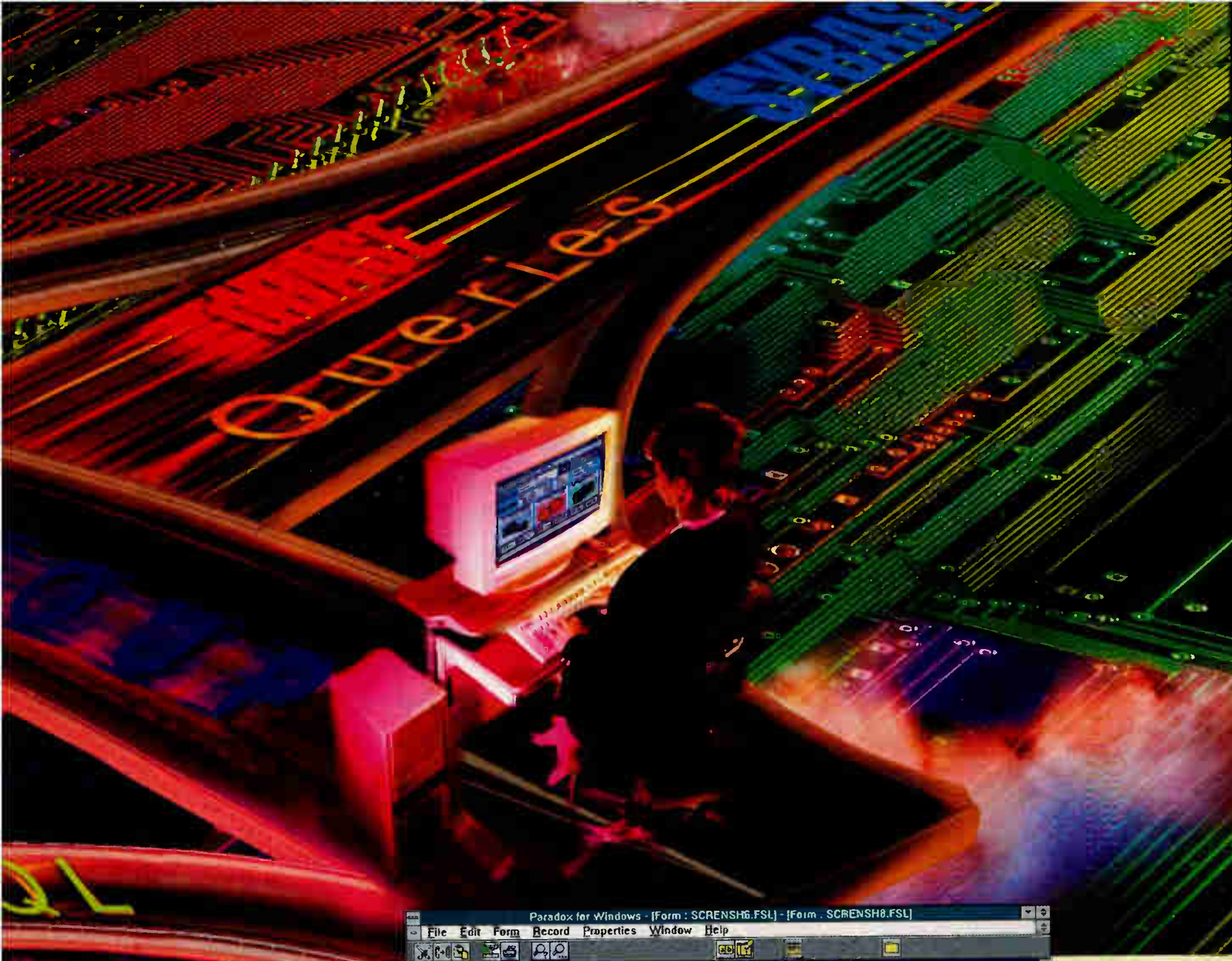
New
version 4.5

There's lots and lots of data out there. The trouble is, it has to go to the right place in order to be productive. That's the reason we developed the new Paradox® Workgroup Edition. The only database with superior SQL connectivity and workgroup information sharing.

Share data easily with any workgroup

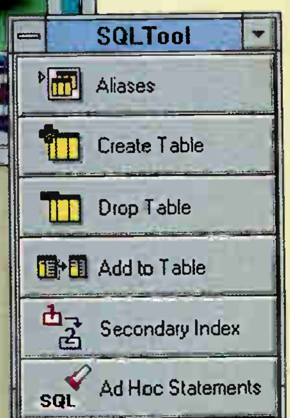
First we built in support for SQL servers, including Borland's InterBase,™ Sybase/Microsoft,® and Oracle, so you can work with information from corporate databases as if it were on your desktop. But we didn't stop there. We added the Workgroup Desktop to distribute the data where it's needed. Now anyone with a Workgroup Edition of Borland Paradox (or Quattro® Pro) can exchange data over local and wide area networks, or via electronic mail.* You can establish and modify workgroups instantaneously to meet the needs of a given project or organizational structure. And there's no need to buy expensive hardware upgrades or learn separate "workgroup" software. *Everything you need is built-in!*

You can share virtually any type of data—Paradox or dBASE® tables with associated indexes, SQL data, OLE or multimedia objects, forms, reports, and queries, and even non-Paradox files such as WordPerfect documents, or entire applications. You simply "publish" the information to your list of workgroup members. Whenever you update a version of the published data, your selected "subscribers" automatically receive the new information. Everyone is more efficient because everyone is working with the same up-to-date information.

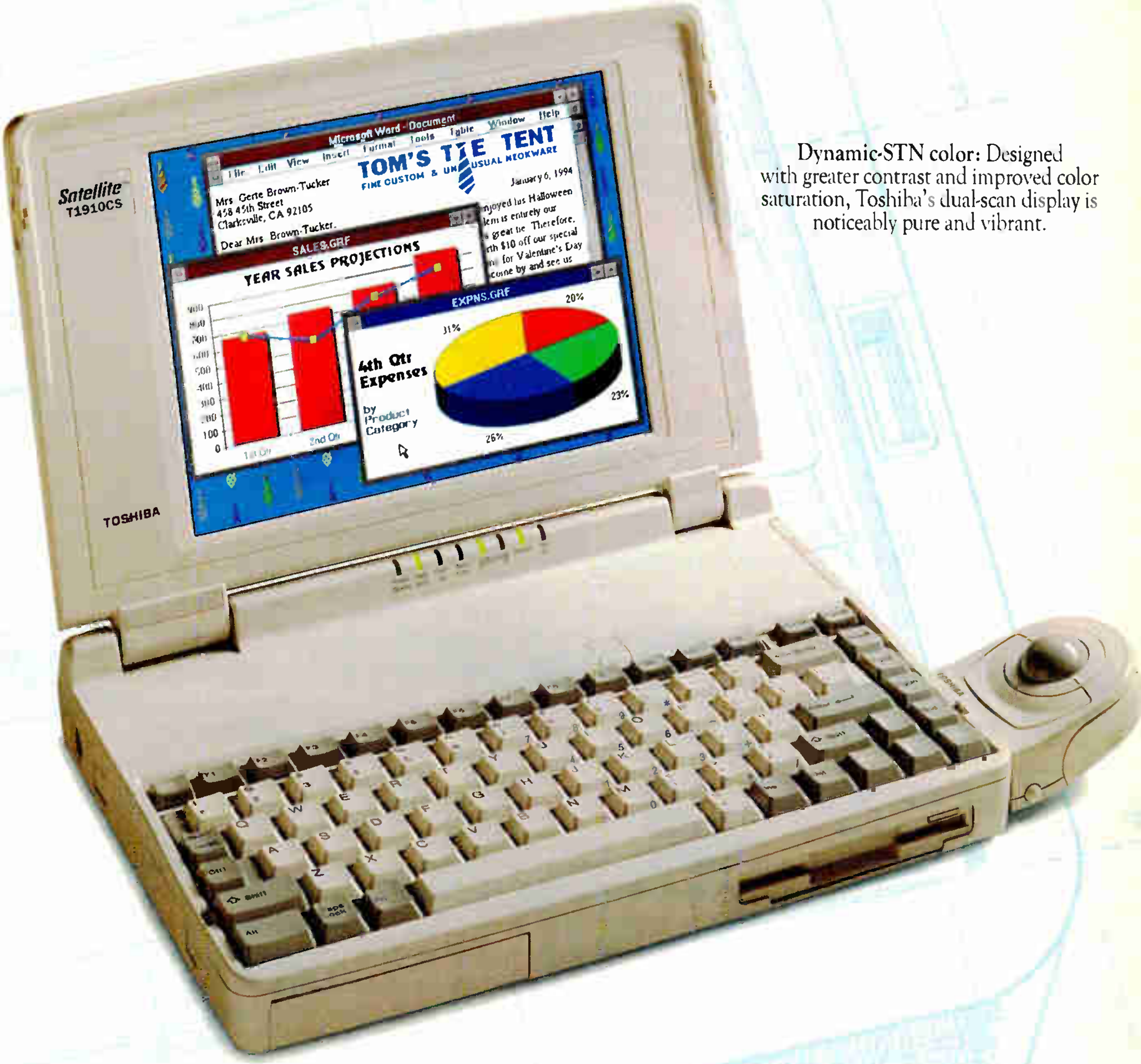


▲ *Keep colleagues up to date quickly, easily. The* ***Workgroup Desktop*** *lets you distribute data over a variety of paths—in a mouse-click.*

▼ ***New! SQL connectivity*** *gives Paradox access to the corporate database.*



▲ *Paradox is the Windows database that lets you work with pushbutton ease—so you get your work done faster.*



Dynamic-STN color: Designed with greater contrast and improved color saturation, Toshiba's dual-scan display is noticeably pure and vibrant.

Rugged Design: Rounded corners and a tough lightweight casing are just a few of the details that make this notebook engineered to last.

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News & Views

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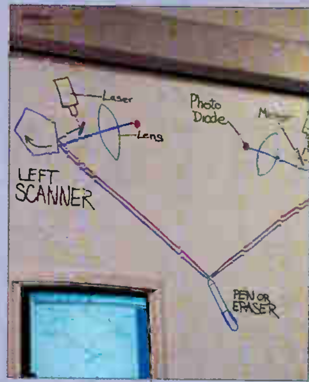
SPECIAL REPORT: THE RISC DECISION

Reviews



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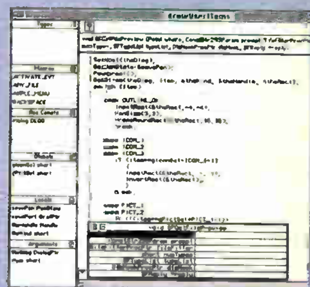
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Opinions

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Hands On

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BYTE

Contents by Platform

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Compaq And Microsoft.
The Connection That's Making
"Plug And Play" A Reality.

Just about everyone who's ever used a computer has experienced the same thought: Wouldn't it be great if setting up or upgrading your machine was as easy as turning it on?

The idea is called "Plug and Play." People have been talking about it for years. But now, an ongoing partnership between Compaq and Microsoft, working with other industry leaders, is actually making it happen.

Plug and Play is the result of some very fresh thinking in both hardware and software – an accomplishment that tapped the combined engineering expertise of both companies. Together, Compaq® computers and the next version of the Microsoft® Windows™ operating system (code-named Chicago) will deliver the long-promised benefits of true Plug and Play: easy setup, easy expansion and easy connection to peripherals.

Which means no more configuration headaches. No more hidden switches, cryptic codes or mystery.

Even today, Compaq is shipping computers that will take full advantage of Plug and Play technology as soon as the forthcoming version of Windows is available. So the Compaq & Windows combination will quickly become the standard for Plug and Play computing. A welcome reassurance for people who buy computers.

COMPAQ Microsoft®

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What About Intel?

The King of CISC needs to come up with an adequate response to the RISC phenomenon

With all the talk about the benefits of RISC microprocessors, you have to wonder about the King of CISC, Intel. The RISC architecture has long promised lower cost and higher performance than the CISC architecture. What CISC has going for it, though, is Intel. Specifically, the Intel 80x86 family of CPUs has been the cornerstone of software compatibility.

But a growing number of analysts—including the editors of this magazine—believe that RISC is the future. Higher performance and lower costs count for a lot in this industry. So does compatibility. However, what if software compatibility weren't an issue? In other words, what if you could buy a system with, say, either a Pentium or a PowerPC and be able to run any Windows applications? That's the question you'll face with Windows NT running in native code on PowerPC systems.

Much of the compatibility question simply evaporates because Windows NT will run on PowerPC systems. The point is, if a system can run Windows, it doesn't matter if it's "Intel Inside"—especially if the RISC-based alternative delivers better performance.

That's the scenario using today's paradigm. Let's look beyond that. Apple is shifting its entire line of computers to incorporate the PowerPC, and as a result, the Apple platforms will take on more of the PReP (PowerPC Reference Platform) attributes. IBM will roll out its Power Personal systems later this year, and they will be extensions of PReP, too. We are also likely to see a good number of so-called clone makers roll out their PowerPC systems based on PReP later this year. Pretty soon, the standard of compatibility will be whether a system is PReP-based—not whether it runs Windows.

That has to be troubling to Intel. After the company has poured buckets of money into promoting "Intel Inside" as an assurance of compatibility, the whole compatibility premise as it has applied to Intel may become moot.

And it's not like Intel has made a lot of loyal PC manufacturing friends over the years, either. In Asia, for example, makers of systems and motherboards are anxiously awaiting an opportunity to end their dependency on Intel. Largely because of Intel's very unpopular chip-allocation policy, Asian PC makers have often found competing difficult because they could not get enough Intel CPUs. An added slap on the face for Asian PC makers was Intel's recent attempt to demand royalties on PCs that used Intel-compatible chips from AMD.

Things may be a little more friendly in the U.S., but the situation is still not good. IBM sells an incredible number of PCs, and IBM is leading the move to the PowerPC. Also, Apple's move to evolve its line into a higher-performance arena will bolster the success of the PowerPC.

These are formidable challenges for Intel. We are on the verge of a mass exodus from the CISC architecture to the RISC architecture. Motorola made the move by getting on the RISC bandwagon with IBM and Apple as part of the PowerPC Consortium. Traditional workstation CPU makers made the commitment to RISC long ago with Alpha, Mips, and SPARC. That leaves Intel and compatible makers Cyrix and AMD as the remaining CISC players. Of those three, shifting gears into RISC will probably be easier for Cyrix and AMD because they have proven themselves to be excellent niche players in the CPU market.

For Intel, on the other hand, it's a different story. Intel has based its CPU business on all the compatibility baggage it has accumulated over the last decade or so. That wasn't the wrong thing to do; we demanded compatibility, and Intel, with the help of Microsoft, supplied it. But that was then, and this is now: The compatibility baggage just weighs too much. To get the performance gains we need in computing, we have to shed some of that chip-level compatibility. Let the operating systems' microkernel take over some of that burden, and let the CPUs run faster.

That means that Intel has to find a way out of its 80x86 debacle. Sure, millions of 80x86 and Pentium systems will still be sold, but more and more of the market—and eventually, nearly all of it—will move to RISC. So far, Intel hasn't given any real hints as to what its response will be. The P54C—and, based on sketchy preliminary reports, the P6—are not an adequate response to the RISC phenomenon. Unless Intel mounts a more meaningful response, the King of CISC might become nothing more than king of the hill after all the other players move to another hill. ■

DENNIS ALLEN, EDITOR IN CHIEF
(dallen@bix.com)

MAKE YOUR WINDOWS 3.1

go faster.

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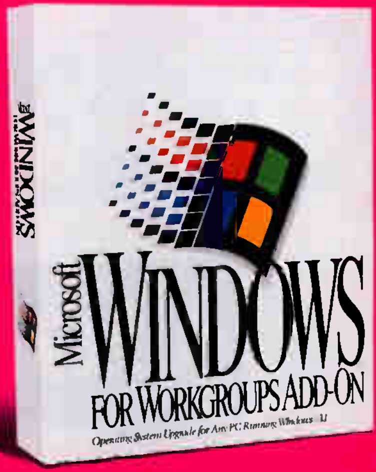

Microsoft® Windows™ for Workgroups 3.11 is fast. Very fast.

In fact it might be more appropriate to call it Microsoft Windows GTI. Because, for local disk access, it's now up to 150% faster than Windows 3.1 operating system. This added speed, powered by 32-bit technology from our "Chicago" project, means applications can be loaded at twice the speed. It also makes searching for files and loading Windows up to 100% faster.*

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Packed with new features like Microsoft At Work™ fax technology and super-fast networking that works with Novell® NetWare®, Windows NT™ and other standards, Windows for Workgroups 3.11 is an essential upgrade for any Windows 3.1 user. But there's only one way to experience this speed and power. Drive it.

Microsoft

*Performance figures may vary depending on configuration. Ziff-Davis WinBench™ speed tests were average performance runs (100 being baseline avg.) based on a Zenith Znote 425 Lnp+Intel 80386-based computer and an 80846-based computer (both uncompressed and compressed disk volumes used) with 4MB RAM, 200MB hard disk 512 cache and IDE disk controller. Test was run using MS-DOS® 6.2. Test not verified by Ziff-Davis. Microsoft and MS-DOS are registered trademarks and Windows, Windows NT and Microsoft At Work are trademarks of Microsoft Corporation. Novell and NetWare are registered trademarks of Novell Corp. In the 50 United States, call (800) 426-9400. Customers in Canada, call (800) 563-9048; outside the 50 United States and Canada, call your local Microsoft subsidiary or (206) 936-8661.

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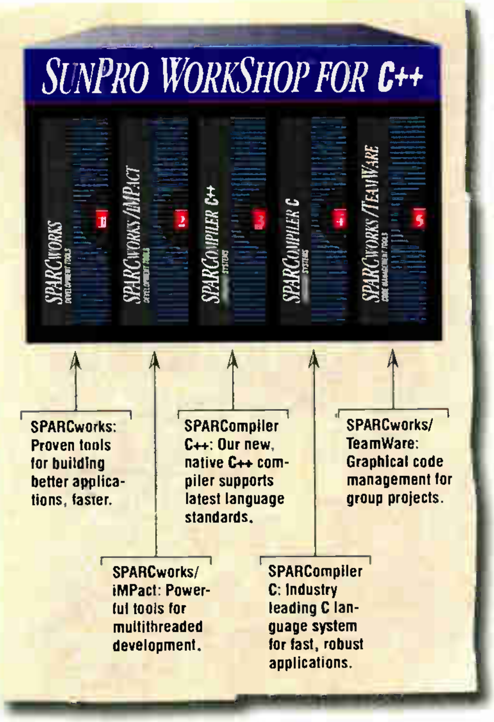

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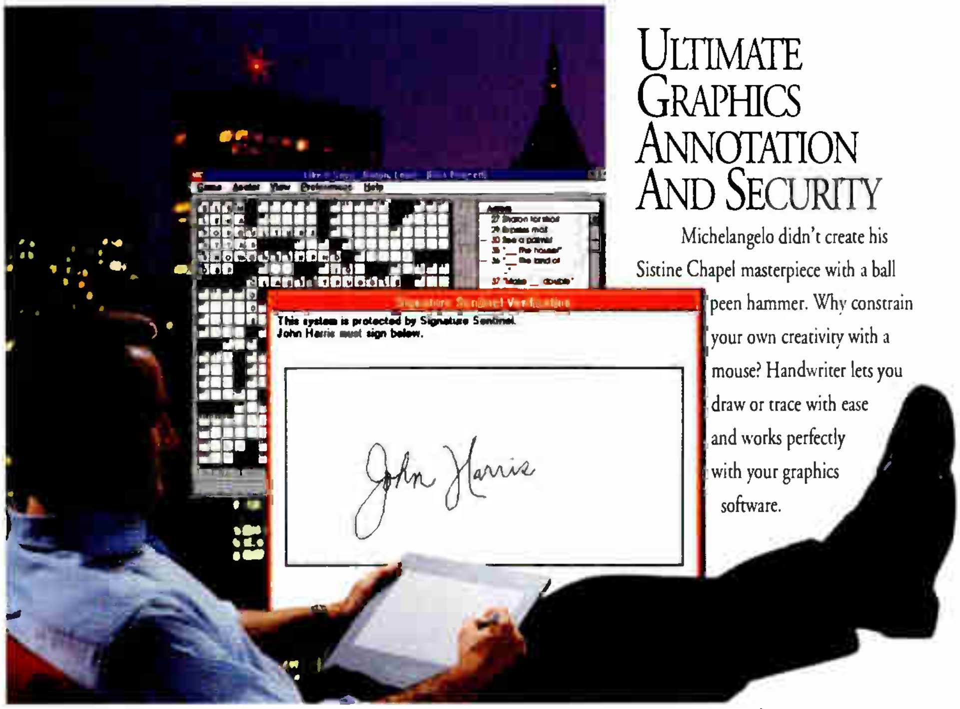
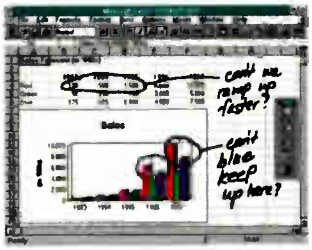


Ultimate Graphics Annotation And Security

Michelangelo didn't create his Sistine Chapel masterpiece with a ball peen hammer. Why constrain your own creativity with a mouse? Handwriter lets you draw or trace with ease and works perfectly with your graphics software.



Shown above is handwritten annotation to a spreadsheet. Each member of a workgroup makes their annotations in uniquely colored ink. A pen is such a perfect complement to your keyboard, you'll probably never use a mouse again — in your whole life.

Ultimate Security: Your Signature

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IBM	Symbol Tech.
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James Coates, Chicago Tribune

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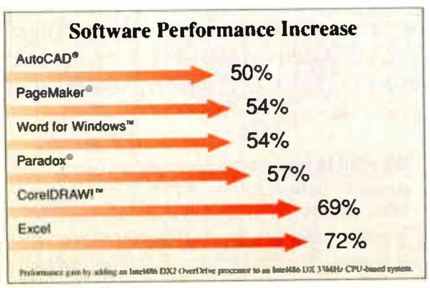

To install the Intel486 DX2 OverDrive processor, you can either plug it into the OverDrive socket or swap it with your original microprocessor, depending on your system design.

To get a better idea of how the OverDrive processor boosts performance of your software, call 1-800-354-3112, Ext. 5719,* for a free demo disk. It could be the greatest show on earth.

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Choosing a True Color Accelerator

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Performance = 64+24

True color (referred to as 24-bit, or 16.7M colors) requires a graphics board to process three to four times more information than it would for 256 colors. Fast 64-bit graphics chips with complete hardware-assist functions for 24-bit acceleration are best suited for fast true color use. Some accelerators offer only 32-bit graphics engines or limited 24-bit color drawing functions. When comparing graphics performance, be sure to ask your vendor for results in true color mode, not just in 256-color mode.

Don't Reboot Windows

Conventional 2MB graphics cards force you to choose between high resolution graphics at 1280x1024 with only 256 colors or true color with only 800x600 resolution. Since you can't have high resolution mode for detailed text work and true color mode for rich photographic colors at the same time, you have to compromise.

To switch modes, conventional boards require you to leave the application and then restart Windows. This process is inconvenient and time consuming. Look for features like ATI's WinSwitch, which allows you to quickly and conveniently toggle between high resolution mode and true color mode using a simple keystroke without closing your applications or leaving Windows.

VRAM Really Matters

Only VRAM memory guarantees stable performance in true color modes because of their dual port design. Most DRAM accelerators may look fast in 256-color mode, but will offer only a fraction of the performance of VRAM accelerators in true color mode. Avoid DRAM memory for serious true color work.

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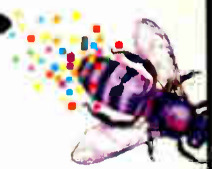
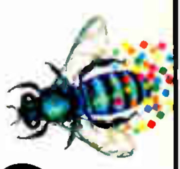
GRAPHICS AND MULTIMEDIA ACCELERATOR • GRAPH

Attack of the Killer Pixels

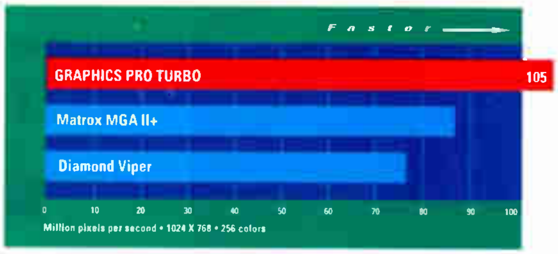




There's millions of them, and they're moving fast to infest every PC with deadly precision and terrifying speed. The hordes of killer pixels from ATI's GRAPHICS PRO TURBO will turn your PC into an amazing hive of graphics activity.

64-Bit Stinger

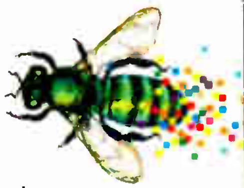
Stirred up by our 64-bit *mach64* accelerator chip, the GRAPHICS PRO TURBO sends your applications swarming across the screen at fantastic velocities – over 100 million Winmarks*. Work faster not harder, even in demanding high resolution, true color applications.



GRAPHICS PRO TURBO outperforms other accelerators.

GRAPHICS PRO TURBO is the ideal card for today's hot PC architectures. With up to 4MB of memory for 1280x1024 graphics in 16.7 million colors, VRAM ensures consistent performance across all display modes. And unlike a lot of other accelerators, the GRAPHICS PRO TURBO is frantically fast not just in Windows, but in DOS and other environments as well.

True Killer Color

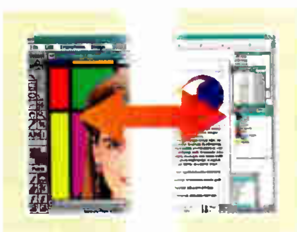


ATI's new strain of pixels is not only fast, it's vibrantly colored as well. GRAPHICS PRO TURBO gives you accelerated 24-bit true color that never stops working, even at resolutions as high as 1280x1024. In fact, it runs in 16.7 million colors as fast as other cards do in just 256. Our exclusive software keeps all that color under control. Color calibration software provides a perfect match for graphic arts applications. Plus

•105+ Million Winmarks†
•1280x1024 in 16.7M colors

Introducing the
GRAPHICS PRO TURBO™

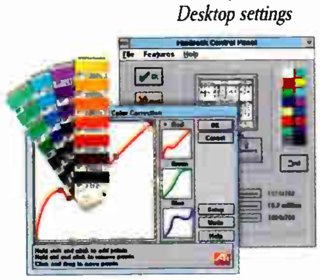
our unique WinSwitch feature lets you change color and resolution modes to suit your application requirements, quickly and conveniently ... without restarting Windows.



True Color + High Resolution
WinSwitch changes color and resolution...without leaving Windows Desktop settings

Wilder Windows

Windows users, get your screens up: GRAPHICS PRO TURBO is going to give you a real buzz. With acres of virtual desktop and a complete control panel, plus flicker-free graphics at up to 100 Hz refresh, the GRAPHICS PRO TURBO is absolutely the fastest, most convenient card for Windows.



Color calibration
Easy control of desktop settings and color calibration with FlexDesk panel.

Vicious Video

As an added bonus, the GRAPHICS PRO TURBO is ready to make motion video fly. With accelerated image scaling and enhanced pixel smoothing, it displays motion video with no additional multimedia hardware.

Bee The Best

Our high quality design ensures a perfectly clear picture ... no color bleeding or blurry images. And ATI's solid support, with regular no-bug software updates, will keep your system humming. So don't bee stung by lesser graphics. Get the GRAPHICS PRO TURBO. It's a honey of a card.

COMPLETE PERFORMANCE DATA
(Larger numbers are better)

	GRAPHICS PRO TURBO	Matrox MGA II+	Diamond Viper
Winbench 4.0* 1024 X 768 [illegible] mpels/sec	36.2	28.0	20.0
Winbench 4.0* 800 X 600 16.7M [illegible]	25.7	12.1	4.6
VGA Performance †† kpels/sec	8,482	993	2,953
Motion Video Performance ††† frames/sec	24	11	13

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* All performance tests done on a Pentium 66MHz, 16MB RAM, 256K cache, 200MB HD at 60Hz, using 2MB versions of PCI graphics cards. † Winbench 3.11 at 1024x768 resolution in 256 colors
†† VGA performance tested using PCBench 7.01 (video harmonic) ††† Motion Video performance measured under Windows using 65K colors. Test clip recorded at 320x240 at 30 fps using Indeo codec.

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News & Views

PROCESSORS

Intel Pushes the 80x86 Envelope

In terms of sheer processing power, Intel is behind the RISC curve. Its next-generation Pentium, the P6, may only keep the gap from widening even further. But for Intel, that may be enough.

BY DAVE ANDREWS

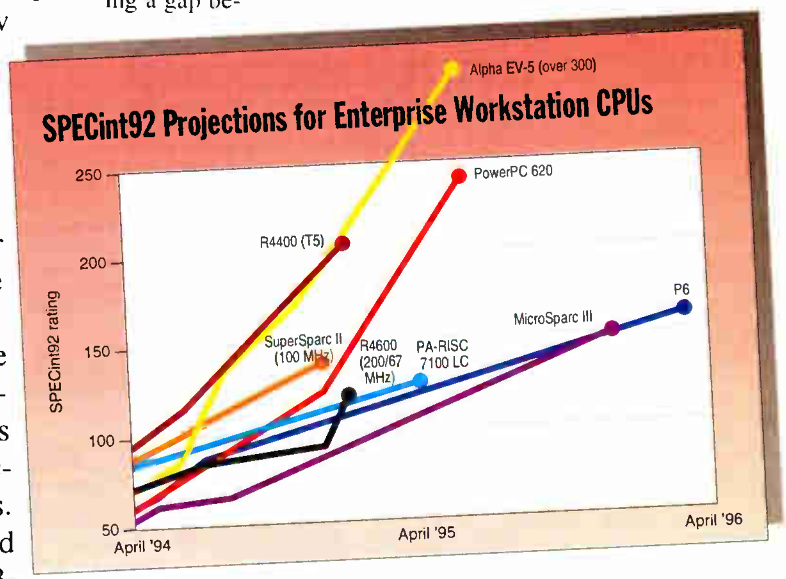
On April 1, Intel will reduce the price of its 66-MHz Pentium chip from $871 to $750 each in quantities of 1000, company officials say. Given that chip's optimized SPECint92 rating of 67.4, that means a system vendor will pay about $11.12 per SPECint92 for a 66-MHz Pentium at the new price. By comparison, Sun Microsystems' MicroSparc II processor running at 70 MHz delivers a 54-SPECint92 rating at a volume price of $400 each, or about $7.40 per SPECint92. And the PowerPC 601 chip, running at 66 MHz, delivers a rating of 60 SPECint92, for about $6.45 per SPECint92—roughly half the cost of the 66-MHz Pentium.

Industry experts and analysts agree: In the microprocessor war, Intel has lost the price/performance battle to RISC. Intel's response? It's getting more aggressive on pricing and is accelerating the introduction of new processors. It was expected to introduce in March 90- and 100-MHz versions of a new 0.6-micron, 3.3-V Pentium family, code-named the P54C, that analysts expect will offer a 30 percent to 50 percent performance boost over today's Pentium.

Intel's other recent processor introductions include the DX4/100, a 486 processor that operates at 100 MHz internally and is about 50 percent faster than a 486DX2/66, neatly filling a gap between the fastest 486 and the slowest Pentium. Says Lew Paceley, marketing director for the P6 line at Intel, "We just keep driving our engine harder and harder."

Intel says its next-generation 80x86 processor, code-named P6 and slated to start appearing in late 1995, will deliver roughly 300 MIPS, compared to the approximately 100 MIPS that you get from a 60-MHz Pentium today. Such an accomplishment—if Intel can meet that goal within that time frame—means the company will have reduced the amount of time between the introduction of its successive next-generation microprocessors by about a year. A late-1995 rollout of the P6 will represent an elapsed time of only 33 months after the first Pentium was announced in March 1993; 44 months passed between the introduction of the first 486 and the debut of the Pentium.

But by late 1995, Motorola



Projections are based on interviews with company officials and industry analysts. In addition to the cost of the microprocessor, other factors influencing overall cost of a system include level of processor integration, operating-system RAM requirements, chip die size, availability of low-cost peripherals, and application prices. Because many enterprise applications will rely more on integer than floating-point performance, processor SPECfp92 ratings are not shown.

and IBM expect to be deep into volume production on the PowerPC 620, which Motorola says will deliver four times the performance of today's PowerPC 601. Sun expects to deliver by the end of 1995 its next-generation MicroSparc III processor, which will achieve a rating of 150 SPECint92. Other companies, including Hewlett-Packard, DEC, Mips, and their partners, are pushing their RISC architectures up the performance curve as well (see the chart, below left).

"Even though the P6 looks impressive, it's still going to be well behind the performance of the PowerPC and other RISC chips," notes Linley Gwennap, editor in chief of the *Microprocessor Report* (Sebastopol, CA). "The rule of thumb is that RISC is either twice the performance at the same [chip] price as Intel, or the same performance at half the price." Gwennap also says that Intel is investigating multichip-module packages for the P6 that can increase performance and reduce footprint but would also be much more expensive than stand-alone CPUs.

Pure processing power is not the only way to measure the strength of a particular computing platform, however. Platforms are also measured by the breadth of available applications that are written by ISVs (independent software vendors). The 80x86 architecture, unlike RISC, runs thousands of DOS and Windows applications at native speeds without having to resort to slower software-emulation solutions such as Wabi or Insignia Solutions' SoftWindows. "The PowerPC and other RISC guys need to work on the software problem," Gwennap says.

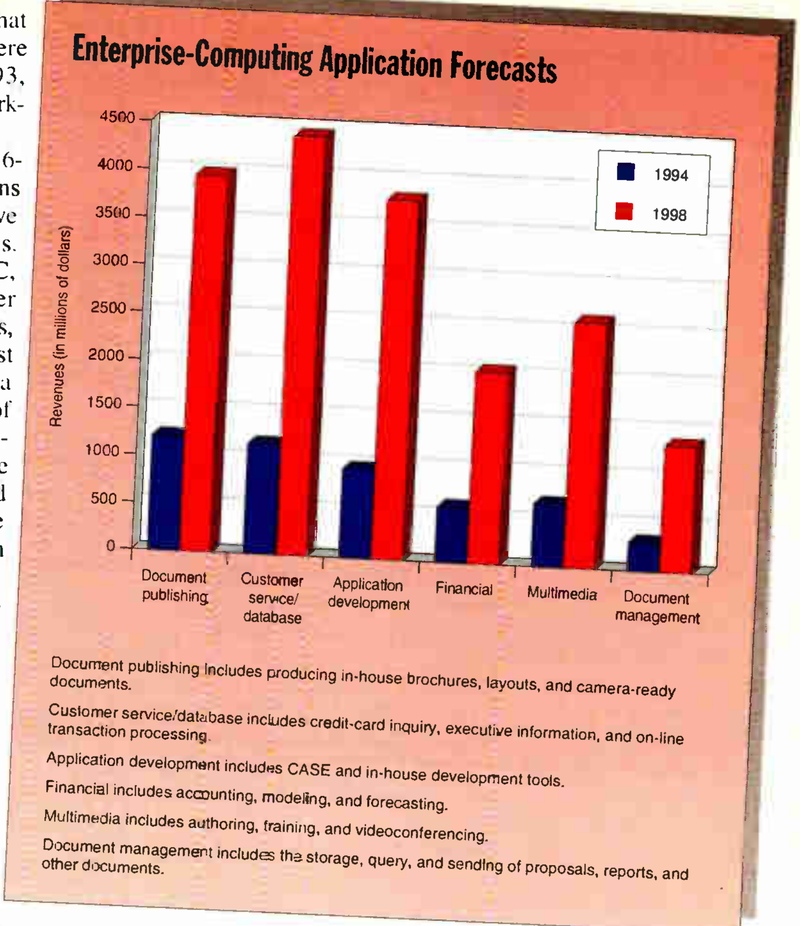
Until more ISVs introduce 32-bit applications that run native on a given RISC platform, Intel will have a strong argument to stay with its 80x86 architecture. If you are looking for full compatibility and the fastest possible execution of today's Windows applications, the 80x86 architecture is for you. Indeed, the Framingham, Massachusetts–based International Data estimates that over 36 million PCs were sold worldwide in 1993, versus about 1 million workstations.

But fast execution of 16-bit Windows applications is not the chief objective of these new RISC PCs. Companies such as DEC, HP, and IBM, together with their system partners, are developing low-cost RISC-based PCs for a new emerging market of low-cost enterprise workstations. The enterprise workstation arena should see the most intense competition between RISC and CISC.

Enterprise workstations integrate high-performance CPUs with 32-bit operating systems such as Unix, Windows NT, and OS/2 and run applications that manage processes that directly affect a company's bottom line. These applications, according to Frost & Sullivan, a Mountain View, California–based market-research firm, include customer information systems, client/server databases, production, and R&D programs.

"The enterprise desktop is a market that is primarily business-operations-oriented," says Andrew Allison, consultant and editor of *Inside the New Computer Industry* (Carmel, CA), a newsletter that focuses on this new breed of PC. "It's far from clear that Intel has any software advantage in that market."

By their very nature, enterprise-critical applications have to run on operating systems that offer the stability and fault tolerance that are not available in today's fragile DOS-based environment. Intel's overall system-price advantage is eroding as well: This year, you can expect to see a wave of high-performance desktop RISC workstations selling in the $3000-to-$4000 range (e.g., HP's Series 700 systems, which start at $3995).



Databases will be a key application for enterprise workstations as companies turn to these programs to manage their high-volume, real-time data-entry and update needs, according to market-research firm Frost & Sullivan. Database applications do not generally require excellent floating-point performance, unlike complex financial-modeling and 3-D graphics applications.

Start-up companies such as Deskstation Technology (Lenexa, KS) are banking their future on developing low-cost, high-performance, RISC-based Windows NT PCs for companies that are downsizing their business operations. For example, Deskstation is now shipping its v4600, a low-cost workstation based on IDT's R4400-compatible R4600 processor running at 100 MHz internally. It comes with 16 MB of RAM and a 240-MB hard drive and costs $2995.

Don Peterson, Deskstation president, says that over the next two years the company will deliver a range of systems designed to satisfy the needs of customers using everything from desktops to data centers; by the end of the year, the company plans to offer multiprocessor systems that will run demanding database applications. "We believe we'll be able to deploy low-end servers for under $10,000 that will offer performance that's better than [that of] a two-processor Pentium," Peterson says.

The degree to which Intel can convince customers to purchase Pentium-based enterprise workstations that offer RISC-like performance depends in large part on Microsoft and how well Chicago, the next generation of Windows, succeeds in integrating 16-bit DOS and Windows in a 32-bit multitasking operating system that runs well on 8-MB-RAM PCs. If businesses decide that Chicago doesn't offer a compelling enough platform to run their applications, they will closely examine the new breed of RISC PCs, which will have the horsepower to run the next generation of sophisticated, layered 32-bit operating systems, such as Windows NT and CPU-hungry videoconferencing, database, and 3-D graphical applications.

OPERATING SYSTEMS

Apple Opens the Mac OS

After years of carefully guarding its Macintosh system software, Apple (Cupertino, CA) is taking steps to spread the Mac OS to several different platforms, including the unprecedented step of licensing System 7 to third-party clone makers. However, there will probably be a few strings attached, and Apple is still working out the details.

One catch is that System 7 will be licensed only for systems and devices that are based on the PowerPC. Another is that Apple is unlikely to sanction Mac clones that compete head-to-head against genuine Macs in Apple dealer channels. Instead, Apple suggests, clone makers will be encouraged to explore new global and vertical markets that aren't central to Apple's hardware business.

This is similar to Apple's strategy for licensing Newton technology. Although Newton partner Sharp (Japan) sells a hand-held PDA (personal digital assistant) that's almost identical to the Apple MessagePad, other Newton licensees are working on a variety of devices, ranging from digital cable TV set-top boxes to intelligent fax machines.

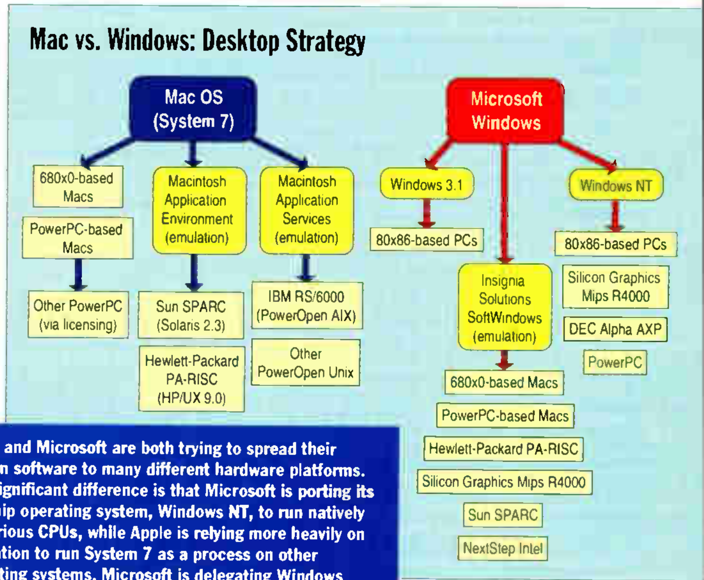
Why won't Apple license the Mac OS to run on Intel 80x86-based PCs? Because when Apple approached several potential licensees, says an Apple spokesperson, there was little interest in putting System 7 on PC clones. Instead, the vendors expressed more interest in building new PowerPC-based systems.

As with Apple's Power Macs, future "clone" systems could run the latest PowerPC Mac programs as well as existing Mac software, thanks to the 680x0 emulation built into the PowerPC version of System 7. An 80x86 version of the Mac OS would either require developers to port their software to that CPU or require Apple to add equally powerful 80x86 emulation to System 7. Neither task is trivial.

Another problem is that true Mac clones would require additional hardware not found in PCs, such as the ADB (Apple Desktop Bus) and Apple's implementation of SCSI. Although Apple hasn't worked out all the details, licenses might include rights to proprietary Apple hardware as well as system software.

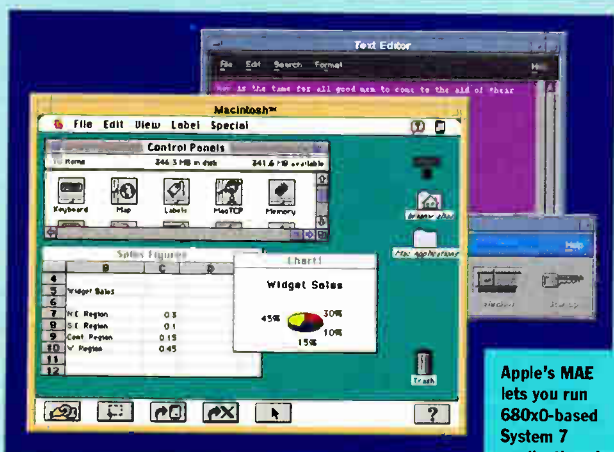
"This exercise is as much an art as a science," says Apple spokesman Frank O'Mahoney. "We're trying to make a marriage between two different business models—Apple's internal business model and those of our partners—and between two different technologies—our operating system and our partners' hardware."

—Tom R. Halfhill



Apple and Microsoft are both trying to spread their system software to many different hardware platforms. One significant difference is that Microsoft is porting its flagship operating system, Windows NT, to run natively on various CPUs, while Apple is relying more heavily on emulation to run System 7 as a process on other operating systems. Microsoft is delegating Windows emulation to a third party (Insignia Solutions).

APPLE'S 680X0 EMULATION FOR UNIX

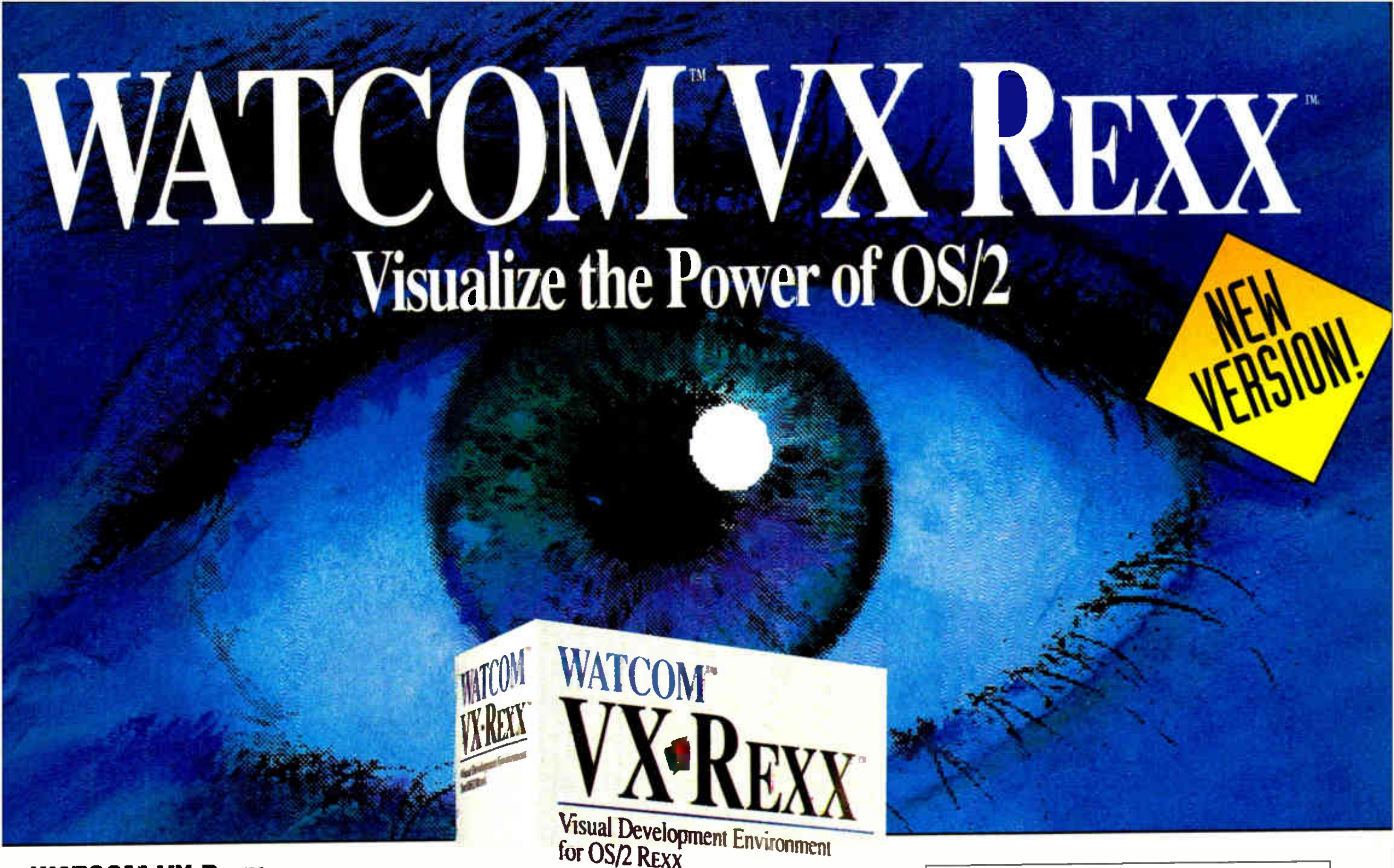


Apple's MAE lets you run 680x0-based System 7 applications in an X window.

Licensing System 7 to third parties isn't the only part of Apple's spread-the-Mac strategy. On March 14, Apple also announced the Macintosh Application Environment, or MAE, a new Mac-on-Unix emulator that runs a System 7 session in an X Window System window on Sun SparcStations and Hewlett-Packard Series 700 workstations. MAE (see the photo) will allow 680x0-based Mac applications to retain their original look and feel while running under HP/UX 9.0 or Solaris 2.3 with either Motif or Open Look.

However, don't confuse MAE with MAS (Macintosh Application Services), Apple's previously announced Mac-on-Unix solution. Both are based on similar emulation technology (see "Emulation: RISC's Secret Weapon" on page 119). But MAS runs both 680x0 and PowerPC Mac software on PowerOpen-compliant versions of Unix, such as IBM's forthcoming revision of AIX. MAE is limited to 680x0 emulation on HP/UX and Solaris, although future versions may support AIX and even PowerPC emulation on other RISC platforms.

—T.R.H.



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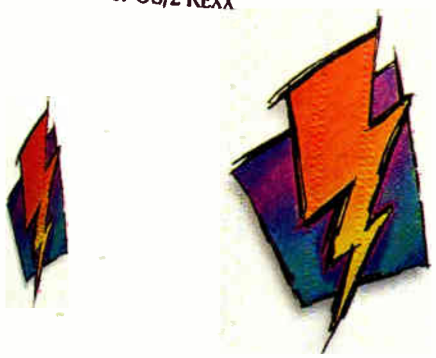

Experts Agree... *"All in all, VX•REXX stands out for ease of use, versatility, and power. And at $199, including free tech support and free application distribution, it's also a sensational value."*
PC Magazine, February 8, 1994.

"(VX•REXX) applications can be multithreaded and REXX is probably the easiest language in which to learn the OS/2 thread model."
Software Development, November, 1993.

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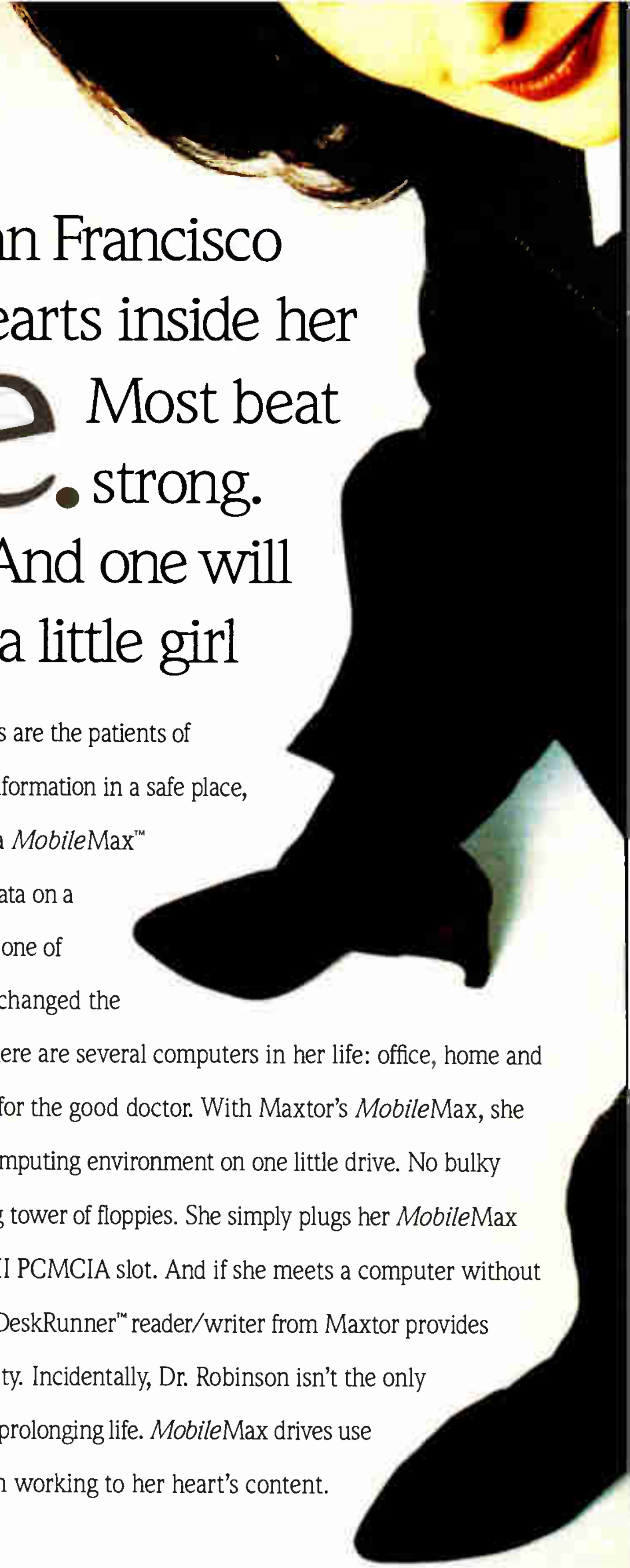

There's a woman in San Francisco who carries 14 or 15 hearts inside her purse. Most beat strong. One needs repair. And one will soon find its way into a little girl named Katie.

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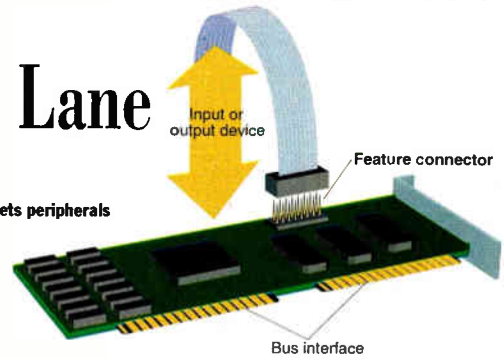
News & Views

PC VIDEO ACCELERATORS

Video Acceleration in the Fast Lane



A feature connector lets peripherals such as graphics and video cards communicate and share information over cables.

When designing multimedia PCs, systems engineers face a number of factors that conspire to make digital-video-capable PCs pricey while limiting their digital-video playback to quite unexciting, often postage-stamp-size movies. The price problem is due to a duplication of components in which PCs have two RAMDACs; two frame buffers; and two controllers, one each for video and graphics. The small-size movies and dropped frames are caused by architectures that can't transfer video at a fast enough rate.

Two coalitions offer new graphics standards to speed digital video across the desktop. The first, VESA (Video Electronics Standards Association), offers two solutions: VAFC (VESA Advanced Feature Connector) and VMC (VESA Media Channel). The other coalition, an Intel-ATI pairing, offers SFBI (Shared Frame Buffer Interconnect).

All three standards will require new graphics board designs and associated drivers to implement their promised speed boost. These new boards will plug into ISA, EISA, VL-Bus, PCI (Peripheral Component Interconnect), or Micro Channel slots. The first boards for VL-Bus and PCI are expected to be announced by the time you read this.

VAFC is a 32-bit replacement for the old and sadly out-of-date 8-bit VGA connector. While the old VGA feature connector supported a video in a window with a resolution of only 640 by 480 pixels and 8-bit color, VAFC supports video at much higher resolutions and in better color (up to 1024 by 768 pixels at 256 colors with a 75-Hz refresh rate).

VMC, like VAFC, offers a 32-bit data path. But VMC supports up to 15 video streams simultaneously and offers a more long-term solution for video computing than VAFC. One developer described VMC as "a video superhighway that bypasses the already-crowded system bus." Since VMC is a dedicated channel for real-time video, peripherals can communicate independently and without slowing the system CPU. VMC decouples the memory subsystem from the video transfer specification, allowing graphics board manufacturers to offer a variety of boards with differing types of graphics memory—DRAM, VRAM (video RAM), synchronous DRAM, RAMBUS, and other future memory standards.

Hossein Yassaie, vice president of engineering for VideoLogic, says that adding VMC capabilities to a system increases the cost to the consumer by $10 to $30. He adds that the cost to add videoconferencing hardware to a VMC-equipped system would be about $600, compared to the $3000 or so that the hardware costs today.

Intel-ATI's SFBI combines frame buffers and memory used by each multimedia subsystem into a single, shared memory pool of up to 8 MB, with a protocol for arbitrating among devices attempting to tap into that memory. The design goal is to keep all components on one board while reducing board cost by eliminating duplicated memory among multiple devices. However, unlike VMC, SFBI currently mandates using either VRAM or DRAM.

SFBI is faster than VAFC and VMC, offering a top-end transfer rate of 200 MBps, but that rate is for a 64-bit datapath implementation. In 32-bit mode, SFBI offers closer to 100-MBps data transfer. To tweak the speed further, SFBI includes SynchroLink, a channel that coordinates video and sound sources without accessing the host processor.

Although the SFBI scheme provides no external feature connector, you can connect an SFBI card to another SFBI card over the host bus or, if you have an interface on the SFBI card that can connect to a VMC or VAFC card, you can connect the two cards that way. Indeed, Don Fraser, ATI product manager of video components, contends SFBI complements, rather than competes with, VAFC and VMC.

At press time, three companies had announced boards that are based on one of the new standards and illustrate the benefits of these new video architectures. For example, Matrox's $649 MGA Ultima-VAFC for PCI allows video playback at resolutions of 1280 by 1024 pixels at 30 frames per second. Matrox ((514) 685-2630) plans to introduce the MGA Video-Pro, a PAL and NTSC video-encoding board with a VAFC connector, in the second quarter of this year.

ATI's Video-It video-capture board offers real-time compression of video from a camcorder or a VCR, as well as live video in a window display at any resolution. ATI ((905) 882-2600) says it will release Video-It in mid-April for $499.

VideoLogic's 928Movie (from $349), a multimedia accelerator board developed jointly with IBM, combines graphics acceleration with VideoLogic's custom ASIC PowerPlay Digital Movie Accelerator. VMC add-ins from VideoLogic ((617) 494-0530) for MPEG video capture and playback are scheduled for release in the second quarter of this year.

Other vendors are sure to release board products throughout the year.

—Russ Lockwood

VIDEO FAST-LANE LINEUP

VESA Advanced Feature Connector	VESA Media Channel	Shared Frame Buffer Interconnect
A short-term solution for video overlay in high-resolution graphics modes	A separate channel that merges graphics and video	Predominantly a single-card solution; merges graphics and video
150-MBps transfer rate	Maximum 132 MBps in 32-bit mode	Up to 200 MBps in 64-bit configuration
Eliminates RAMDAC duplication	Eliminates RAMDAC, frame-buffer duplication	Eliminates RAMDAC, frame-buffer duplication
No shared frame buffer	Designed for current and future RAM technologies	RAM and DRAM only
N/A	Supports any codec	Currently supports Indeo codec only

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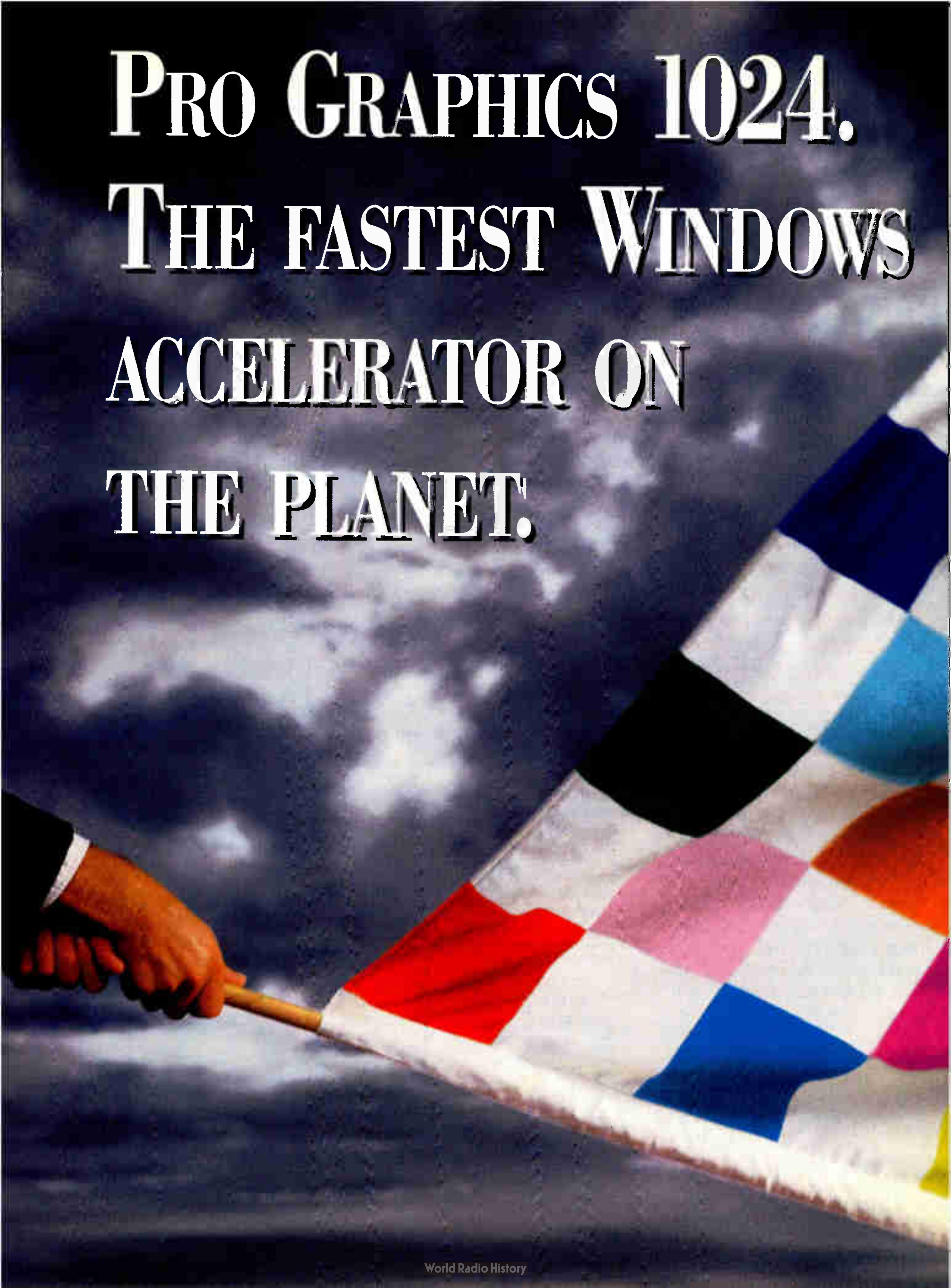
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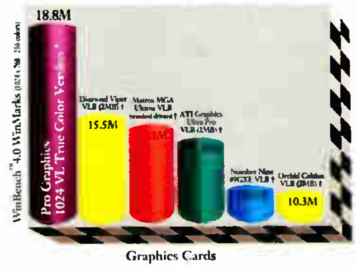

For starters, consider Pro Graphics 1024's superior 72-bit engine. Specifically designed to increase your graphics speed, it makes the difference between just getting by and lightning speed.

In fact, most other Windows accelerators can't even come close to giving you 16.7 million colors and 1024 x 768 resolution at the same time. Nor can they give you a photo-realistic display with command of a larger Windows desktop. And a 76Hz refresh rate that makes "flicker" a thing of the past.

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So what does this all mean when you put Pro Graphics 1024 up against other Windows accelerators? Well, we did a comparison test to answer that question.

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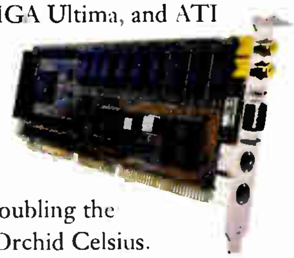

So as you can see, Pro Graphics 1024 not only outperforms other Windows accelerators, it pushes your graphics over the line. The finish line, that is.

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Test performed using Ziff Davis Labs' WinBench® V4.0. * Test conducted by Media Vision without independent certification from Ziff Davis. Based on Micronics VL motherboard, Intel 486DX2/66 CPU, 8MB RAM, 256K cache, Western Digital Caviar 2250 IDE hard drive, MS-DOS 5.0 and Windows 3.1 enhanced mode. All products are shipping versions. † Benchmark results as published by Ziff-Davis in PC Magazine December 7, 1993 issue. Based on Micronics EISA/VL motherboard, 486DX2/66 CPU, 8MB RAM, 256K cache and 153MB hard drive. All products are shipping versions. ©1994 Media Vision, Inc., 47300 Bayside Parkway, Fremont, CA 94538. (510) 770-8600. Pro Graphics 1024 is a trademark of Media Vision, Inc. Any other trademarks and registered trademarks are owned by their respective holders.

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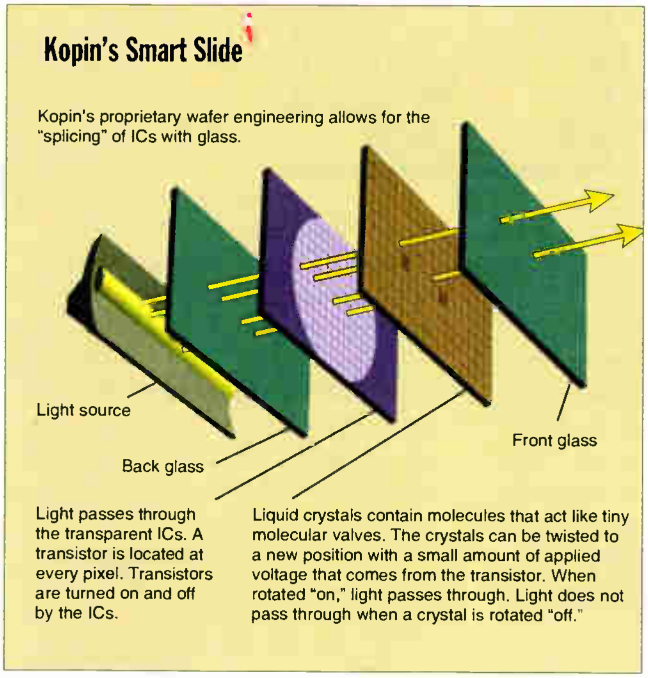
DISPLAY TECHNOLOGY

35mm-Size Display Has VGA Resolution



Kopin's Smart Slide imaging device consists of a thin-film, transparent IC containing the active matrix, the drive circuitry and other logic, and the liquid crystal, which is sandwiched between two glass panels.

It may not be long before you can wear a head-mounted display that's about the size of a 35mm slide yet sports 640- by 480-pixel VGA resolution. The technology behind the so-called Smart Slide from Kopin (Taunton, MA) is the ability to place active-matrix display circuitry on a single-crystal silicon wafer. The top layer of the silicon wafer, which contains the pixel array and integrated circuitry, is lifted and transferred to glass, leaving a transparent IC.

According to Dr. John Fan, Kopin's president and CEO, one of the major advantages of placing the display circuitry directly on silicon is that standard IC-fabrication techniques and facilities can be used rather than the specialized equipment used for the typical (and expensive) "silicon-grown-on-glass" LCD-fabrication method.

The limitation of this technique is the size of the silicon wafer. Although silicon wafers are available in sizes of up to 12 inches, it is more economical to use projection, since this technique allows a pixel resolution of 2000 lines per inch or even better, Fan says. "There are many ways to enlarge an image from a small display," he says. Therefore, the company is focusing on miniaturized displays and on projection systems that project the image from the Smart Slide to a larger screen.

Fan says that the Pocket Pro compact projection system, Kopin's first commercial product, will be available for $1500 in "a few months" and that once mass production starts, the price will drop steeply.

—Nicholas Baran

DISPLAY TECHNOLOGY

Motif Offers Variation on LCD Theme

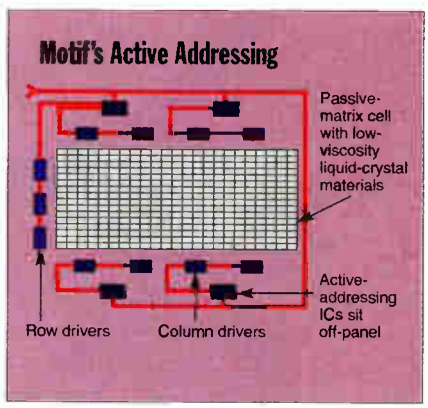
It's been a scant eight months since the Clinton administration repealed the anti-dumping tariff on imported active-matrix LCDs. But in the meantime, a potentially less expensive display technology has surfaced as a threat to active-matrix color.

Active addressing, developed by Motif (Wilsonville, OR), a company jointly owned by Motorola and In Focus Systems, uses much of the design of less expensive passive-matrix displays but with the response rates of active matrix. The cost of active-address display technology should fall somewhere between the prices for passive- and active-matrix screens. Motif recently showed BYTE a prototype screen that had a slight muddiness compared to an active-matrix screen. But its response rates matched those of active matrix during the playing of a digital video movie clip.

According to David Lunsford, director of advanced portable technology for Dell Computer, active addressing's improvements over dual-scan STN (supertwist nematic) could potentially bring down the prices of higher-end color notebooks.

The first products implementing active addressing could be announced by late this year. Display-product marketing manager Joel Pollack of Sharp Microelectronics (Camas, WA), Sharp's LCD engineering division, praises Motif's accomplishments. But he claims that by the time active addressing becomes as bright as TFT and attains VGA and higher resolutions at standard notebook LCD sizes, Sharp's investment in LCD technology will have begun to pay off in the form of less expensive TFTs. If this proves to be true, Motif will find its niche—but at the expense of passive- rather than active-matrix screen technology.

—Ed Perratore



With active addressing, proprietary ASICs (application-specific ICs) that sit off the panel can address many rows simultaneously. The ASICs take the image from the graphics card and quickly calculate in real time where voltages need to be applied to the crystals. According to Motif, this technique provides near-TFT performance at a slightly higher cost than passive matrix.

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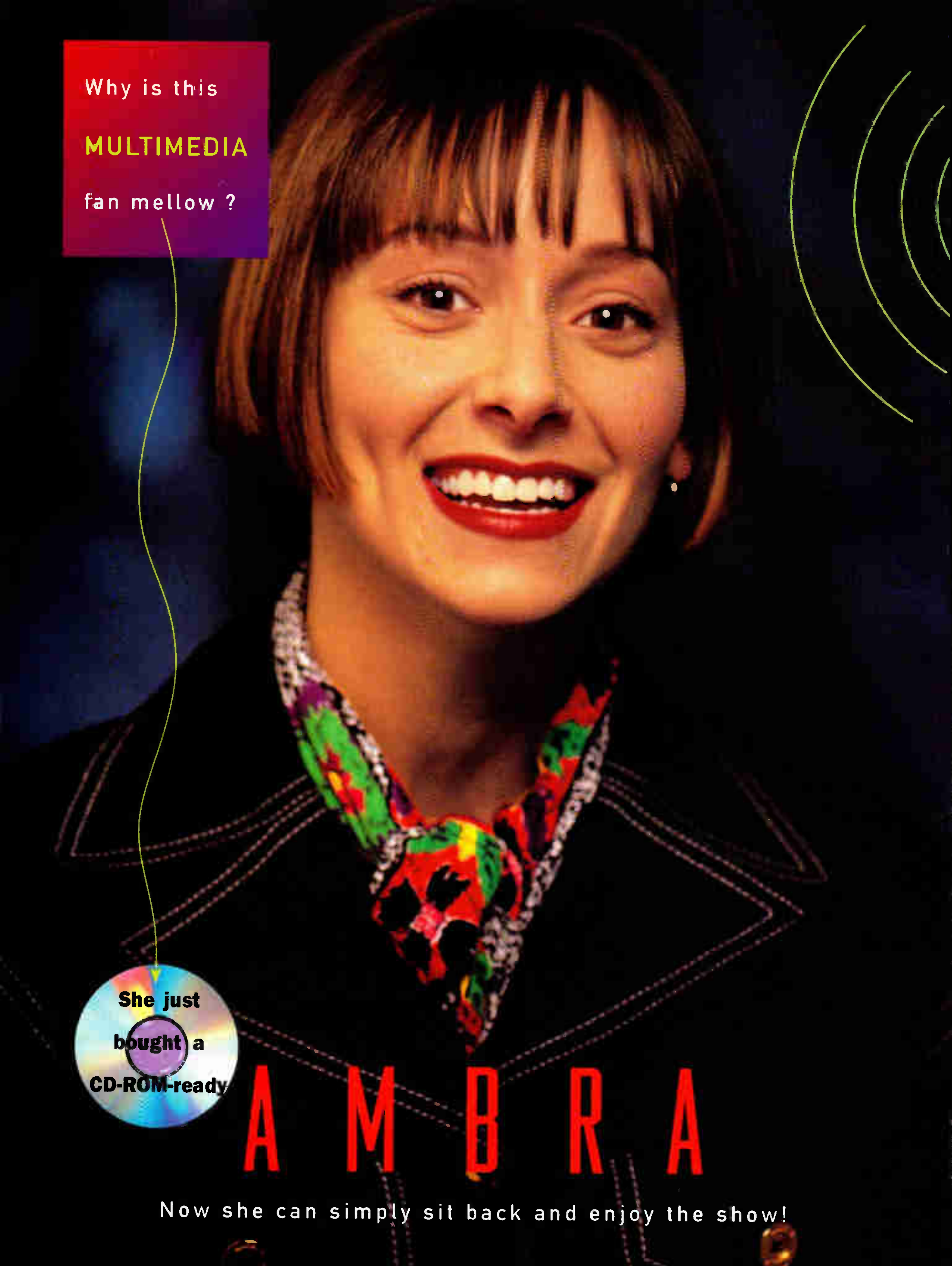
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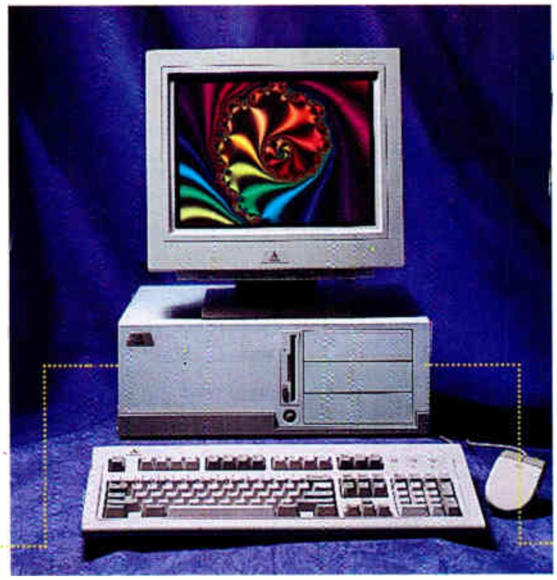

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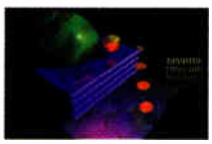

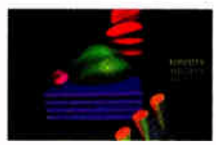

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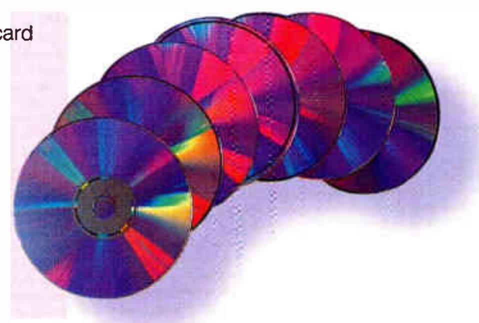

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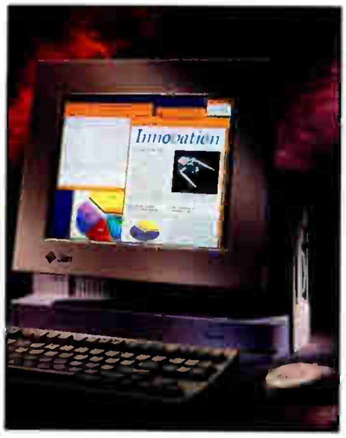


Until now, Sun Microsystems has been content to let companies such as RDI Computer (San Diego) and Tadpole Technologies (Cambridge, U.K.) sell portable, Sun-compatible systems. But with the new SparcStation Voyager, the Mountain View, California–based company is finally offering its own workstation-class portable. The catch is that this system is far from svelte: It weighs 13 pounds (5.9 kg).

Built around a 60-MHz MicroSparc II processor from Fujitsu, the SparcStation Voyager (see the photo) offers performance that's benchmarked at roughly 43 SPECint92 and 47 SPECfp92, says Sun. Prices are expected to range between $10,000 and $15,000.

Desktop replacement could turn out to be a key application for the Voyager because it faces stiff competition in the mobile arena. If Sun is serious about competing in the mobile RISC-computing arena, it needs to channel the engineering achievements of the Voyager into even more aggressive designs.

—**Andy Reinhardt**

Six Accomplishments of AI

1. AI software, and software in general, is now much faster, more accurate, and more logical than most humans. For example, an expert system at DEC uses hundreds of IF...THEN rules to configure DEC computers for customers far faster than any human could.
2. Expert systems are now standard tools at many of the Fortune 500 companies, and neural networks are gaining in popularity, especially on Wall Street. One firm, which prefers to remain unnamed, makes most of its profits automatically by computer, locating tiny discrepancies in futures pricing.
3. Industrial robots are now more or less standard in Detroit, and they can be considered a mature AI technology with huge payback. The vast majority of General Motors cars are painted automatically by robot (a dirty and unhealthy task for a human). In the field of medicine, delicate hip operations are now performed entirely by software-controlled "robot surgeons."
4. American Express, located in Boca Raton, Florida, has standardized on neural network technology to read millions of charge slips each day. The neural networks can gradually improve their ability to read handwritten numbers and letters.
5. The phrase *artificial intelligence* is now starting to sound reasonable, as opposed to the old connotation of *hype*. Intelligent people expect computers to gradually become more intelligent by supporting voice control and other advanced technologies.
6. Deep Thought, a computer program now sponsored by IBM, has won at least one chess game against a grand master.

—Joseph Weintraub (joweintraub@delphi.com)

CODE TALK

RICK GREHAN

Mad Macs and the Code Warrior

Lately, a great deal of attention has been focused on all the new CPUs supporting (or promising to support) Windows and Windows NT. As wonderful as the multiple-CPU support sounds, it hides a tough decision facing developers: Recompile for each CPU, or hope that the emulation is up to snuff. Mac developers are in the same boat, of course, as the arrival of PowerPC-based Macs draws nigh. Time to recompile for the PowerPC? If so, with what?

Enter MetroWerks' ((514) 747-5999) Code Warrior, a C/C++ development package for both 68K (i.e., 680x0) and PowerPC Macs. Code Warrior possesses—and extends—many of the features that have made Symantec's Think C such a popular and enjoyable C/C++ compiler. Forget hand-built make files; simply open a new project, select the source files you need, and add them to the project window.

It's easy to see that the architects of Code Warrior have done plenty of programming themselves. For example, from an open project window, you can open a pop-up window that contains a list of all the include files referenced by a particular source file. Double-clicking on any filename opens an edit window on the file. The pop-up window also carries a "touch" entry; activating it issues a "touch" operation on the source file. That means it will be recompiled the next time you rebuild the project, whether or not you've made any editing changes on the file.

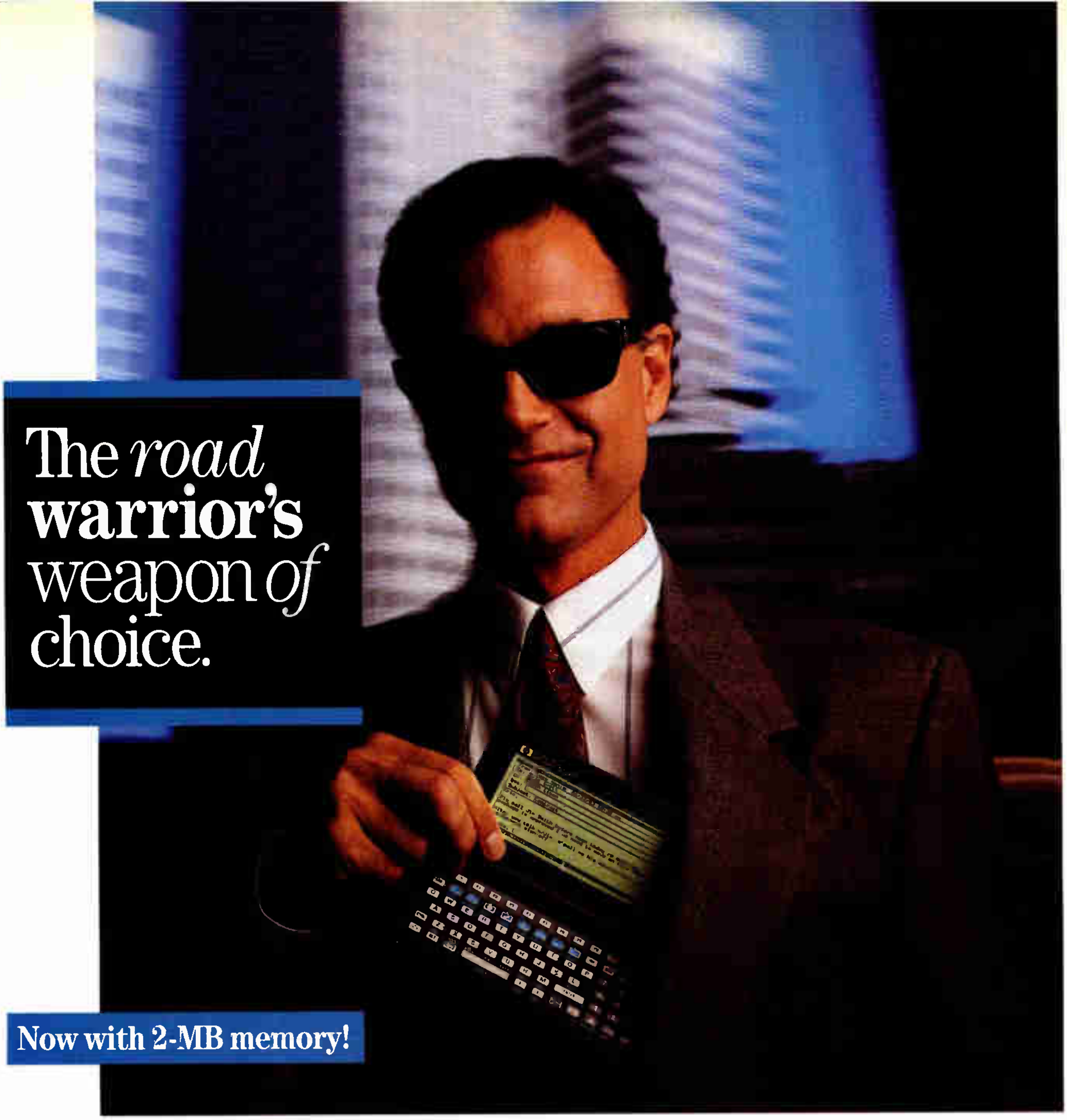
Of course, as with other modern compiler packages, you get more than just a compiler. Code Warrior's symbolic debugger runs native on either 68K Macs or PowerPC Macs. (The developer version we tested still had some rough spots; for example, you could only view a variable, not modify it.)

Code Warrior's PowerPlant is a C++ class library tailored for building Mac applications. Because PowerPlant's class members support Apple Events, you can build Mac programs that can be controlled by scripts or through recorded macro commands. You also get Toolserver (a kind of stripped-down MPW shell that lets you run MPW tool programs) and Sourceserver, a version-control and source management package. Finally, MacApp developers will be happy to know that Code Warrior is MacApp-compatible.

Ultimately, Code Warrior will be available in three versions: Bronze (which emits code for 68K Macs), Silver (which emits PowerPC code), and Gold (which emits code for both Mac platforms). The Bronze and Gold versions are available now in developer-release form. Silver's developer release is due to appear when the first PowerPC Macs appear, and the general release of all three versions will coincide with the World Wide Developer's Conference in May.

Pricing at the time of this writing places the Bronze version at $199, Silver at $299, and Gold at $399. That's quite good, especially considering how much software it buys you. Not only do you get C and C++ compilers, you also get a Pascal compiler, as well as the PowerPlant application development system and the other tools mentioned earlier. Furthermore, the MetroWerks compilers and tools are "fat binaries"; that is, each executable program contains both 68K and PowerPC code and will therefore run native on both 68K and PowerPC Macs.

While working with the developer version, it became apparent to me that Code Warrior still has a way to go. For now, it represents a substantial value for anyone developing for both 68K and PowerPC Macs.



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A harbinger of the object-oriented future of the user interface, CrossTies insulates you from data files and applications and lets you concentrate on the work you need to do.

In an industry riddled with buzzwords, the term *object-oriented* is one of the most abused. Most accurately described at the programming level as self-contained and reusable modules of code, objects have become the darlings of marketing managers and the cause of no end of confusion for users. In fact, John Faig, senior research analyst at the META Group (Westport, CT), calls it "a disaster as a term, thrown about with abandon."

Still, a product that its maker describes as object-oriented is causing a stir in industry circles. CrossTies for Windows ($149) from CrossTies Software (Carrollton, TX) goes beyond the usual PIM (personal information manager) approach of calendars, phone books, and to-do lists by insulating users from Windows' familiar, albeit frustrating, Program and File Managers. (As this went to press, WordPerfect announced InfoCentral, a $149 information manager that also lets you classify people, things, and events as linkable objects.)

CrossTies for Windows lets you create multiple links among all sorts of computer-based information, which the company calls "objects." You can link applications and data to people, projects, and activities. The software also allows information to be named with up to 256 characters. More than just a PIM posing as a Windows shell, CrossTies is intriguing because it doesn't force you into one way of getting your work done. You can customize it as much as you desire, although that freedom comes with a relatively steep learning curve.

Industry analysts who have used CrossTies—and generally praise it—caution that calling it a true object-oriented product is perhaps a marketing stretch. Hugh Bishop, an analyst at Boston's Aberdeen Group, calls it "more object-like," but stresses that CrossTies' biggest strength is its ability to organize information in a way that's most comfortable to individual users.

Those who have followed the object-oriented saga might be wondering what happened to Hewlett-Packard's NewWave, the closest thing to a true object-oriented shell for Windows, which was introduced with huge fanfare back in 1989. HP has repositioned NewWave as a "desktop manager" with nary a mention of object orientation. Mike Webb, NewWave marketing manager, says the company's research revealed that users "didn't understand and didn't care about objects, but they did like things like long filenames and color-coded folders."

—Stan Miastkowski

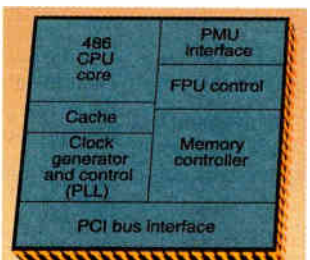
NOTEBOOK PROCESSORS

TI Charges into the Notebook CPU Wars

What do you want from a notebook chip set? Texas Instruments is betting that it's PCI (Peripheral Component Interconnect) bus speed combined with 3.3-V, clock-doubled 486 power and extremely low power consumption. TI says Rio Grande–based notebook PCs should start appearing this fall.

At the heart of the Rio Grande is a TI486 CPU that comes in external/internal clock-speed versions of either 25/50 MHz or 33/66 MHz. Because it's on the same silicon as the CPU, the integrated memory controller allows memory accesses at the chip's full internal speed.

Unlike Intel's 486SL chip family, which integrates an ISA bus controller, the Rio Grande integrates a PCI controller. By placing this controller on the same low-powered chip as the CPU, TI enables manufacturers to bring local-bus, high-bandwidth devices, such as high-performance IDE drives, to laptops and notebooks.



TI packs many devices into its Rio Grande chip set, but perhaps the most intriguing is the Power Management Unit (PMU) interface. TI says its 486 can turn off and on between keystrokes by switching the CPU off and on in 2 percent of the time required by rival active power management systems. TI hopes this feature will double a notebook PC's battery life.

Like the 486SX, the Rio Grande does not include an FPU, although it has an FPU interface. TI also includes a PCMCIA bus controller on the chip, which manages two PCMCIA slots and bridges the gap between the PCMCIA bus and the PCI bus with a four-level, 32-bit buffer.

Linley Gwennap, editor in chief of the *Microprocessor Report* (Sebastopol, CA), says that a potential benefit of the Rio Grande to system makers is that the chip's projected cost premium of approximately 20 percent over a 486DX chip is much better than the 80 percent higher manufacturing cost incurred by Intel in its now-discontinued 486SL line of processors.

—Alexis Tannenbaum

WinBench scores (average of 10 runs):
Close-Up 1,613,118
pcAnywhere 194,093
CarbonCopy 168,397

WinBench™ 3.11 by Ziff-Davis Labs Tests Remote Windows™ Speed

This graph shows the speed of the three leading remote control programs when transferring Windows screens. As you can see, Close-Up handles more pixels, faster, meaning you spend less time waiting for Windows screens.

The industry standard test, WinBench 3.11, is perfect for testing the speed of remotes. It is an accurate measure of video throughput. Video throughput is the limiting factor in remote operations, because remote programs must transmit Windows video functions from one PC to the other.

New Remote Software Sets Windows Speed Record

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2. Photographic Memory
3. Non-Intrusive Technology
4. Expert System
5. Video Translation

Why Is Close-Up So Fast?

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Other remote programs permanently slow Windows and usually reduce your video resolution and depth of color, even when they are not in memory. That's because they permanently change your system.ini file. Close-Up's breakthrough Non-Intrusive Technology does not modify any of your sensitive Windows files including the system.ini. Close-Up is the only remote that when not in use, allows Windows and your PC to run at normal optimal levels.

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Norton-Lambert

We invite you to reproduce this test. We used two identical Gateway 4DX2-66V's with 66-MHz Intel 486DX2-66 CPUs, 16 MB RAM, 256KB RAM cache, 340 MB HD, IDE controller, no hardware disk cache. Video: Local Bus ATI Ultra Pro with 2MB VRAM, 640 by 480 pixels, 16 colors, VGA.DRV dated 3/10/92. Monitor 72 Hz. MS-DOS 5.0, SMARTDRV 2 MB cache. Modems: two 14,400 baud V.32bis. Test performed without verification by Ziff. All products are shipping versions. WinBench trademark of Ziff Communications Co. Windows trademark of Microsoft Corp.

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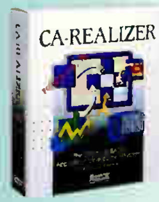

Defines a new generation of development tools that handles the mechanics of event-driven programming, message passing, process sharing and other complexities behind the scenes. Combines a structured superset of BASIC extended to access Windows and OS/2 objects and resources, a visual development tool and Programmable Application Tools. CA-Realizer will help you create spreadsheets, charts, text editors, animation, graphics tablets and user-friendly forms from tools that can be created and manipulated by simple commands.

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PRODUCT OF THE MONTH

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Janus/Ada 9X Professional Development System
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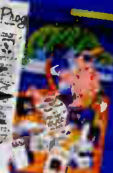

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32-bit optimizing FORTRAN 77 compiler and tools for DOS, Novell NLM, OS/2 2.x, Windows NT, Win32s, & Windows 3.x. Comprehensive language support with FORTRAN 90, DEC VAX & IBM VS language extensions. Advanced processor optimizations including 486 & Pentium instruction scheduling. Multi-platform toolset includes linker, debugger, profiler, royalty-free DOS extender with VMM & more.

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NEW THIS MONTH

ReferencePoint Personal Assistant
by ReferencePoint

ReferencePoint Personal Assistant automatically makes an index of any information that you create or modify anywhere on your computer system, so that you can find any file, instantly, whether from a word processor, database or spreadsheet. So, type what you want to find, and Personal Assistant will locate every file in the computer containing those words. ReferencePoint Royalty Free SDK for DOS, Windows, Mac, OS/2 and UNIX also available from Programmer's Paradise®. Call for pricing.

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WATCOM™ C/C++32 v9.5
by WATCOM

C/C++32 is a professional, multi-platform C and C++ development system supporting 32-bit extended DOS, OS/2 2.x, Windows 3.x, Windows NT, Win32s, and AutoCAD ADS/ADI. The complete toolset includes: C and C++ optimizing compilers, royalty-free DOS extender with VMM support, licensed components from the MS Windows 3.x SDK, interactive source-level debugger, linker, profiler, supervisor for executing 32-bit applications and DLLs under Windows 3.x, 32-bit run-time libraries for extended DOS, OS/2 2.x, Windows 3.x and Windows NT, and more.

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Mwave™ Developers Toolkit with IBM WindSurfer™ Bundle
by Intermetrics, Inc.

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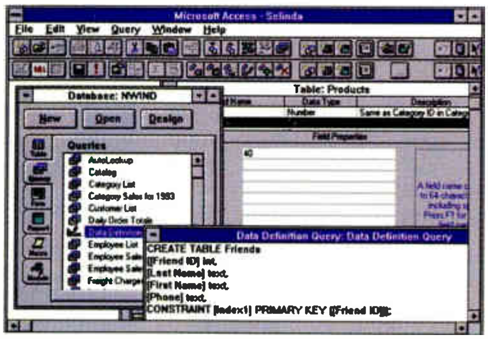
WINDOWS DATABASES

New Access Targets Wider Audience



Access's ease-of-use features should appeal to end users and developers alike. For example, to create a table, you can either use a Table Wizard or write a SQL statement in a data-definition query. Microsoft has added FoxPro's efficient Rushmore technology to make set queries execute much faster than in Access 1.1.

Although Access 1.0 did an admirable job of allowing developers to write applications without having to delve into code, Microsoft's $99 introductory price tag attracted many end users who were overwhelmed by the program. Microsoft has added ease-of-use features to Access 2.0 for end users and developers alike while also improving its programming capabilities. Access 2.0 is what Microsoft wanted Access 1.0 to be: an easy-to-use, full-featured, relational database for Windows.

Although Wizards and Builders guide the creation of tables, forms, and queries, Access 2.0 is not a simple program. Yes, Access targets end users, but it also serves power users and developers. Based on my use of a preliminary version of Access 2.0, the new ease-of-use features will be welcomed—and needed—by less-technical end users.

For the first-time database user, I still lean toward Lotus Approach for Windows: It's less intimidating, and its learning curve is not as steep as Access's. But Access 2.0's ToolTips, Wizards, and cue cards have narrowed the end-user gap significantly. And, with Access 2.0, Microsoft's adherence to the menu structure found in other Microsoft Office Windows applications is paying off. Users familiar with other Office products will be able to perform basic commands immediately.

Lotus and Borland both target a narrower segment of the database audience with their respective Windows databases than does Access: Approach targets end users who want to create applications without having to confront programming tools, and Paradox targets developers. However, Lotus plans on eventually adding its own programming language, LotusScript, to Approach. And Borland will add tools to make Paradox easier to use for end users, says Vince Casarez, product manager for Paradox. But if you want a Windows database today that offers both power and ease of use, the nod goes to Access 2.0.

—Selinda Chiquoine

Access 2.0 Highlights for Programmers

Subforms

Although not new to Access 2.0, the subform feature lets you show an embedded subform on a main form. This type of display is convenient for showing one-to-many relationships, such as line items on an invoice. The main form can show an invoice's number and date, while an embedded form shows the invoice line items.

Control Wizards

Control Wizards make it possible to add command buttons, list boxes, combo boxes, and option groups by responding to a sequence of dialog boxes. These Wizards make it easy for developers to assign actions, such as running queries and opening tables, to controls. Developers can subsequently edit the code that Control Wizards build automatically.

New Macro Capabilities

New macro actions enhance object manipulation and interoperability. For example, the OutputTo action allows a developer to output a Datasheet with its formatting in an RTF format and then invoke Word for Windows so that it opens the RTF file.

Rich Event Model

A new Build Event shortcut menu in the Design window makes it easy to program actions in response to default events, such as mouse-clicks, the loading of a form, or the passage of time. Developers can edit the event that invokes a procedure or macro in the Properties window. This window lists the subset of events that pertain to each object (e.g., a command button or form).

OLE 2.0

OLE 2.0 implements OLE Automation, the new technology that lets you manipulate an application's objects from outside that application. For example, you can print a Word 6.0 document through the click of a command button in Access 2.0. Unfortunately, the rules for implementing this kind of automation vary slightly, depending on whether you are manipulating objects from Word 6.0 or Excel 5.0. Access 2.0 is both an OLE container and an object controller, but it is not a controllable object from outside the Access application via OLE. **—Rick Mara**

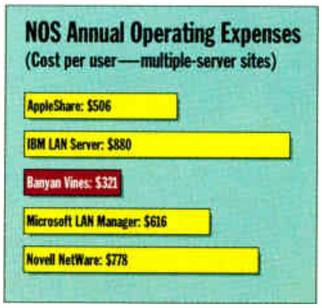
NETWORKS

Banyan Breaks Out

Banyan is expanding beyond the NOS (network operating system) business and bringing its Enterprise Network Services to other leading platforms. Banyan has already ported ENS to Novell NetWare, SCO Unix, and HP-UX; the company plans to port it to SPARC and AIX platforms in 1994.

"Banyan has built a substantial legacy of excellent network services," says Greg Cline, director of network integration and management at Business Research Group (Newton, MA). "The company is moving beyond network operating systems [and getting] into the network services arena." Banyan is also getting into the client business: The company recently acquired Beyond, which is known for its E-mail filtering and forms technology.

A recent report by the Business Research Group (Newton, MA) shows that in multiserver sites with over 100 users, Banyan Vines has the lowest maintenance cost per user. Although Vines was overall the most expensive network to operate, the survey notes that Vines servers also had the highest average number of users (1059) per multiple-server site. Cost calculations are based on the percentage of time an administrator with an annual salary of $55,400 devotes to supporting the network.



Intel Technology Briefing

Plug and Play

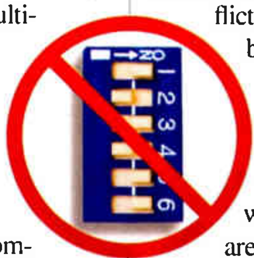
Making Add-in Cards Play Automatically

Now Playing: Automatic Card Configuration.

Since add-in cards first appeared over a decade ago, they've given users a lot of different ways to improve their PCs—and given them a lot of installation headaches. In this brief, we'll tell you how Intel, together with industry leaders, has spent years developing Plug and Play technology to make add-in cards both easier to use and install.

Trial and Error Configuration.

Never before has the PC had as many capabilities as it does today. That's due in part to the large number of add-in cards available, like those for multimedia and fax-modems. Yet, as more cards are added to a PC, their installation can become quite complex. Installing a card can be a time-consuming and technical process, and there's no guarantee it will even work the first time. Sometimes the user must configure the card manually, which means selecting a variety of system resources for each card. These include Interrupt Requests (IRQ), I/O and memory addresses, and Direct Memory Access (DMA) channels.



Every PC has a limited number of these resources available, and each card is designed to use a small group of them. Assigning these resources means opening the computer and physically setting the jumpers and DIP switches. And since no standard has been set to determine which cards can use which resources, numerous conflicts can arise between cards. Often, it's a process of trial and error to determine which resources aren't already being used by other cards.

Looking for a Solution.

Since the ISA bus was introduced, several new bus architectures have followed to solve the resource allocation problem. For example, the MCA* and the EISA bus standards both defined a mechanism where add-in cards were configured somewhat automatically. These bus architectures allocated the resources, but the process wasn't always flexible and still required some manual intervention. And they still left the current ISA cards without a solution.

Plug and Play Technology.

Plug and Play technology, co-developed by Intel and other industry partners, consists of hardware and software components that card, PC, and operating system manufacturers incorporate into their products. With this technology, the user is responsible for simply inserting the card. Plug and Play makes the card capable of identifying itself and the resources it requires. The system's software automatically sets up a suitable configuration for the card.

Newly developed PCI and Plug and Play ISA cards are all built to eliminate user intervention during the installation process. Newly designed PCMCIA* cards can also be inserted or removed without powering down the system.

Plug and Play-enabled systems also make the installation process easier for the millions of non-plug and play ISA and EISA cards that currently exist.

Plug and Play Partnerships.

Intel is working with the computer industry to make Plug and Play happen on a couple of fronts.

First, we helped define and develop the PCI local bus standard to improve I/O performance and to allow for automatic configuration of PCI-compliant add-in cards.

Secondly, using the PCI standard as the model for auto configuration, Intel is working with OEMs and add-in card vendors to add a similar capability to ISA bus-based systems and cards. Intel is also working with operating system vendors to assure current and future OS support, including Microsoft's Windows* 3.1. Users will get Plug and Play capabilities when manufacturers pre-install the necessary software on their PCs and cards.

PLUG AND PLAY

2. Resource Allocation.

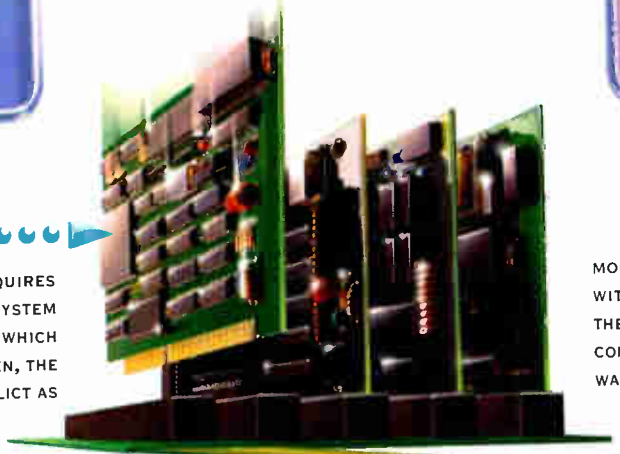
Each time the PC is booted up, the Plug and Play software extensions in the system BIOS look at all the cards and devices installed. Next they go through a process to determine which resources are best used where, and then communicate to each card which to use. Conflicts not resolved by the BIOS are handled by a higher level software component called the Configuration Manager.

1. Card Identification.

Plug and Play hardware logic, built into PCI and ISA cards, enables the cards to communicate to the system exactly which resources they are capable of using.

3. Card Configuration.

Once the resources are allocated, the card's hardware logic electronically sets the card configuration, eliminating the need to move jumpers and DIP switches. (Eg. IRQ3, DMA2, etc.)



Each add-in card requires one or more system resources, some of which are shown below. Often, the requirements conflict as more cards are installed. But with Plug and Play technology, the resources are dynamically configured based on the hardware present at boot-up.

IRQ

1 2 3 4 5 6 7 8

An IRQ, or interrupt request, is a signal which alerts the CPU that an add-in card requires attention. (For example, when a fax board has an incoming call.) The PC has 16 IRQs, but typically eight or more are used for standard system functions.

I/O

A0 A1 B1 B2 C2 C3

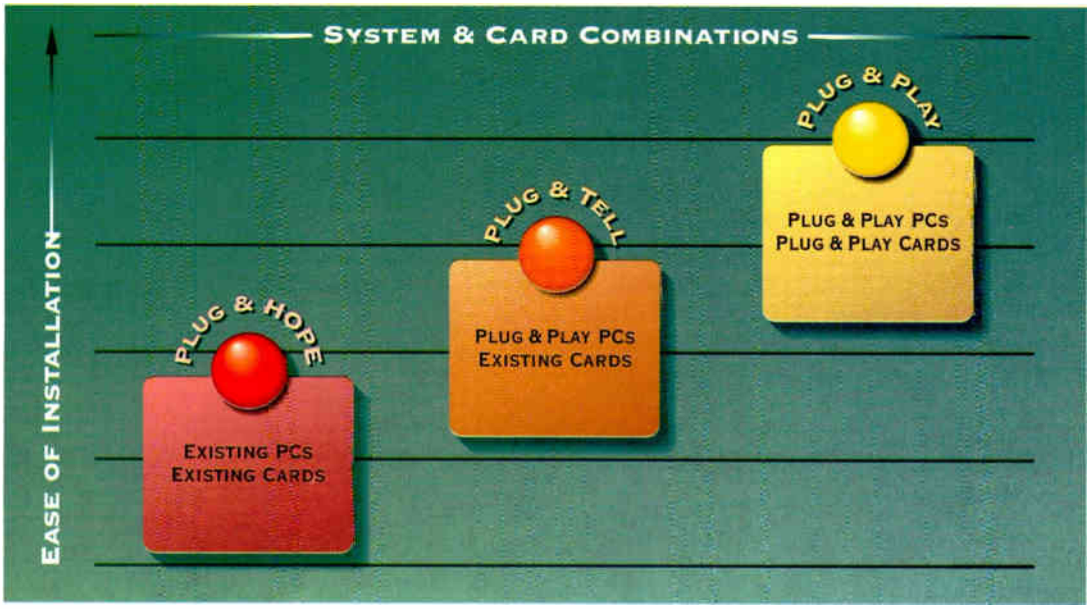
The I/O address tells the CPU where the card is located on the expansion bus, allowing it to transfer data to and from the right locations. Often hundreds of I/O addresses are available, but cards typically use the same ones, causing conflicts.

DMA

0 1 2 3

Direct Memory Access (DMA) channels provide an efficient mechanism for transferring data directly between a peripheral and memory without burdening the CPU. A typical system has 4 DMA channels.

PLUG AND PLAY ALTERNATIVES



IN THE PAST, CARD INSTALLATION HAS BEEN A LENGTHY, TECHNICAL PROCESS REQUIRING THE USER TO MANAGE AND ALLOCATE SYSTEM RESOURCES MANUALLY.

INSTALLING EXISTING ISA CARDS ON PLUG AND PLAY-ENABLED PCS IS NOW EASIER WITH INTEL'S ISA CONFIGURATION UTILITY. AFTER USERS SELECT THE CARD, THE UTILITY TELLS THEM HOW TO ALLOCATE SYSTEM RESOURCES.

WITH PLUG AND PLAY TECHNOLOGY, RESOURCE ALLOCATION IS AUTOMATICALLY DETERMINED AND IMPLEMENTED. USERS WILL BE ABLE TO ADD A CARD ALMOST AS EASILY AS INSERTING A FLOPPY DISK.

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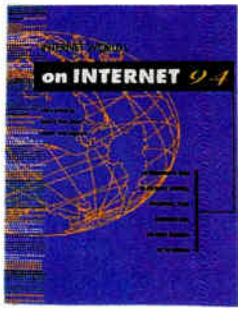
Internet Resource Guide



DAVE VISLOSKY

On Internet 94 claims to be the most authoritative and comprehensive guide to resources on the Internet, and I wouldn't dispute the claim. Because of the fluctuation of the Internet's contents—mail lists, discussion forums, and databases are being added or wiped away daily—the prospect of a single guidebook listing every current address is unreasonable. However, with over 6000 listings, *On Internet 94* is certainly a useful reference, even if it is not precisely up to date.

The guide provides addresses, descriptions, and access information to all categories of electronic journals, newsletters, texts, discussion lists, and mailing lists available across the Internet. Also included are listings of Usenet newsgroups and databases accessible by WAIS (Wide-Area Interconnect Service). If you're new to the Internet, the introduction gives a few helpful hints on how to join discussion lists, access electronic journals and databases, and use the `telnet` and `ftp` functions.

When using resource books like this, I find myself constantly using the subject index. Unfortunately, for all the effort expended to include a vast number of useful and interesting Internet resources, the subject index did not receive the attention it deserves.

For example, if you're interested in computer science, flip to the back of the book where the subject index resides. Find the subject "computer science," and you're faced with over 100 listings. Here's where the guessing game begins. We could assume that Info-Pascal is a discussion list on Pascal programming, which it is. But I have trouble discerning the meaning of Mossba, which, incidentally, is the Mossbauer spectroscopy discussion list. If you want to find a discussion forum on legumes, however, you're in luck. There's only one forum listed under legumes, Bean Bag.

I would have been much happier if this Internet resource guide had added more detailed subjects to the index. Also, some of the indexed address listings, albeit very few, are followed by brief descriptions, something that would have been helpful next to every listing. Not to mention that each address listing is followed by the chapter rather than the page where it resides: Find your listing, find the chapter, and find the address listed alphabetically in the chapter. This is not the most efficient method when using a resource guide. However, even with a few shortcomings in the subject index, *On Internet 94* provides a wealth of Internet addresses that will be of interest to both beginning and professional Internet explorers. ■

ON INTERNET 94

Tony Abbott, ed.
Mecklermedia
ISBN 0-88736-929-4

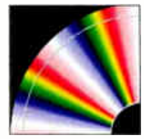
$45

Dave Vislosky is a BYTE senior technical editor at large. You can contact him on the Internet or BIX at visco@bix.com.

COMPUTER DESIGN

CONCEPTS IN COMPUTER DESIGN: A PROFESSIONAL PERSPECTIVE by Dawn Erdos and Leslie Singer **MIS Press, ISBN 1-55828-297-1, $34.95**

The bookshelves in my home office are overflowing with all the how-to books I've collected covering desktop publishing techniques and software. *Concepts in Computer Design: A Professional Perspective*, however, is the kind of book I tend to keep by my bedside for quiet perusal during downtime. While



USEFUL REFERENCES

PATENT EXPLORER CD-ROM **Research Publications, 1921 Jefferson Davis Hwy., Arlington, VA 22202, (703) 413-5050, $1995**

INFORMATION USA MULTIMEDIA CD-ROM FOR WINDOWS **Infobusiness, 887 South Orem Blvd., Orem, UT 84058, (801) 225-0817, $69.95**

Software developers may lose huge amounts of R&D dollars, or be forced to pay royalties, if they are not aware of existing patents of competitive products. Patent Explorer CD-ROM provides full-text descriptions of more than 10,000 software patents from 1972 to 1993. The CD-ROM does not rely on the U.S. Patent and Trademark Office's classification of software patents because that classification assigns many software patents to categories other than software. Instead, Patent Explorer CD-ROM has grouped software patents into clusters based on the technology each patent contains.

The full text of the software patent is provided, which may vary from a few paragraphs to several pages of description. A natural-language engine can search on full sentences in addition to individual keywords. In an age in which we're seeing more and more litigious behavior—witness Compton New Media's, Lotus's, and Borland's patent infringement lawsuits—this reference disc is an excellent source of existing software patents.

In the same vein, the U.S. government is a vast repository of useful information. The catch is that this information is difficult to find. The Information USA Multimedia CD-ROM for Windows aptly fills this void. It includes video, audio, and textual information on all 1261 Federal Domestic Assistance programs administered by 51 agencies, including contact addresses and telephone numbers. Subjects include educational grants and scholarships, labor statistics, market studies and research findings, tax advice, sources of loans, lists of surplus property, and more.

You can search on every word, print information in a variety of formats, write and edit notes within the software, and, in short, save a bundle of time and frustration getting information from the U.S. government.

—Rich Friedman

Books & CD-ROMs

it doesn't offer specific how-to information or in-depth technical coverage of desktop publishing considerations, it does provide a broad summary of where the industry is today, along with specific case studies of creative projects.

Each chapter features an in-depth look at how a real-world product is produced and how some of the newest technologies are being employed. The authors cite examples from the entire spectrum of professional applications of desktop publishing, including daily newspapers (*USA Today*), magazines (*Wired*), brochures (Ben & Jerry's), advertising, and package design. Interviews with people involved in the creation of these products provide insight into where the industry is going and what some of the pitfalls are.

The book also includes detailed lists of equipment and software used for each project and mentions the extent to which desktop publishing is used. Some operations are 100 percent desktop produced; others, for practical reasons, have had to devise hybrid systems that let them move slowly into the desktop arena. If I might paraphrase, desktop publishing is 90 percent perspiration and 10 percent inspiration. This helpful book provides the 10 percent needed to get the job done.

—Roger Goode

BOOKS FOR SORE HANDS AND WRISTS

REPETITIVE STRAIN INJURY, A COMPUTER USER'S GUIDE by Emil Pascarelli and Deborah Quilter John Wiley & Sons, ISBN 0-471-59533-0, $12.95

PREVENTING COMPUTER INJURY: THE HAND BOOK by Stephanie Brown Ergonome, ISBN 1-884388-01-9, $19.95

Repetitive strain injuries are on the upswing, according to the U.S. Department of Labor. *Repetitive Strain Injury, A Computer User's Guide* thoroughly explains the causes of the injury, describes what the authors believe is good treatment, and emphasizes prevention of the disability. This is done in a knowledgeable and accessible manner. The authors cite the epidemiology of this condition and explain who is most at risk. The book presents multiple checklists for recognizing the problem and its risk factors, along with advice on how to cope with the emotional component of the injury. From a physical therapist's point of view, the recommended program is good practice.

Preventing Computer Injury: The Hand Book describes and illustrates exercises that can be used to prevent repetitive strain injuries. It discusses hand positions and motions to avoid and suggests appropriate substitutes. The author does not go into any depth of medical description. Instead, she concentrates on the clearly defined and pictured preventive exercises and hand and body postures. Brown writes in a simple, accurate, and easily understood manner; this book will be helpful to anyone who sits at a keyboard. ■

—Lee Zaslow

Lee Zaslow teaches physical therapy at Hahnemann University in Philadelphia, Pennsylvania. You can reach her on BIX c/o "editors."

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Sooner or later, you'll get an "Out of Memory" message. Whether you have 1 megabyte or 16.

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Adding RAM to your PC just gives you more expanded or extended memory — accessible to some programs, but not to TSRs like fax utilities, device drivers or network utilities like Novell NetWare. Fortunately, there's an easy software solution to "out of memory" problems.

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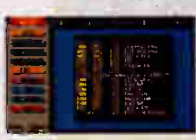

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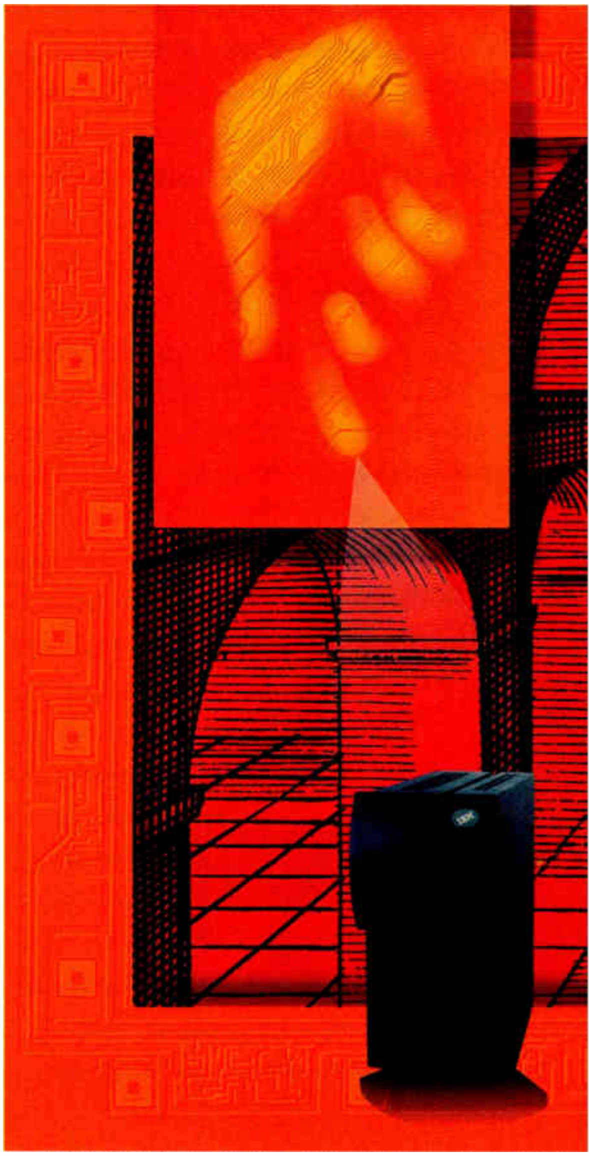
How we got the chart numbers: CPU—486/33 ALR Power/business VEISA machine equipped with 16 megs of RAM and running MS-DOS 6. Comparisons were done using the following memory managers: QEMM 7, QEMM 6.02, MS-DOS 6 MemMaker. In addition to the driver (or drivers) required by each memory manager, the following drivers, DOS resources and programs were loaded for all comparisons: in the CONFIG.SYS file: SETVER.EXE, DOS=HIGH, FILES=20, BUFFERS=10, STACKS=0,0, MVSOUND.SYS, SNDBK12.SYS, SLCD.SYS, DOS SHELL statement in the AUTOEXEC.BAT file: VSAFE, MSCDEX, UNDELETE, LSL.COM, NE2000.COM, IPXODI.COM, NETX OR EMSNETX, MOUSE.COM, SMARTDRV.COM, PRTSCCAP.COM.

Cover Story

APPLE, IBM BRING POWERPC TO THE DESKTOP



Apple and IBM want to change your concept of the desktop PC. Specifically, they want to throw out the notions that you pay a premium for going to the next performance level, that you are locked into one operating system by the hardware, and that the term *PC* automatically refers to an 80x86, CISC-powered system. To them, the PC as we know it is dead.

But long live the new PCs. Apple and IBM will introduce the first PowerPC systems this year. Preliminary benchmarks show that these systems will offer better-than-Pentium performance, in some cases at lower-than-Pentium prices. They discard the 10-year-old IBM AT architecture in favor of more flexible, open designs. And most obviously, they replace the venerable Intel 80x86 CPU with the RISC-based PowerPC.

Significantly, they accomplish this while providing compatibility for the huge installed base of existing CISC-processor software under both DOS/Windows and System 7. Yet portions of the underlying hardware and software are designed to enable totally new classes of applications that were simply not possible before because of performance constraints. On March 14, Apple started shipments of Macs based on the PowerPC 601. In the second half of this year, IBM plans to release desktop and notebook computers based on the PowerPC 601 and PowerPC 603, respectively.

continued

The first-generation PowerPC desktop systems from Apple and IBM have arrived. They offer blazing performance and unique features at affordable prices. The downside? Few native applications, slow software emulation, and unfinished system software.

TOM THOMPSON AND BOB RYAN

POWERPC ON THE DESKTOP

Apple's Power Macintoshes

- Three PowerPC 601–based desktop models running at 60, 66, and 80 MHz
- Prices starting at $2100 for a fully equipped system
- True Mac look and feel, plus a high degree of compatibility with existing applications
- A nanokernel allows the Power Macs to support both the PowerPC and emulated 680x0 architectures

IBM's Power Personal Systems

(see page 60)

- An attempt to establish a new standard architecture for the PC
- Eliminate hardware dependencies by separating the operating system from the hardware
- Planned support for OS/2, Windows NT, AIX, Solaris, and Taligent
- "Human-centered" user interface will eventually provide voice control, handwriting recognition, and agents

ILLUSTRATIONS: MARC YANKUS © 1994

A New Breed of Mac

Apple's PowerPC systems are called Power Macs. Unless you happen to notice the PowerPC logo on the housing, a Power Mac looks just like a regular Mac. It behaves like a regular Mac, too—except that it's much faster. Three systems are available, representing three price/performance levels. The Power Mac 6100/60 uses a 60-MHz 601 processor and costs $2209 complete with a keyboard and monitor—that's slightly less than what you would spend for a fully equipped Pentium PC when this was written. The Power Mac 7100/66 fills the midrange at 66 MHz and costs $3379. Finally, the Power Mac 8100/80 runs at 80 MHz and costs $4869.

Apple was able to achieve some cost savings by basing the Power Mac systems on existing 680x0 Mac chassis. This strategy also gives current 680x0 Mac owners the opportunity to upgrade to a Power Mac system by a main-logic-board swap.

Bundled with these Power Macs is system software that includes the QuickTime extension for multimedia support, PlainTalk text-to-speech and voice-recognition software, and AppleScript, which is a scripting language that uses high-level events to automate tasks and customize the operation of applications. More important, these systems also ship with Insignia Solutions' SoftWindows, an emulation package that can run DOS and Windows software. So, these systems offer you a choice of operating systems, a feature found in other RISC-based computers.

The Power Macs provide much of the AV Macs' capabilities in that the telephony, fax modem, and digital speech software is bundled with these computers. If you need the video capabilities, an AV Technologies card is available. It provides two S-video connectors and a DB-15 monitor connector. This AV card provides 24-bit video on the monitor and uses a new video chip set for video capture and scaling. It also has the DAV (digital audio video) connector found in the AV Macs.

For those who already own Macs, there are a number of upgrade options. If you have a Mac with the same chassis type as the Power Mac, a main-logic-board swap is available. For owners of other Macs, Apple offers a Power Mac Upgrade Card ($700) that plugs into a 68040 PDS (Processor Direct Slot). It has a 601 processor, Power Mac ROMs, and 1 MB of level 2 cache SRAM (static RAM) on it. The Upgrade Card uses a PLL (phase-locked loop) that doubles the clock speed of the host Mac's bus clock (i.e., an Upgrade Card plugged into a 33-MHz Quadra 800 runs at 66 MHz). The PLL circuit also helps keep the plug-in board's bus synchronized to the computer's CPU bus, which reduces data transfer delays between the two. DayStar Digital (Flowery Branch, GA) will also offer PowerPC accelerator boards for all color Macs.

With the Power Macs, the Mac OS is reborn, shedding the vestiges of its decade-old design so that it can grow in new directions. Gone are the segmented application architecture and single-mode operation. Now there's a nanokernel, supervisor and user modes, and DLLs, so the Mac OS can become a preemptive multitasking operating system. Future Power Macs will incorporate the PCI (Peripheral Component Interconnect) bus, a growing industry standard for computer peripherals. Finally, with Apple planning to license the Mac system software to other PowerPC systems designers, at long last the Mac will become a truly open standard (see "Apple Opens the Mac OS" on page 24). Apple intends to promote the unique features of the Mac OS—such as peer-to-peer file sharing, multiple network protocol stacks, color matching for output, and plug-and-play architecture—as the new operating-system standard for RISC computers.

Meet the Macs

The 6100/60 uses the same "fat" pizza-box chassis found on the Macintosh Centris 610/Quadra 610. The 8 MB of RAM is expandable to 72 MB by using 32-MB SIMMs.

Faster versions of the 6100 and other Power Macs will use the same name; only the trailing digits, representing clock speed, will change. This eliminates the product-line confusion created by Apple's previous naming scheme, where minor changes to existing Macs begot whole new model names. It also explicitly states the processor speed, which is useful when comparing systems.

The midrange Power Mac 7100/66 uses the Mac IIvx/Centris 650/Quadra 650 chassis. It has four 72-pin SIMM sockets that allow RAM to be expanded to 136 MB. Interestingly, the 601 PDS holds a display board containing 1 MB of VRAM (video RAM) that's expandable to 2 MB. This means that the 7100/66 comes out of the box ready to support a second monitor. With 2 MB of VRAM on the board, you can have 16-bit-deep video on 21-inch monitors.

One caveat is that the Power Mac's VRAM display board uses the old DB-15 video connector, while the built-in video port uses the new HDI-45 connector. The HDI-45 has extra lines to handle voice input and stereo sound I/O on Apple's AudioVision monitor. You'll need an adapter to plug an existing monitor's DB-15 cable into the built-in video connector, but not the VRAM display board.

The Power Mac 8100/80 is based on the Quadra 800/Quadra 840AV mini-tower design, with a 200-W power supply and internal bays for three hard drives. Eight 72-pin SIMM sockets can expand RAM from the standard 8 MB to 264 MB. Like the 7100/66, the 8100/80's standard configuration supports a second monitor. The VRAM display board plugged into the PDS comes with 2 MB of VRAM and is expandable to 4 MB. With 4 MB of VRAM, a second monitor attached to the VRAM display board supports 24-bit color on 21-inch monitors, making the system ideal for professional graphics and high-end imaging work.

Be aware that on these systems you're not required to use the built-in video. You can opt to connect a single

Power Macintosh Vital Statistics

Power Macintosh 6100/60
60-MHz PowerPC 601
160-MB hard drive

Power Macintosh 7100/66
66-MHz PowerPC 601
250-MB hard drive

Power Macintosh 8100/80
80-MHz PowerPC 610
250-MB hard drive

- ■■■ One Processor Direct Slot
- ■■■ 8 MB of RAM
- ■■■ 16-bit stereo sound I/O
- ■■■ Microphone
- ■■■ Built-in 16-bit video
- ■■■ SCSI bus
- ■■■ LocalTalk
- ■■■ Built-in Ethernet
- ■■■ Cache SIMM socket
- ■■ Three NuBus slots
- ■ Fast SCSI-2 bus

Left to right: the Power Mac 7100/66, the Power Mac 8100/80, and the Power Mac 6100/60. The systems are shown with an optional CD-ROM drive. A plug-in board provides AV capabilities.

monitor to the VRAM display board. The 8100/80 supports two SCSI buses (internal and external). The internal SCSI bus uses a fast SCSI-2 controller. Combined with the SCSI Manager 4.3 (first used in the Quadra 840AV), the controller enables SCSI-2 fast transfers of up to 10 MBps on the internal bus. To wring the best possible performance out of the 8100/80, its cache slot contains a SIMM that implements a level 2 cache with 256 KB of 14-nanosecond, synchronous SRAM.

Interiors

All the Power Macs use a common design, with only a few modifications for specific systems. They have 4-MB 100-ns ROMs mounted on a SIMM socket. The SIMM socket allows the possibility of upgrading the system software at a later date. These ROMs are twice the size of those found in the Centris 660AV and Quadra 840AV. They contain new features and some operating-system code that was formerly stored on the hard drive.

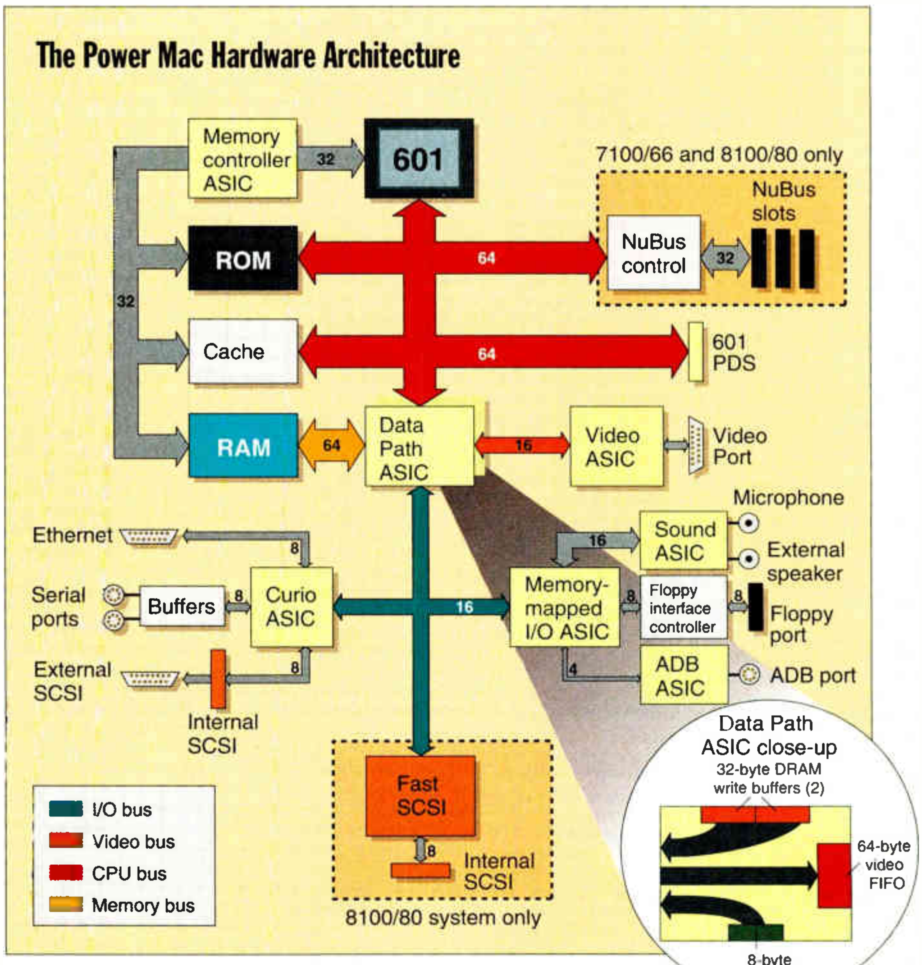
A 64-bit data bus links the 601 processor to the ROM, RAM, cache slot, and expansion slots (i.e., PDS and NuBus). The design supports a level 2 cache that's from 128 KB to 1 MB in size. The memory subsystem uses one- (up to 64 bits, or 8 bytes) or four-cycle (32 bytes) burst transfers to feed the ravenous appetite of the 601 processor. However, this subsystem does not support any of the 601's extended protocol-bus transactions that provide bus snooping to maintain memory coherency.

All three systems use 80-ns DRAM, which reduces system costs. Also, the CPU bus is clocked at half the rate of the processor (in other words, when the processor is clocked at 66 MHz, the CPU bus operates at 33 MHz). This lets the Power Mac design borrow existing 33- and 40-MHz components used in the Quadra 800 and 840AV. However, this design also exacts a performance penalty, because the memory subsystem injects a lot of wait states when accessing this slower DRAM.

The 601's own on-chip 32-KB cache minimizes some of the effects of this design compromise. So does the wider 64-bit bus, which moves twice the data per bus cycle than the Quadra's 32-bit CPU bus. Because of the wider bus, when you add extra memory to a Power Mac, the RAM SIMMs must be of the same size and added in pairs.

Placing faster RAM in the SIMM sockets won't boost performance because the memory-controller ASIC (application-specific IC) that controls memory accesses runs at fixed speed. It's possible to reprogram the timing on this ASIC to handle faster DRAM, but because the 8 MB of RAM on the main logic board is soldered down, any timing changes would be detrimental to this slower memory. However, the programmability of this memory controller means that you'll find it in future Power Macs that use faster memory. Unlike the Quadra 800 and 840AV, the Power Mac's memory is not interleaved.

A custom video ASIC integrates a CLUT (color lookup table) and a DAC (D/A converter) to implement the Power Mac's built-in video. For 14-inch monitors (640 by 480 pixels), the built-in video



The Power Macs use a 64-bit data bus for high performance. A Data Path ASIC buffers the video data and blasts it to the 16-bit video bus in eight cycle bursts. Another buffer handles processor writes to DRAM. The Data Path ASIC can manage two bus operations in parallel: While it fetches data from DRAM and pumps it to the video ASIC, it simultaneously handles processor accesses to the I/O bus or memory. Notice that the 64-bit ROMs, expansion slots, and cache slot reside on the CPU bus, isolated from DRAM by the Data Path ASIC. This lets the 601 access these devices without bus contention.

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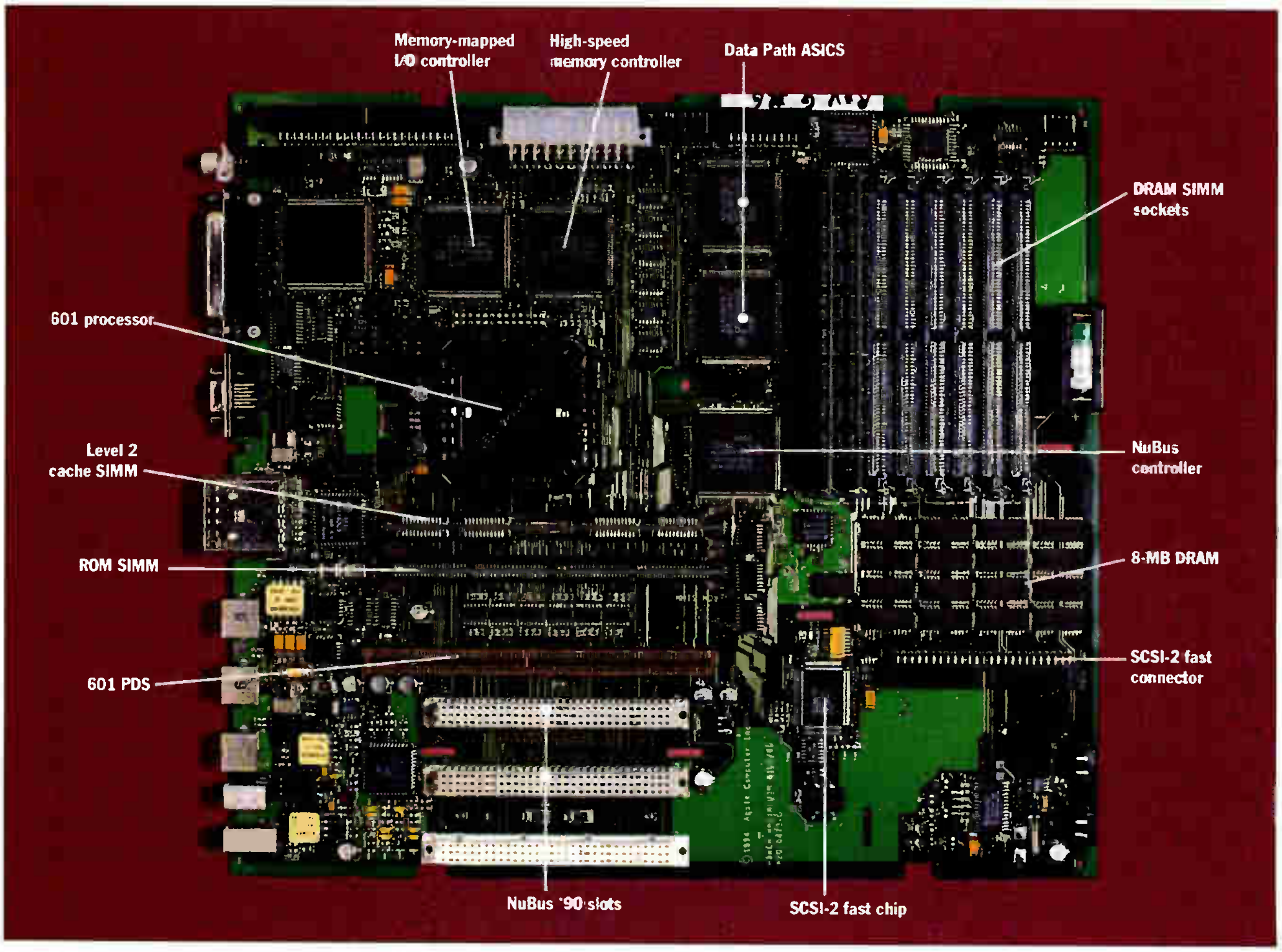


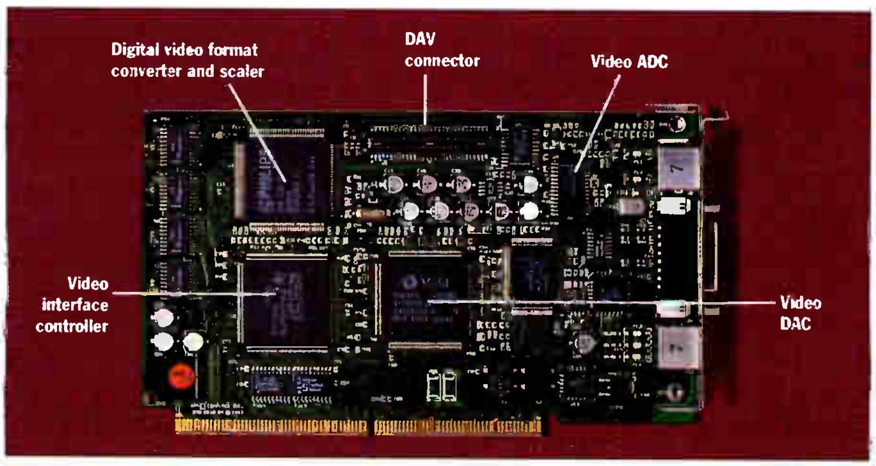
The main logic board of the Power Mac 8100/80. The ROMs are 4 MB in size and contain both 680x0 code and PowerPC code.

supports a color depth of 16 bits. For 16-inch monitors (832 by 624 pixels), the color depth is 8 bits. The cost compromise here is that the built-in video's frame buffer resides in main memory and consumes 600 KB. As with previous Mac systems that used this design, there's a performance hit when both the processor and the video circuitry contend for access to DRAM.

Apple's solution to this problem is another custom ASIC, called the Data Path. Two of these Data Path ASICs sit squarely in the middle of four buses: the CPU bus, the I/O bus, the memory bus, and the built-in video bus. These Data Path ASICs handle byte lane routing between the 64-bit buses and 8- and 16-bit I/O devices. They also buffer transfers among the CPU, I/O, memory, and the video bus.

Because the 601 spends most of its time accessing ROM code or the cache, this design minimizes any bus collisions when the built-in video is in use. Of course, there are a few pathological situations where a program might copy off-screen video data to the frame buffer, which defeats this design. On the plus side, owners of the 7100/66 and 8100/80 can opt to use only the VRAM display board, thus eliminating use of the built-in video and avoiding its performance penalty. The Data Path ASICs in this instance still minimize bus contention among the processor, memory, and I/O subsystems.

For high I/O throughput, the Power Macs have a custom I/O ASIC that handles Ethernet, serial, and SCSI I/O. It provides two 8-byte FIFO (first-in/first-out) buffers for serial I/O. The I/O ASIC implements an NCR 53C94 SCSI-2 controller chip and has a maximum transfer rate of 5 MBps. On the Power Mac 8100/80, a second SCSI-2 controller chip, the NCR 53CF96-2, is connected to an internal 50-pin SCSI bus. By using SCSI-2 fast transfers, this



The AV Technologies card provides digital video capture and manipulation functions.

internal bus can attain a transfer rate of 10 MBps and would be useful for implementing internal RAID arrays. The I/O ASIC also has a 50-pin internal connector that handles slow internal devices like the optional CD-ROM drive.

The Power Macs provide the usual two serial ports. Both ports use the new nine-pin GeoPort connector that is plug-compatible with existing mini-DIN-8 connectors. Either port can be configured for GeoPort modem/telephony or AppleTalk protocols (i.e., the LocalTalk network connection is no longer restricted to the printer port, and the GeoPort connection is no longer limited to the modem port).

Another custom ASIC melds a waveform amplifier with a 16-bit digital sound encoder/decoder to handle the Power Mac's sound I/O. This sound ASIC manages 16-bit, 44.1-kHz stereo sound I/O and sound input through the Power Mac's built-in microphone. The ASIC also assists the system software with PlainTalk speech-recognition and speech-generation software.

For maximum compatibility with the existing installed base of NuBus expansion boards, the Power Macs offer NuBus slots. Future Power Macs will employ the PCI bus when PCI expansion boards become plentiful. The NuBus slots on the Power Mac 7100/66 and 8100/80 follow the NuBus '90 specification, supporting 20-MHz transfers between NuBus boards. The NuBus controller ASIC that connects these slots to the CPU bus can act as a bus master. NuBus block transfers between boards are supported. On the 8100/80, the NuBus ASIC supports block transfers to and from the CPU bus. The controller enables direct access between RAM or ROM and the NuBus boards, but not to I/O devices.

A custom memory-mapped I/O controller ASIC provides the control and logic signals for most I/O devices in the system, except the built-in video. It provides DMA channels for Ethernet I/O (two channels), the floppy drive, the serial ports (four channels), sound I/O (two channels), and SCSI (two channels—one for the regular SCSI bus, and one for the fast SCSI). The DMA can relieve the 601 processor of the chore of transferring data between memory and these devices and allow it to spend processing power on more crucial tasks.

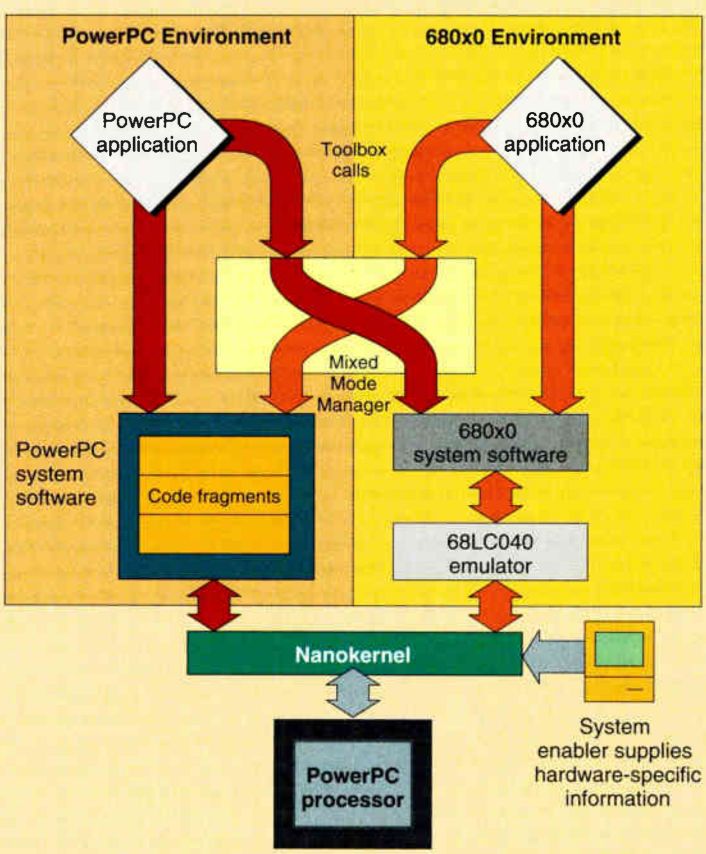
It's important to note that because the serial ports use DMA, this also provides DMA support for LocalTalk transfers. Previous LocalTalk implementations required extensive processor overhead to reliably manage AppleTalk packet transfers. The Power Mac DMA design leveraged off the experience gained from the AV Macs, which were the first Macs to extensively use DMA channels to manage device I/O.

Note that while the Power Macs have DMA channels, they can't be used effectively at this time, because most drivers and applications currently use synchronous I/O calls (i.e., the driver or function waits until the requested I/O operation completes). If the software is retooled to use asynchronous calls, applications will be free to perform other tasks while the I/O operation occurs. When the operation completes, the driver calls the application's completion function so that it can deliver a buffer of data (e.g., a read operation) or a status value.

The AV Macs use a DSP (digital signal processor) to handle voice-recognition preprocessing (i.e., echo cancellation from the walls of the room and other acoustic effects); sound generation; and modem, fax, and telephony functions. On the Power Macs, the PowerPC processor handles these tasks. A demonstration showed the 8100/80 handling a 2400-bps fax transmission while still recognizing voice commands. This is a distinct improvement over the Quadra 840AV, where you can use the modem/fax functions or the voice recognition, but not both. While the 601 appears to have plenty of power to bear on these sorts of things, you'll have to wait and see if this is the best solution, especially for the 6100/60 and 7100/66.

Apple has made some intelligent compromises in the first-generation Power Mac design. Cost-driven decisions like the slow RAM are partially canceled out by performance-driven choices like the wider data bus and burst transfers. There's room for faster systems with the basic hardware. According to Jonathon Fitch, one of Apple's PowerPC hardware managers, the custom ASICs "were designed to be compatible with the 603 and 604 buses."

Power Mac Processor Support



The Power Mac supports two different processor architectures simultaneously. The nanokernel provides a hardware abstraction layer, which the PowerPC system software and a 68LC040 emulator use. A Mixed Mode Manager handles context switches between the two environments.

System Software

A Power Mac presents no surprises to the seasoned Mac user. It boots like a 680x0 Mac, using the prerequisite System enabler file tailored for the Power Mac's hardware, and runs System 7. However, this resemblance is only superficial, because the core system software is fundamentally different. These changes go far beyond recompiling the system software for a different processor. The system's run-time architecture has been completely revamped. It provides a simple and clean design that will ultimately support a future microkernel-based operating system. However, it also supports the existing 680x0 application architecture.

continued

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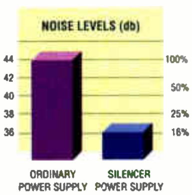

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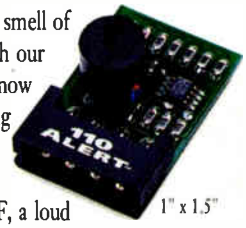

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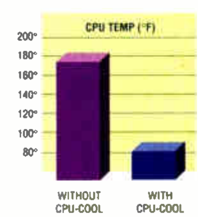

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Cover Story

How the Power Macs Measure Up

BY TOM THOMPSON

While Apple's Power Macs represent a tremendous technical achievement in providing compatibility with the existing software base, the question everyone will ask is: How fast are they? Answering this question required running the BYTE low-level and application benchmarks (which test the 680x0 emulator), the BYTE native benchmarks (which test native performance), and two Windows applications (which check the 80x86 emulation). These results were on preliminary systems, and Apple plans a system software release this summer that will make more of the Toolbox code native.

Power Mac performance ranges from that of a IIci (which uses a 20-MHz 68030) to better than that of a Quadra 840AV (which uses a 40-MHz 68040), depending on how much native Toolbox code the application uses during the course of operations. The application benchmark results are skewed downward, because Excel and Mathcad, upon detecting the lack of an FPU (because the emulator reports that it's a 68020), did their own computations. This kept execution in the emulator, impairing performance. The word processing test, which makes heavy use of native QuickDraw code, shows better results: The low-end 6100/60 outgunned a Quadra 950 (a 33-MHz 68040 system), and the 8100/80 did better than the Quadra 840AV.

Native results showed that the 6100/60 and 7100/66 trailed the RISC systems BYTE tested (see "Windows on RISC" on page 109), but this was because they lacked the level 2 cache that most of the other RISC systems possessed. (An optional level 2 cache SIMM is available for these Power Macs.) The 8100/80, with a 256-KB level 2 cache as standard equipment, fared much better, posting an overall index close to that of the Sun SparcStation 10.

Windows emulation, supplied by Insignia Solutions, was on par with other RISC systems—slow. Excel 4.0 and Word for Windows 2.0 benchmarks indicate that even lacking the level 2 cache, the 6100/60 and 7100/66 were in the middle of the RISC pack on word processing tasks. The 6100/60 trailed the pack on spreadsheet operations, while the 7100/66 did as good as the DEC Alpha, and the 8100/80 was on par with the 200-MHz Carrera Cobra. Considering that the prices of the RISC pack range from $4000 for a basic system up to $25,000, the Power Macs do an impressive job.

Again, remember that performance is a moving target here. The Power Macs will get faster in the future as Mac applications are ported to native code, which eliminates the overhead of the emulator. Also, Apple plans to keep moving more of the Toolbox to native code, and these changes will be distributed periodically with system software releases.

MAC LOW-LEVEL AND APPLICATION INDEXES

LOW LEVEL	QUADRA 840AV	POWER MAC 6100/60	POWER MAC 7100/66	POWER MAC 8100/80
CPU	7.11	2.96	3.34	4.08
FPU	57.64	26.22	29.98	36.32
Disk	2.85	2.51	2.53	3.28
Video	7.62	4.48	5.86	7.29
APPLICATION				
Word Processing	2.61	2.25	2.45	3.68
DTP	4.50	2.11	2.28	3.32
Database	6.28	3.84	4.21	5.98
Development	4.25	2.83	3.09	3.58
Graphics	4.57	2.50	2.63	3.37
Scientific	14.25	6.29	6.62	9.20
Spreadsheet	13.23	2.36	2.62	3.78
Overall	49.69	22.18	23.91	32.89

SPREADSHEET AND WORD PROCESSING PERFORMANCE INDEXES UNDER EMULATION

	SPREADSHEET	WORD PROCESSING
IBM PowerStation 250 (Wabi)	0.14	0.14
DeskStation Tyne v4633v (Wabi)	0.21	0.21
Sun SparcStation 10 (SunPC)	0.21	0.25
Sun SparcStation 10 (Wabi)	0.08	0.19
HP 900 Series 700 (SoftWindows)	0.21	0.28
HP 900 Series 700	0.21	0.47
DEC Alpha 200 AXP	0.14	0.32
NEC RiscServer	0.24	0.47
Carrera Cobra	0.18	0.29
PowerMac 6100/60 (SoftWindows)	0.12	0.34
PowerMac 7100/66 (SoftWindows)	0.14	0.31
PowerMac 8100/80 (SoftWindows)	0.18	0.45

NATIVE PERFORMANCE INDEXES

Carrera Cobra	3.61
DeskStation Tyne v4633v	2.88
NEC RiscServer	2.73
IBM PowerStation 250	2.57
HP 900 Series 700	2.36
DEC Alpha	2.22
Sun SparcStation 10	1.96
PowerMac 8100/80	1.90
PowerMac 7100/66	1.50
PowerMac 6100/60	1.37

The Power Macs compare favorably with other RISC systems on the Windows emulation. Native performance was lower, but the 6100/60 and 7100/66 lacked a level 2 cache, as did the IBM PowerStation 250 and HP 900 Series 700. The native benchmarks were compiled using a beta version of the MPW PowerPC compiler. On all results, a higher number indicates better performance.

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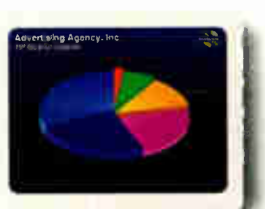

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Inside the 4-MB ROMs, you find the usual suspects: Toolbox code (i.e., functions that provide application interface services like window creation and menu selection), operating-system functions (e.g., file I/O, allocating memory, and device drivers), and QuickDraw (i.e., the imaging engine). There are also some new features, such as a 68LC040 emulator and the Mixed Mode Manager (used to handle context switches between 680x0 emulated code and PowerPC code).

SCOTT PARKER, AVIS STUDIO © 1994

"How will [RISC PCs] interface with our Banyan Vines network?"

— Bruce Smith MIS Director EVSR Consulting and Engineering

Last but not least, these ROMs also contain a nanokernel. This nanokernel acts as a thin hardware-abstraction layer that provides low-level interfaces for interrupts, exception handling, and MMU (memory management unit) operation. It's also responsible for booting the system and initializing the 68LC040 emulator. The nanokernel's interfaces are private and are used only by the operating system.

Significantly, the nanokernel is the only supervisor-mode code in the Power Mac, while everything else—including the operating system—runs in user mode. Previously, nearly all Mac software, including applications, ran in supervisor mode. This probably simplified the system software design for early 680x0 Macs, but it created problems in making improvements to the system software later.

Because applications ran in the same mode as the operating system itself, it made implementing memory protection difficult. Also, there was nothing to prevent an application from executing privileged operating-system-level instructions. Because only the nanokernel runs in supervisor mode, it provides core functions that will evolve into a microkernel that supports preemptive scheduling, multiple address spaces, task synchronization, message passing, and other sophisticated operating-system services.

The run-time architecture of system software and applications has seen a dramatic change . Instead of the 32-KB segmented code structure used in 680x0 applications, the Power Mac uses *code fragments.* A code fragment is the basic unit of executable PowerPC code and its associated data. Code fragments can be any size; native Power Mac applications are actually single code fragments. Code fragments can export or import symbols that represent functions or data. Portions of the ROM code are shared-library code fragments that export symbols for use by the operating system and applications. At run time, on the launch of an application, a Code Fragment Manager resolves these symbols into physical addresses, a process that is called *dynamic linking*.

This setup allows applications to easily access information. Under the 680x0 architecture, timing tasks, plug-in modules, and extensions required programmers to write assembly language code to access data within an application or the operating system. Now you simply export or import the data and functions that you need from within the high-level programming language.

Code and data are handled as separate objects by the dynamic linking mechanism. This design enables the operating system to perform some rudimentary memory protection. Because the code portion of a fragment isn't segmented and contains no data, the operating system treats it as a read-only object. With virtual memory on, a fragment's code gets loaded into memory that the MMU then marks as read-only. If an errant application attempts to write to this portion of a fragment, it immediately generates an exception error.

Because a code fragment's variables are frequently updated, they reside in an area of memory with read/write access. Bogus writes to data variables can't be detected with this scheme. Nevertheless, the current memory-protection scheme in the Power Mac goes a long way toward making the operating system more robust.

While the current virtual memory implementation was grafted onto the existing 680x0 Mac architecture, the Power Macs have virtual memory designed into them from the ground up. The separate code and data sections of the code fragments enable a faster, more efficient virtual memory system. When more memory is required, because the code sections of the fragments in RAM are read-only objects, they are simply discarded. Only the data portions of the code fragments have to be written to the virtual memory's disk swap file. Also, a new Memory Manager that's fine-tuned for RISC processors has been implemented for the Mac OS. For compatibility, the Memory Control Panel lets you run the Power Mac using the old CISC-tuned Memory Manager as may be necessary.

Mixed Mode and Emulation

As mentioned earlier, the Power Mac ROMs contain a 68LC040 emulator and Mixed Mode Manager to support existing 680x0 application binaries. The emulator implements all of the 68040 user-mode instruction set. With an assist from an ASIC, the emulator can queue and handle 680x0 processor interrupts.

However, for compatibility with the widest range of 680x0 applications and drivers, the emulator uses a 68020 exception stack frame. It doesn't support any MMU or FPU instructions. That's because MMU operations are the responsibility of the operating system, and floating-point calculations can be handled by using either the Mac's hardware-independent SANE (Standard Apple Numeric Environment) API or PowerPC 601 floating-point instructions.

The emulator is comprised of two components: a lookup dispatch table and a code block that contains functions pointed to by the dispatch table. When a 680x0 instruction is processed, it goes through the dispatch table. If a single 601 instruction can handle the 680x0 instruction, that instruction is found in the dispatch table. Otherwise, the dispatch table points to a sequence of PowerPC instructions that emulates the 680x0 instruction.

The dispatch table also contains entries for *A*- and *F*-line 680x0 processor trap instructions. Because Apple uses the *A*-line trap as a mechanism to implement the entry points into the Mac Toolbox and OS, this feature allows an emulation of the original 680x0 trap dispatch tables used by the Mac software (not to be confused with the PowerPC emulator's dispatch table). It also enables existing 680x0 extension files—which add enhancements to the system software by patching the trap table—to function.

While the lookup-table design makes for faster instruction processing, let's face it: Emulation does exact a performance

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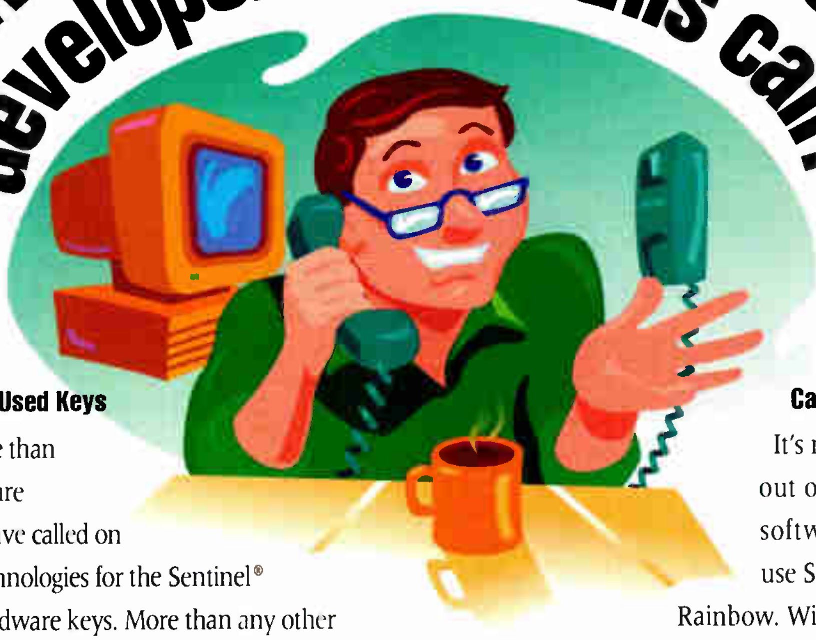

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penalty. Apple did code profiling of Mac applications and determined that they spent 60 percent to 80 percent of their time in Toolbox code. Thus, if the Toolbox code could be written as PowerPC code, the result would be that emulated 680x0 applications would run faster than expected because the application would spend more time in PowerPC code than in the emulator.

Apple therefore rewrote about 16 percent of the most heavily used Toolbox calls in PowerPC code so that 680x0 applications could benefit from this characteristic of the run-time environment. The Toolbox calls rewritten for the first Power Macs include portions of the following: QuickDraw, the Font Manager, TrueType, QuickTime, the Resource Manager, the Memory Manager, fixed-point math, SANE, and the Script Manager (for foreign-language support). Again, not all the calls in these managers were ported. only the most heavily used ones.

Apple's reason for not rewriting all the Toolbox code is twofold. First, rewriting it would delay getting the Power Macs onto the market. Second, it could introduce compatibility problems. Apple plans to rewrite more of the Toolbox over time, so Power Macs will become faster as system software upgrades are introduced.

This setup does introduce the complication that the Mac OS must maintain two radically different instruction-set architectures as the software executes. A Mixed Mode Manager handles the context switches between the two environments. It uses new header information embedded in the Toolbox calls, known as *routine descriptors*, to take the arguments passed to the function, massage the PowerPC stack appropriately, and transfer control to the appropriate code fragment. On return from the PowerPC code, the Mixed Mode Manager adjusts the stack again (so the function results appear in the appropriate emulated 680x0 processor registers) and restarts the emulator. The overhead of a context switch is roughly 50 to 100 680x0 instructions.

This overhead incurred by the Mixed Mode Manager doesn't seem bad. However, many Toolbox functions call other Toolbox functions, which in turn call still other Toolbox functions. These "call chains" can execute rapidly as long as no context switches occur. Unfortunately, when Apple rewrote some of the Toolbox code, certain Toolbox functions actually became slower because the call chain these functions threaded caused two or more instruction-set-architecture context switches.

JEFFREY YARDAS © 1994

"[RISC PCs] will be an improvement for the knowledge makers, the decision-making process, and the decision makers."

—Joe Correira
VP of Technology
The Travelers, Inc.

The solution was to write critical Toolbox functions in both PowerPC and 680x0 code, creating a "fat trap." Because the Mixed Mode Manager knows what instruction-set architecture the software is currently in, and Toolbox routine descriptors describe the instruction-set architecture of the next function, it can keep a call chain in the current instruction-set architecture when necessary for maximum performance. All these efforts are usually hidden from software developers, unless they're writing special programs (e.g., plug-in modules, I/O completion functions, or extensions). In this case, the only extra code the programmer writes is routine descriptors that describe the function's arguments and the instruction-set architecture it uses to the Mixed Mode Manager.

Works As a Mac Should

Compatibility with 680x0 software was simply superb. After extensive testing with dozens of applications, we discovered only a handful of applications that didn't work on a Power Mac. Some applications (e.g., Aldus PageMaker 4.0 and Microsoft Word 4.0) that crashed or ran erratically on Quadras worked without a glitch on the Power Macs.

Even more amazing was that all the usual Control Panels and extensions worked, even those that patched the 680x0 trap table heavily. For example, Shiva's networked modem software, which patches the serial interface, and Adobe Type Manager 3.6, which patches QuickDraw so that it can rasterize PostScript fonts on the fly, continued to work.

The real potential of the Power Macs appeared in our limited tests with beta versions of native applications. For example, we used Adobe Photoshop 2.5 and a native beta version of Photoshop to perform some editing tasks on a 15.7-MB 24-bit-color scanned image. On a Power Mac 8100/80, the native application was twice as fast as the 680x0 application. In certain situations, the native application was even faster. An unsharp mask-filter operation on the file took 335 seconds using the 680x0 application, while the native application finished the job in 85 seconds—easily four times faster.

BYTE's cross-platform benchmarks show that the Power Mac 6100/60, with an index of 1.37, delivers Pentium-caliber performance. The Gateway 2000 P5-60, Ambra DP60E/VL, and ALR Evolution V, all 60-MHz Pentium systems, posted native averages of 1.41, 1.33, and 1.45, respectively. Of course, the Power Mac 7100/66 and 8100/80 had higher indexes.

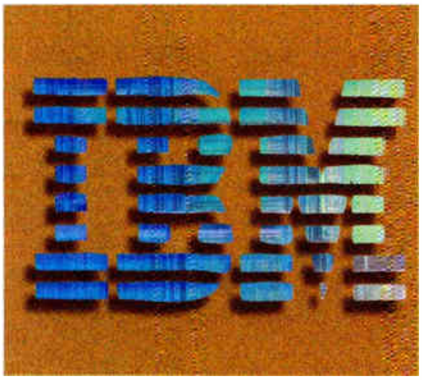
The Winds of Change

The Power Macs deliver plenty of horsepower, especially in the area of floating-point calculations, to enable a host of new applications. Adobe, Aldus, and Macromedia are retooling some of their graphics applications to take advantage of the PowerPC's strengths. Multimedia applications, which process a lot of digital video and sound, especially stand to benefit. There's also power to spare for *agents*—which could be AppleScript programs or other programmable applications—that quietly operate in the background or are started with a PlainTalk voice command. These agents might search databases or retrieve and sort the day's E-mail as you work.

Then there's the fact that you can have Windows running simultaneously with System 7. This is particularly true of the Power Mac 7100/66 and 8100/80, where you can have two monitors, each one dedicated to a different operating system.

RISC PCs such as the Power Macs "will be an improvement for the knowledge makers, the decision-making process, and the decision makers," says Joe Correira, vice president of applied technology at The Travelers Insurance Companies (Hartford, CT). The extra processing power on the desktop will let it perform data analysis that is traditionally handled by mainframes or minicomputers, he says.

continued



IBM Power Personal Strategy

If anything, IBM's plans for the PowerPC are more ambitious than Apple's. IBM wants nothing less than to create a new PC standard around the PowerPC family of chips.

In this context, the term *PC* requires some explanation. At the most basic level, a PC is a system that runs DOS and Windows on an 80x86 processor. The software communicates with the processor through a specific, well-defined hardware and firmware interface. This interface was defined de facto in the design of the original IBM AT in 1984 and is perpetuated in the BIOS and interface chip set contained in every PC-compatible computer. It is now so complex that the definitions of its different functions fill a 1200-page reference book (*PC Interrupts, Second Edition: A Programmer's Reference to BIOS, DOS, and Third-Party Calls,* by Ralf Brown and Jim Kyle. Addison-Wesley, 1994).

In addition to the design definition, however, the term *PC* also implies a functional definition. A PC is a computer you use to run widely available, shrink-wrapped personal-productivity applications and to connect to departmental and enterprise-wide shared resources. Workstations, by way of contrast, are used more as scientific and engineering tools and are considered incomplete if they don't come with a compiler. By this definition, the Mac also qualifies as a PC.

It is this second definition that IBM is targeting with its PowerPC-based systems. It wants to create a flexible platform definition for systems that function as PCs. It wants to stimulate a robust, independent market for third-party hardware, operating-system, and applications-software developers. IBM intends to compete at many levels in this market—as a component, system, and operating-system vendor—but the company fully realizes that a PC standard that isn't available from multiple vendors and subject to competitive pressures can't hope to make major inroads against the Intel-based DOS/Windows juggernaut.

To create such a standard—and to develop such a market—IBM has launched the IBM Power Personal Systems Division, with development facilities in the following locations: Austin, Texas; Boca Raton, Florida; and Yamato, Japan. In addition to developing IBM's PowerPC-based PCs, the division is also charged with establishing the standard for such systems and developing technologies to advance the standard. The Power Personal Systems Division publishes the definition of standard PowerPC systems in the PReP (PowerPC Reference Platform) specification.

Inside PReP

First published in alpha form in late 1993, PReP defines the devices, interfaces, and data formats that make up a PReP-compliant system. Its purpose is to let vendors create systems that, when accessed via the hardware-abstraction layer of supported operating systems, will be compatible with all other PReP systems. PReP also contains recommendations for the minimal functionality of different types of systems: notebooks, desktops, servers, and so on. Vendors can add value by building on this minimum specification.

The common ingredient in any PReP system is a PowerPC processor. The PowerPC architecture was jointly defined by Apple, IBM, and Motorola; the instruction set demonstrates its PC bias. For example, one of the features of the instruction set is its multiply-accumulate instruction, which makes it relatively easy to implement DSP functions on the PowerPC. Signal processing, of course, is the core technology used to implement sound and video processing on PCs.

This multimedia slant is carried through into the chip implementations. In the 601, for example, the performance of single-precision, floating-point operations is optimized at the expense of double-precision performance. The rationale is that multimedia signal processing doesn't need double precision. Fast double-precision performance is required by scientists and engineers—the types of people who buy workstations, not PCs. In fact, although the 601 is fully IEEE-754-compatible, it also implements a fast "sleaze" mode that can be used by applications that don't require the iron-plated protection of the IEEE floating-point specification.

A memory-mapped I/O system lets the processor communicate with I/O devices using load/stores. The I/O subsystems must be able to translate load/store addresses in the memory space of the processor into I/O addresses that the external devices can understand. Optionally, a PReP system can have I/O devices that have their own memory—a graphics buffer is the most common example—and a level 2 cache.

In addition to hardware requirements, the PReP specification sets down some architectural rules. PReP systems have a layered topology, with the processor, level 2 cache, and system memory connected to the processor bus, and I/O subsystems connected to I/O buses. These I/O buses

The PReP Minimum Requirements and Goals

Requirements

Processor: PowerPC

Memory: 8 MB, 16 MB recommended minimum

Other memory: system ROM for the start-up code, 4 KB of nonvolatile RAM for configuration information, and a memory-mapped I/O system

Mass storage: 80 MB; 200 MB is recommended

Hard drive controller: IDE or SCSI

Floppy drive: 3½-inch 1.44-MB MFM

CD-ROM (optional): ISO 9660; SCSI bus recommended

Input devices: keyboard or other alphanumeric input device and a pointing device, such as a mouse, connected with either the Intel 8042AH or Apple Desktop Bus

Audio: 16 bits at CD audio sample rates

Graphics: 8 bits, 640 by 480 pixels; higher-resolution, higher-color graphics recommended

I/O ports: EIA-232C serial port supporting at least 19.2-Kbps and bidirectional Centronics parallel port; IEEE P1284 Enhanced Capability Port recommended

Expansion bus: none required, but PCI, ISA, or PCMCIA strongly recommended

Other: real-time clock, DMA, interrupt controllers, timers, and configuration registers, with the DMA subsystem being capable of addressing 32 bits

Goals

- **Create an open standard.**
- **Target traditional types of systems.**
- **Use readily available components.**
- **Support standard buses and interfaces.**
- **Allow differentiation while maintaining compatibility.**
- **Keep hardware details hidden from software.**
- **Promote operating-system-based power management.**

The PowerPC Family

First PowerPC
Architecture: 32-bit
Superscalar: 3-issue
Clock: 50, 66, and 80 MHz
Performance: 85 SPECint 92, 105 SPECfp 92 at 80 MHz
Available: Now

Power-Managed
Architecture: 32-bit
Superscalar: 3-issue
Clock: 66 and 80 MHz
Performance: 75 SPECint, 85 SPECfp at 80 MHz
Available: Now

Fast Double-Precision Floating-Point
Architecture: 32-bit
Superscalar: 4-issue
Clock: Not available
Performance: Not available
Available: Second half of 1994

Will Challenge DEC Alpha
Architecture: 64-bit
Superscalar: 6-issue
Clock: Not available
Performance: Not available
Available: First half of 1995

can be cascaded onto one another, with bridges connecting them to one another and to the processor bus. Other architectural issues covered in PReP include bi-endian support, word alignment, multiprocessing, memory maps, configuration and testing, and power management. PReP recommends that all systems be power-managed and defines five system states—Full On, Enabled, Standby, Suspend, and Off—and the power characteristics of each.

The PReP ROM

An important aspect of the PReP specification is the ROM. Here, IBM defines how PReP systems present a compatible interface to supported operating systems.

As IBM—and almost everyone else—sees it, the biggest problem with the AT architecture is that it is defined in hardware. It is thus difficult to evolve the architecture as technologies evolve and at the same time maintain compatibility with the software base. IBM avoids this problem in the PReP specification by keeping the supported operating systems at arm's length from the hardware. PReP relies heavily on hardware abstractions in both the operating system and its own ROM to eliminate hardware dependencies in the operating system.

Unlike the AT, where the system ROM is accessed for as long as your system is turned on, the PReP ROM is designed to initialize the hardware, pass system information to the operating system, and get out of the way. After booting, the PReP ROM is never accessed again.

The start-up process consists of the following steps. First, when you turn the power on, the processor begins execution at address 0xFFF00100, the initial location of the system ROM. This is the entry point for the start-up code and the only "hard-wired" address in a PReP system.

The start-up code makes sure the processor is working and configures base memory. It then copies itself to base memory and continues execution from there. Once in RAM, the start-up code initializes the system console—which is usually the video adapter—so that it can display messages on the screen. It will usually find information about the console, and later about the boot device, in nonvolatile RAM. The next step in the start-up is configuring and testing the rest of system memory, followed by initialization of the interrupt subsystem, CMOS real-time clock, keyboard, and mouse. The start-up code also asks for your password.

The final step in the start-up is booting the operating system. The start-up code first configures and initializes supported boot devices to the point where it can load the boot record and image. Other configuration and device-driver binding is left to the operating system. Boot devices that are supported at start-up may include hard drives, floppy drives, CD-ROM drives, or network adapters.

The code searches the devices for a valid operating-system boot record. When it finds one, the start-up code loads it and discovers the location of the boot image. It then loads the load-image portion of the boot image and passes control to it. The operating system then takes control, overwriting the start-up code in memory. The boot record and image are extensions of their PC counterparts, ensuring that PC and PowerPC media are both compatible and interchangeable.

The current boot process is not the final word in how PReP start-up code will operate. One of the strategic objectives of PReP is to support Open Firmware, the IEEE P1275 standard for boot firmware (see the text box "Open Firmware Provides CPU Independence" on page 62). One of the reasons that IBM put the start-up code of its PReP-compliant systems into flash ROM is to be able to upgrade easily to Open Firmware.

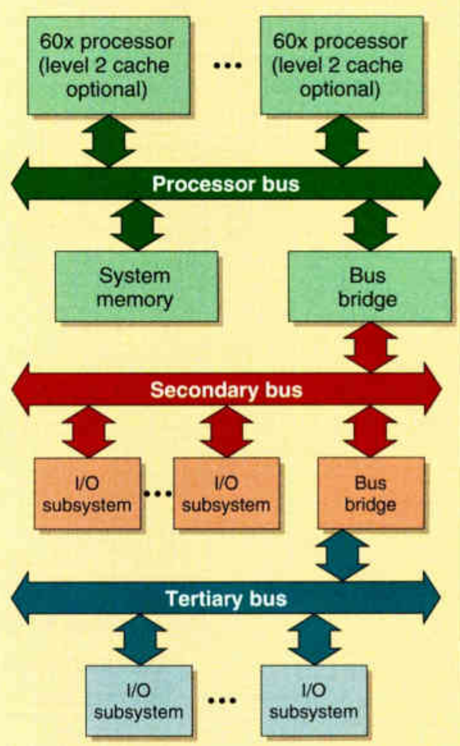
Abstraction to Abstraction

While the boot process does overwrite the start-up code, it doesn't overwrite the residual data structure created by the start-up code in nonvolatile RAM. This data structure contains configuration information about the system, and this information is made available to the hardware-abstraction layer of the operating system. Some operating systems will use these structures directly; others may translate them into a more compatible format.

The PReP specification defines the minimal amount of system information that an operating system must be able to abstract in order to be PReP-compliant. PReP doesn't care how this abstraction is handled by the operating system, only that the operating system handle it.

The operating system must be able to abstract general information such as system memory size, type, and location. It must be able to construct an I/O map that lists the location and type of all buses and of all devices on those buses, and information about the system processor. It must be able

PReP Topology



PReP systems can incorporate many different bus types into a hierarchical structure. At the top is the processor bus, which connects one or more processors and their caches to both system memory and system I/O. Connection to system I/O comes via a bus bridge to a secondary bus; in most PReP systems, this secondary bus will be PCI. The secondary bus can then bridge to a tertiary bus, such as ISA, and so on.

Open Firmware Provides CPU Independence

RICK GREHAN

Suppose for a moment that you're an adapter card. You get plugged into a PCI (Peripheral Component Interconnect) bus and powered up. You have no idea what kind of CPU your host is, but you're expected to (among other things) provide code to the CPU so it can initialize whatever device you're controlling, determine characteristics of the device, and perhaps even boot from the device. What are you gonna do?

Well, you could have your ROM crammed with executable code for every conceivable processor and provide a table that tells the host: "If you're an Intel 80x86, your code is over *there*; if you're a Mips, your code is over *there*; if you're an Alpha, your code is over *there*." and so on. What happens, however, when you get plugged into a system with a brand-new CPU (they're appearing all the time these days) that your designers didn't know about when they burned your ROM?

The above scenario describes precisely the problem that is facing peripheral designers today:They're confronted with platforms hosted by a growing diversity of CPUs. The answer, of course, would be a kind of CPU-independent machine code that can be placed into the adapter's ROM. Right?

Actually, CPU-independent code is only part of the solution, although it's an important part. Both CPU motherboard and adapter-card designers need a clear, agreed-upon set of specifications describing not only the CPU-independent software's syntax, but what services should be provided by code written in that software so that the host has all it needs to get devices up and running.

An Open Solution

One solution is nearing completion even as this article is being written. The IEEE P1275 Standard for Boot Firmware working group, called Open Firmware for short, is chaired by Mitch Bradley of FirmWorks, who did much of the early work on what is now the Open Firmware specification while working for Sun Microsystems. A prototype Open Firmware system first appeared in the SparcStation 1.

The Open Firmware specification consists of three interface definitions: a device interface, which defines the CPU-independent code described above; a client interface, which defines procedures that start-up code (usually an operating system or an operating-system loader) can call to acquire firmware services (e.g., reading data from a boot device); and a user interface, which allows human interaction with the firmware for the purposes of altering the booting process or performing device testing and debugging functions.

The device interface is perhaps Open Firmware's most interesting component. Not only does it provide the mechanism whereby adapter cards achieve CPU independence, but it is made possible thanks to a language that only longtime BYTE readers may be familiar with: Forth.

Why Forth?

Forth is a programming language developed by Charles Moore in 1971. At the lowest level, you can think of Forth as the "assembly language" for an abstract stack-based machine. A small set of primitive instructions take their arguments from and leave their results on a stack; Forth's abstract machine has no registers.

Forth source code is a sequence of text words that list, in left-to-right order, the operations to be performed. You can define new words as sequences of existing words. This ability to extend Forth makes it difficult to characterize it as either a high-level language or a low-level language. Rather, Forth is a language that scales to fit a wide range of needs. In addition to the primitive words, a typical Forth system includes utility words for console and mass-storage I/O, command parsing, memory display, and so forth.

Forth is interactive; you simply type a series of Forth words and they will be executed. By using Forth as the firmware's command interpreter, a complete integrated toolkit can fit easily in a typical ROM. The Open Firmware user interface specifies Forth words for hardware and software debugging, system configuration management, and support packages for various communications protocols. Because these functions are integrated seamlessly into the Forth environment, you can use Forth language facilities to write macros to automate sequences of these operations.

The code in an adapter ROM is a predigested form of Forth source code called FCode, in which the text words are replaced by integers encoded as 1 or 2 bytes each. The execution of an FCode program is functionally equivalent to interpreting Forth source code. The Forth interpreter resides on the host CPU.

How It Works

In response to a hard reset—usually just after power is applied—the host CPU begins executing Open Firmware code stored in ROM on the motherboard. This code initializes the system's internal environment (e.g., checks for available memory, initializes stacks, and determines the configuration of on-board hardware devices).

Next, the code directs the system to explore the devices attached to the expansion bus. The system examines each device's ROM, looking for a signature that indicates the presence and location of FCode. Note that a single ROM might contain multiple code components of differing nature. Typical AT-style BIOS code can be stored alongside FCode, enabling a single board to operate in

Open Firmware Highlights

- **Expansion devices contain processor-independent configuration information.**
- **Forth interpreter in system ROM interrogates the expansion devices, configures the system, and boots the operating system.**
- **User interface lets you interact with the system ROM to select the boot device or perform system testing.**

either an AT-architecture system or a system supporting Open Firmware.

Once the host locates FCode, the FCode interpreter within the host's system ROM begins executing the FCode program. In function, the FCode is just a general-purpose program. It isn't restricted to any particular activity. In most cases, however, the code will probably initialize the board to some state, identify and describe the board, create driver routines for controlling the board, and make those routines available to the system firmware.

This process continues for all adapters attached to the host. In fact, it can even extend to adapters not directly attached. Specifically, Open Firmware lets designers build bridge cards that link one bus to another and thereby permit expandable bus architectures. In practice, the host is directly connected to one bus, but that bus is straddled by a bridge card that links it to another bus. The bridge acts as an intermediary, passing information back and forth between the buses and allowing the secondary bus to be "booted from a distance." This structure can be arbitrarily complex, with a primary bus bridged to secondary buses bridged to tertiary buses, and so on.

Ultimately, the success of Open Firmware depends on its ability to gain a foothold as a standard. Currently, Apple, IBM, Motorola, and Sun head the list of corporations jumping on the Open Firmware bandwagon. Although Open Firmware has been in use on SBus cards for some time now, and there's no reason it can't be applied to other bus architectures (e.g., Futurebus), it appears that real success hinges on how well the PCI architecture fares. The PCI specification for adapter-card ROM contents includes Open Firmware's FCode as one of the possibilities, and the only possibility that provides real CPU independence.

ACKNOWLEDGMENT

Thanks to Mitch Bradley, chairman of the IEEE P1275 working group and founder of FirmWorks (Mountain View, CA), for his help.

Rick Grehan is technical director of the BYTE Lab. You can reach him on the Internet or BIX at rick_g@bix.com.

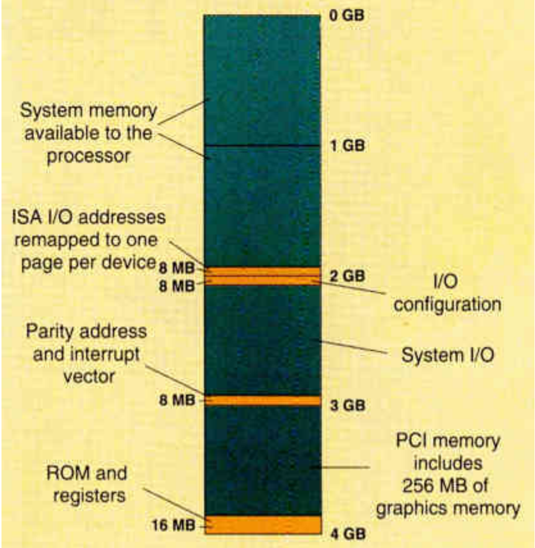
to provide services to the operating-system kernel, such as multiprocessor initialization, I/O buffer completion, instruction- and data-cache coherency, and TLB (translation lookaside buffer) flush and reload. It must be able to virtualize all external interrupts.

The operating-system abstractions layer must be able to isolate devices you want to access directly from any physical-address dependencies and provide a set of function calls for devices that will be accessed indirectly. It must provide DMA services that aren't specific to a particular DMA device. It must be able to read and write nonvolatile RAM, perform power management, and handle hardware faults and errors.

In addition to the above system abstractions, a PReP-compliant operating system must use device drivers to interface with peripheral devices. These drivers should use the abstractions and services provided by the system abstractions to avoid dependencies on a specific device location, DMA controller, or interrupt structure.

PReP uses abstractions to such a degree for two reasons. First, it supports not only shrink-wrapped applications, but shrink-wrapped operating systems and device drivers as well. Second, it seeks to avoid any hardware dependencies that could keep the hardware platforms from taking advantage of new technologies. Present-day PCs are pretty much constrained to implement DMA and interrupt controllers in a way compatible with the IBM AT. Abstractions let vendors differentiate their hardware without imperiling software compatibility.

PReP Memory Map



To the PowerPC processor, the memory of the PReP reference implementation is divided into a number of distinct areas. Accesses to the first 2 GB of memory are decoded by the memory controller as memory accesses to system memory. Accesses between 2 GB and 3 GB are run as I/O cycles with the MSB (most significant bit) of the address set to 0, indicating that the access is to the system I/O range. An access between 3 GB and 4 GB has the memory controller run an I/O memory cycle with the 2 MSBs of the address set to 0. Specific areas within the I/O areas have special functions.

The Reference Implementation

The largest section of the PReP specification is devoted to a detailed description of a PowerPC 601–based desktop computer. Essentially, this section describes the 601-based desktop system that the IBM Power Personal Systems Division will deliver in the second half of this year. The PReP specification also describes portable, medialess, technical workstation, server, and multiprocessor systems, but none in the detail of the reference implementation.

The reference implementation has three buses: processor, PCI, and ISA. ISA was included because PCI doesn't yet have a broad array of available adapters. Notable by their absence are the Micro Channel architecture and EISA. While it is certainly possible to build PReP-compliant machines using these or other buses—such as VME or Futurebus—neither has the performance of PCI or the vendor support of ISA.

One of the problems with implementing ISA is that ISA adapters are built to operate in the upper 360 KB of the 1-MB address range of an 80x86 processor in real mode. The reference implementation offers two solutions to this address hardwiring. In the first, the 64-KB ISA address space is remapped to a contiguous space in the PowerPC memory map. In the second, called *discontiguous memory mapping*, each ISA base address is mapped to a distinct page of the PowerPC I/O memory.

While the first method is simpler and less expensive, it does not offer protection between conflicting device drivers. The second method takes advantage of the fact that the basic granularity of memory coherency in PReP is the page by reserving a page for each ISA device. Thus, each device takes up the first 32 bytes of a 4-KB page, and the attendant drivers can take advantage of hardware memory protection. The reference implementation's memory map also defines system-interrupt assignments, PCI configuration registers, the

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Andrew Wargo, Manager at Baxter Land Company, tried two other brands before Back-UPS. "One lasted a few days, a second one went up in smoke after 48 hours, a third lasted less than 24 hours! I then bought my Back-UPS for less than half of what I had paid for the others. We've purchased three more Back-UPS and for the past 14 months they've been just hummin' away on the same power line that was eating the other brands alive!"

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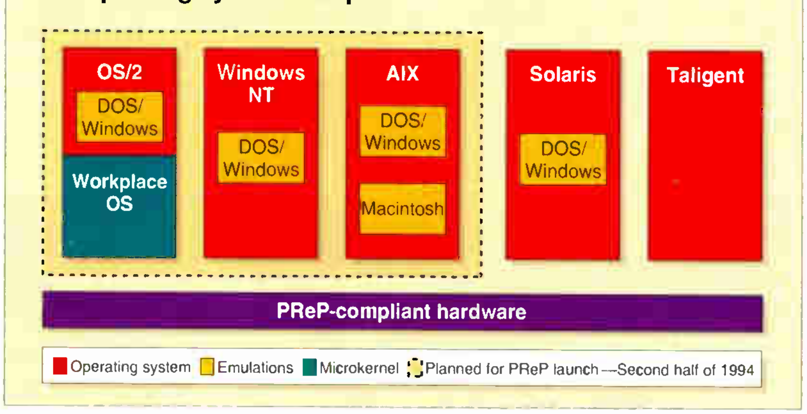
location of I/O memory, and DMA assignments.

Beyond the memory map, the reference implementation details the parts and specifications of the system. The processor is a 601 running at 50, 66, or 80 MHz; the memory controller/PCI bridge is IBM's 27 82650; the flash ROM is implemented with the AMD 29F040-120; SCSI comes from the NCR 53C810; the Intel 82378IB bridges PCI and ISA; and so on. Wherever possible, IBM has used commodity components to implement the system. The idea is to leverage the technology and dynamics of the current PC components' market.

One interesting aspect of the platform is the 200-pin upgrade slot. You can use this upgrade slot to implement a look-aside level 2 cache or, later on, you can upgrade the system to one that's based on a PowerPC 604. The initial 604 is expected to provide at least twice the performance of the 66-MHz 601.

The Operating-System Lineup



To be PReP-compliant, an operating system must be able to abstract information about the underlying hardware, which leaves out DOS/Windows. However, you can run 80x86 binaries on PReP systems by taking advantage of the emulation technologies offered by the different operating system.

Operating-System Issues

The IBM Power Personal Systems Division intends to have three operating systems available for its systems when they start shipping: AIX, Windows NT, and Workplace OS with OS/2 personality. Given that none of the three was yet in beta testing in late January, a second-half release is very optimistic. According to Mark Dean, Power Personal Systems Division director of architecture and hardware reference platforms, AIX and NT won't require extensive beta-testing periods because they are not new operating systems, just new ports.

Workplace OS is a new operating system, although IBM has been working on it for years and has extensive experience

Human-Centered Computing

One critical area where IBM's Power Personal Systems Division is providing key technologies to operating-system vendors and ISVs (independent software vendors) is in value-added software extensions that take advantage of the capabilities of the PowerPC processor. The most important of these extensions enable what IBM calls human-centered computing.

In one sense, Power Personal systems are a triumph of technology transfer from IBM and university research labs to IBM products. For example, RISC processors like the PowerPC trace their heritage back to John Cocke's work on the Model 801 at IBM's Thomas J. Watson Research Center (Yorktown Heights, NY) in the mid-1970s. Research for IBM's instruction-set-translator technology comes from its Haifa, Israel, labs, and the notebook design is being done at the company's Yamato facility in Japan. IBM is also relying heavily on its own research into the areas of speech recognition and AI.

The idea behind human-centered computing is simple: Make computers easier to use by having them conform to how you communicate, and not the other way around. The goal is to have users concentrate on the task at hand as opposed to operating the computer. IBM has married two trends to achieve this goal: Enabling the computer to understand a wider range of natural inputs, and enabling it to use richer data types such as high-quality audio and full-motion video.

Key to human-centered computing is enabling the computer to understand a range of inputs—what Karl Karlson, manager of the Human Centered Conversational Group (Boca Raton, FL), calls multimodal input. For example, when using a spreadsheet, it may be more appropriate to use touch to resize a window or speech to select a range of cells. Unlike today's keyboard-and-mouse interfaces, the human-centered paradigm doesn't constrain you to one method of input.

Not only does human-centered computing enable a range of inputs—voice recognition, handwriting recognition, pointing, pen input, and touch—but it can make intelligent inferences about the inputs. This type of intelligence is supplied by *agents*, software modules that use technologies to understand your spoken or written requests and comply with them.

Called variously an actor or a conversational surrogate, Charlie is an output device that provides a focal point for interacting with your system. Shipping versions of Charlie are expected to be less realistic to be less computationally intensive and less intimidating.

At first, agents will be constrained in their understanding to perhaps command and navigational tasks. As the technology progresses, however, they will develop the ability to perform complex tasks based on your input. One example Karlson uses is telling the computer to "call my wife." The agent would have to infer that *call* refers to making a telephone connection and equate *wife* with a specific entry in your address-book database. It may also need to decide, depending on the time of day, whether to with it on Intel platforms. With over 400 people working to bring it up on Power Personal hardware, IBM thinks it can include Workplace OS with the initial systems. However, IBM won't let a delay in one of the three initial operating systems keep it from announcing and shipping hardware that runs under the other two.

The operating-system count won't stop with the initial three, however. Both the Taligent operating system and Solaris are being actively ported to the PReP platform, although neither is expected to be available at launch. The Power Personal group is also trying to interest other vendors in the platform. Target operating systems are NetWare, UnixWare, Motorola's Unix System V implementation, SCO Unix, a microkernel-based version of System 7, and NextStep.

Supporting five operating systems is a Herculean task, so the Power Personal Systems Division avoids it. Separate divisions within IBM support their own operating systems, as do outside vendors like SunSoft. The role of the Power Personal Systems Division is to define a systems standard and to sell systems that can run all the operating systems.

In two critical areas, however, Power Personal is active in supporting all operating systems. The first is emulation. One goal of Power Personal is that every system, no matter what the operating system, should have the capability to run DOS/Windows binaries. Such support has two components: an API remapper and a binary translator. For example, Solaris uses Wabi to map Windows API calls to the X Window System library and an underlying emulator to translate 80x86 instructions into native RISC instructions.

At the API level, IBM is actively supporting Wabi, as well as continuing development of its Windows capability within OS/2. At the emulation level, IBM has developed an instruction-set translator that in effect compiles blocks of 80x86 code into blocks of PowerPC code on the fly and performs optimizations in the background. This instruction-translation technology can underlay any API remapping technology and is being offered for license by IBM to any operating-system vendor (see "Emulation: RISC's Secret Weapon" on page 119). IBM is also rumored to be integrating parts of its emulation technology into a future variant of the PowerPC. Such a chip would significantly boost the performance of 80x86 software on Power Personal systems.

Software for Hardware

IBM has three general software technologies for use on Power Personal systems. The first is human-centered computing, (see the text box on page 66). The other two are SoftGL and SoftDSP.

SoftGL is a software library that lets a Power Personal system run applications developed for OpenGL, Silicon Graphics' standard 3-D graphics API. SoftGL lets your standard video adapter run OpenGL programs, enabling compelling 3-D applications on even entry-level systems.

Many communications and compression functions are based on digital-processing algorithms. PCs normally require special hardware to run these algorithms effectively, but the PowerPC is different. Because the instruction set includes the basic signal-processing multiply-accumulate operation, PowerPC processors can effectively operate as DSPs. IBM has created a standard library named SoftDSP that enables applications to seamlessly take advantage of the PowerPC's DSP functions. All PowerPC-based systems are thus assured of having a minimum level of signal-processing functionality.

In the future, IBM will use these and other technologies to enable applications that will incorporate digital videoconferencing, integrated telephony, and other communications-oriented functions. These will enable a new level of collaborative computing, with PReP systems at the core.

First Look at IBM's Power Personal Systems

IBM's Power Personal Systems Division says it will release its first three PowerPC systems in the second half of the year. One will be a desktop/deskside system based on a PowerPC 601 running at 66 MHz, while the other two—a power-managed desktop and a portable—will use a 75-MHz 603. All systems are expected to ship with 16 MB of RAM, SCSI-2, a CD-ROM drive, and a full array of interface ports. They will include high-quality graphics and sound.

The most fully fleshed-out system at the time of this writing is the 601-based desktop. Essentially, it is a realization of the PReP reference implementation. The system features a 64-bit processor bus and

place the call to a business or home phone.

Eventually, agents may need to communicate with other agents. Telling your computer to "set up a managers' meeting for early next week" may result in your agent contacting agents on other systems and negotiating a time and date that can fit into the schedules of the other managers. Such capabilities would require that agents be able to learn about your preferences, and this is a key point to the human-centered paradigm—the computer learns about you, as opposed to you learning about the computer.

The visible manifestation of agents is actors—graphical representations that provide a point of contact between you and the human-centered technologies. Actors are output devices that use speech as well as visible clues to indicate the progress of agents in carrying out your requests.

At Comdex in Las Vegas last November, IBM demonstrated Charlie, a 3-D actor that provided feedback from the system. The actors shipped initially with Power Personal systems will probably be visually simpler than Charlie, both to save processing cycles and to present a less intimidating image to end users. Thus, the first actors may resemble Fred Flintstone more than they do Max Headroom. Some people may find actors a distraction, so IBM will provide an easy way to turn them off.

The Power Personal Systems Division is making the various human-centered technologies available to all operating-system vendors and will create an architecture for ISVs that will let their applications interact with the human-centered actors and agents available on a system. ISVs will also be able to create their own services. At this time, it is too early to tell the level at which different operating-system vendors will support the human-centered technologies, or how they will integrate them into their GUIs. IBM reports, however, that operating-system vendors are generally supporting the human-centered technologies.

Karlson expects that the integration of these technologies into operating systems and applications will be an evolutionary process. The technologies may first appear as a distinct operating-system layer and only gradually become more seamlessly integrated with the operating system.

The Power Personal Systems Division has said that the human-centered technologies are a defining element of their Power Personal systems. However, they have not said when specific technologies will appear, except that speech recognition will be included in the first systems.

a 33-MHz PCI bus, which should ensure that its performance at least matches that of its faster-clocked brethren. It also will come with four open expansion slots and an upgrade slot that can house a secondary cache or, eventually, a PowerPC 604 processor. Its architecture reflects the cascading-bus concept that characterizes PReP systems.

At the time of this writing, 603-based systems were not as solid as the 601 desktop. Both use a CPU bus/PCI/ISA hierarchy, but neither is expected to offer bus-expansion slots. Instead, each hangs PCMCIA slots off the ISA bus—two in the notebook, and four in the desktop.

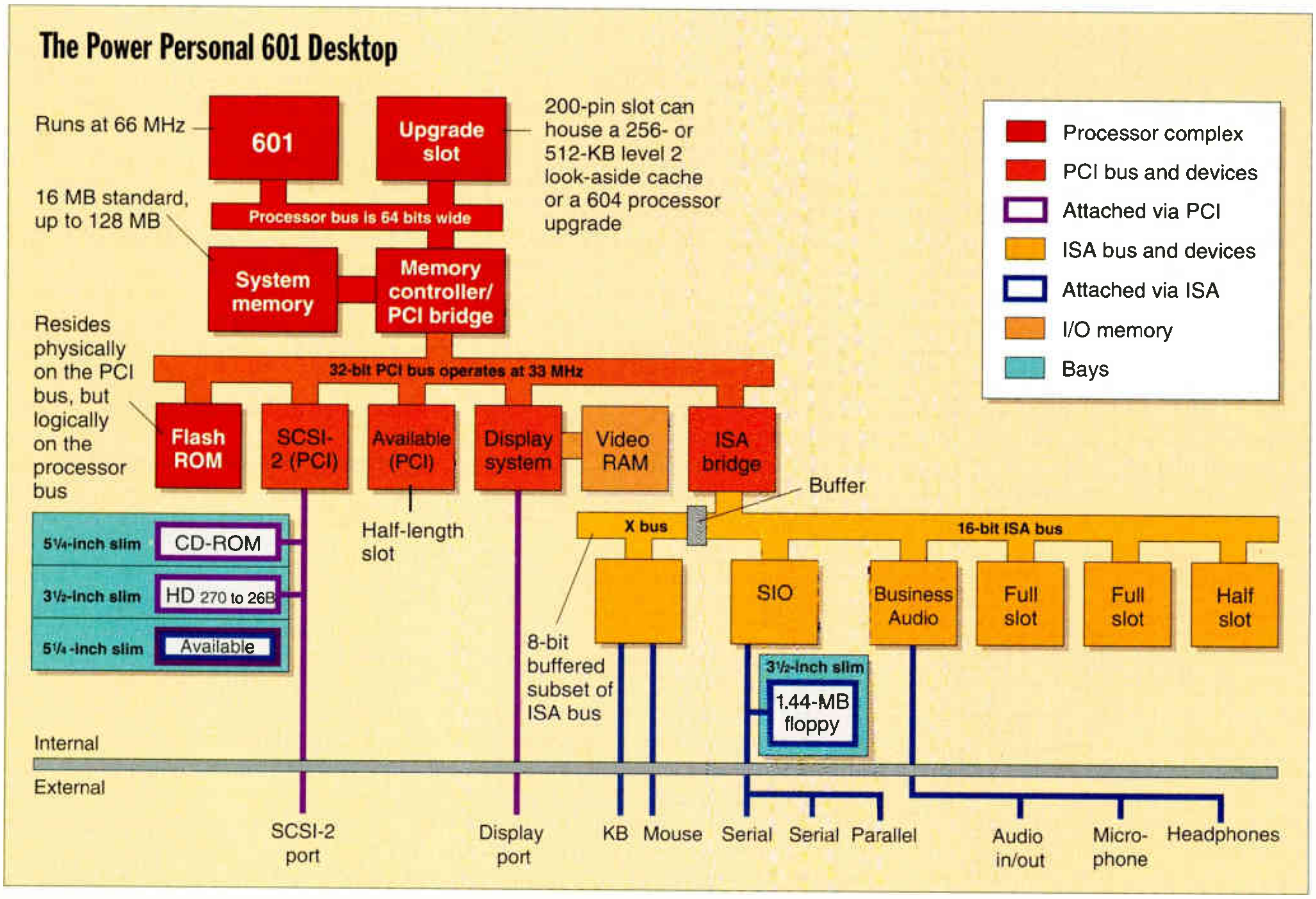
The 603-based desktop can drive flat-panel displays, as well as standard CRTs.

The 603-based systems will run the processor at 75 MHz and the PCI bus at 25 MHz. IBM intends to clock the processors in its Power Personal systems at integer multiples of the PCI bus, which can run at either 25 or 33 MHz. This simplifies system timing. Unlike the 601-based desktop, the 603-based systems will use 32-bit processor buses.

IBM has said nothing about availability beyond the fact that the systems will ship in the second half of the year. Much depends on the availability of the various operating systems. The systems are as yet unnamed. Pricing at this point is up in the air, although given IBM's desire to create a PC standard to compete with the 80x86 standard, you can expect its pricing to be fairly aggressive.

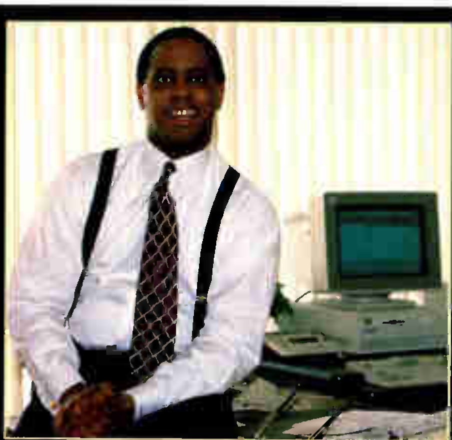
Critical to the eventual success of PReP in general and Power Personal systems in particular is the widespread availability of applications software. At first, there will be a good deal of native software available for Power Personal systems running AIX and less native software for Windows NT and Workplace OS–OS/2. Porting NT software will require little more than a recompilation for ISVs (independent software vendors), while OS/2 developers will first have to ensure that their applications are 32-bit before they can recompile for Power Personal systems. IBM reports that major ISVs have committed to the platform, but the company refrains from preannouncing anyone else's software. "I hope existing applications get rewritten to take advantage of the new systems," says Barry Coleman, senior economist at Texaco (White Plains, NY).

Undoubtedly, in the early stages, most of the personal-productivity software that's available for Power Personal systems will



The basic system in the Power Personal desktop line runs a 601 processor at 66 MHz. The system employs the basic PReP topology of a hierarchy of buses connected by bridges. Most of the components used in the system are commodity components available on the open market.

be DOS/Windows applications running under emulation. This is why emulation technology is critical to IBM; it is the bridge that will provide a software base until faster native applications arrive. DOS users may find emulation unacceptably slow, but Windows applications will probably perform adequately on the Power Personal systems. That performance will only improve as the PowerPC line moves to faster clock speeds and more powerful processors.



PHILLIP MINOTT, TEXACO © 1994

"I hope existing applications get rewritten to take advantage of the new systems."

— Barry Coleman
Senior Economist
Texaco

Future Directions

Beyond the initial systems, the IBM Power Personal Systems Division plans to "churn" the product line on a regular basis—perhaps every six to eight months—to keep current with technology advances and market forces. The 601 desktop will evolve into a line of systems that take advantage of evolving PowerPC processor technology. The original machine will be upgradable to a 604 when that chip ships, and follow-up products will incorporate 604s as well as faster 601 processors. At some point, the desktop line will also include a low-end 50-MHz 601 that some IBM people call their "*Computer Shopper* special."

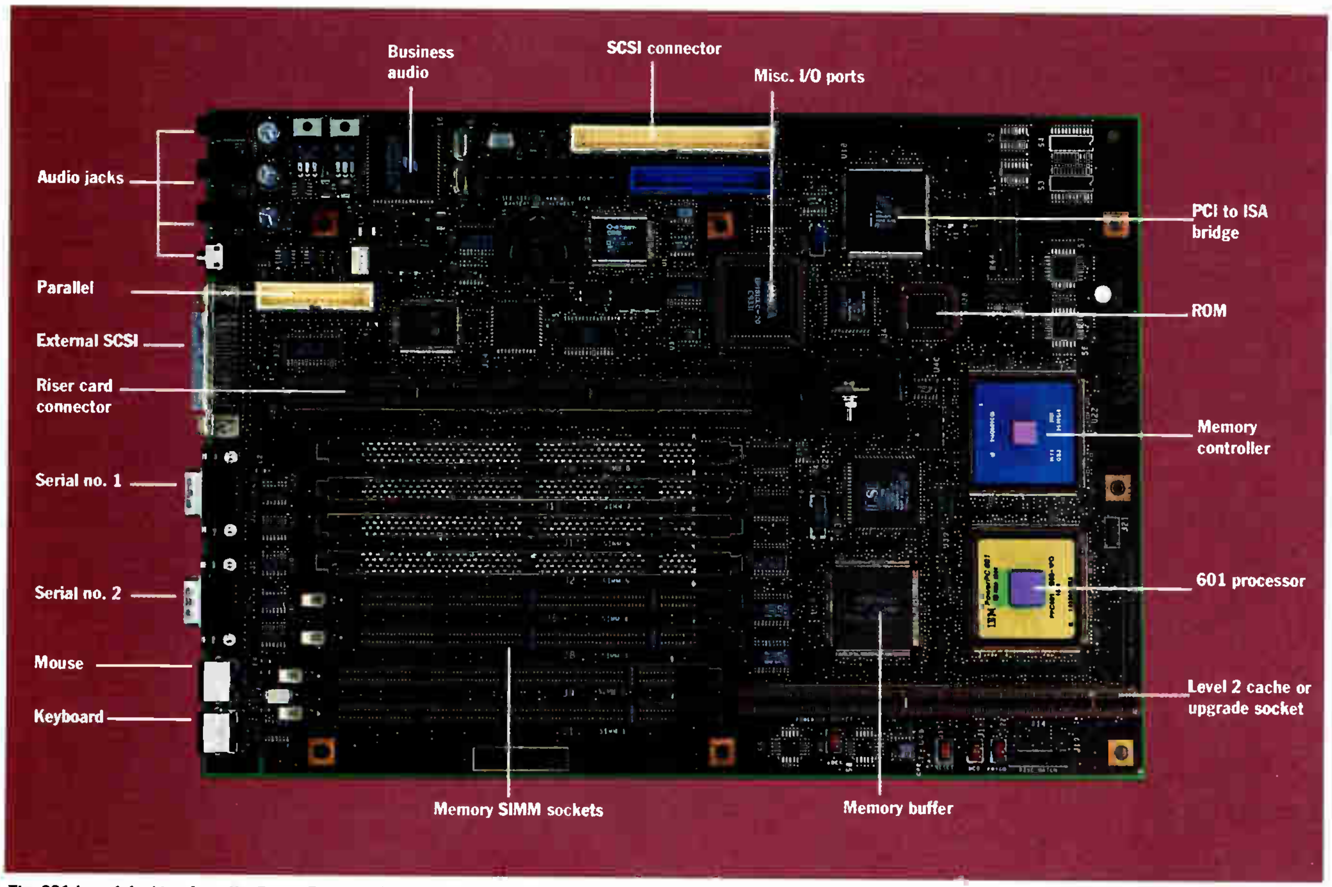
In 1995, IBM will add a server line to the Power Personal line. The servers will incorporate 604- and 620-based machines running at 120 to 150 MHz and include multiprocessors. To meet the expansion needs of servers, the systems will support multiple PCI buses.

On the low end, the notebook line will evolve to keep pace with enabling technologies. As-yet-unannounced types of PowerPC processors will be used in hand-held devices.

Perhaps the most interesting evolution awaits the 603 desktop. Here, IBM plans to break from the standard desktop form factor. The 603 desktops will drive flat-screen displays as well as CRTs. Future 603s will appear in tablet and other forms as well as in traditional system-keyboard-display configurations. Integrated videoconferencing will likely first appear here in the Power Personal line. In addition, the 603 will eventually be available in higher clock speeds, and a variant will integrate a PCI controller, memory controller, and level 2 cache controller. The desktop 603 line will be the focus of IBM's human-centered computing efforts.

IBM on the Move

It is too soon to speculate about the eventual impact of PReP and Power Personal systems. The actual systems will not ship



The 601-based desktop from the Power Personal Systems Division is made up primarily of standard parts. Even the custom memory controller will be made available from IBM Microelectronics.

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

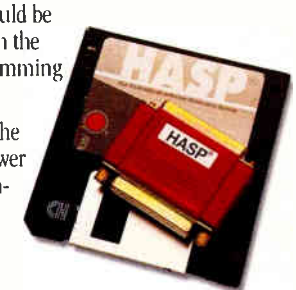
A GOOD HARDWARE KEY

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 to 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.

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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.

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✔ 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.

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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
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NEC (Serial Port): DOS, WINDOWS

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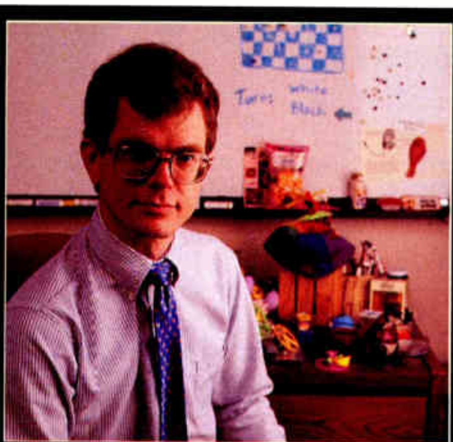
■ **Holland** Akkermans 45 241444 ■ **Italy** Partner Data 2 26147380 ■ **Japan** Athena, 3 58 213284 ■ **Korea** Dae-A 2 848 4481
■ **New Zealand** Training . 4 5666014 ■ **Poland** Systherm 61 475065 ■ **Portugal** Futurmatica 1 4116259 ■ **South Africa** D Le Roux, 11 886 4704
■ **Spain** PC Hardware, 3 4493193 ■ **Switzerland** Opag 61 7112245 ■ **Taiwan** Teco 2-555 9676 ■ **Turkey** Mikrobeta 4-4677504

Circle 63 on Inquiry Card.

for months, the operating systems are not done, and the applications software will be slow in coming. IBM has set a strategic direction and supplied information about how it is moving in that direction. Success or failure is far down the road.



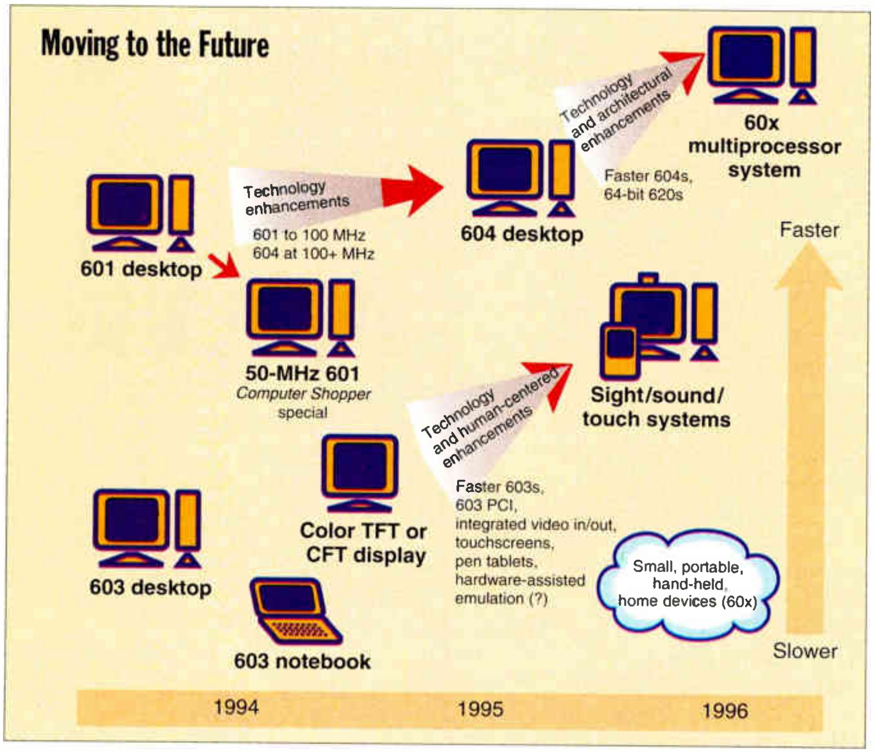
MITCH RICE © 1994

"What's going to be real?"

— Steve Lassagne Information Services Architect Syntex Corp.

The direction, however, is exciting. IBM wants to leverage a lot of different technologies to bring new power and functionality to PCs. Some of these technologies—such as PReP systems' hardware and 80x86 DOS/Windows binaries—are proven and readily available. Others—advanced microprocessors, fast emulators, and operating systems capable of abstracting the underlying hardware—are more on the cutting edge. The combination is a platform with a high comfort level that supports hardware differentiation and can evolve as quickly as the underlying technologies change. This is the great promise of Power Personal systems, and the advantage they have over 80x86 PCs.

IBM hopes that 1995 will be the year that Power Personal and other PReP-compliant systems begin to make a significant impact in the PC marketplace. Such a projection is probably too optimistic; the PC clone market, after all, wasn't built in a year. But 1995 will be indicative of the eventual success or failure of PReP systems. If by mid-1995 such systems are available from multiple sources, and if more operating-system vendors have signed on, and if native applications begin appearing at an ever-increasing frequency, you'll know that the takeoff is only a matter of time.



Speculation about the future evolution of systems that haven't been shipped is fraught with risk, but IBM has provided a general outline of where the Power Personal line is going. Some systems will concentrate on performance, while others will broaden the offerings to include different form factors and human-centered capabilities. The dates given are tentative—even speculative—in nature.

Excitement and Caution

The development of the PowerPC has recreated much of the excitement that surrounded the arrival of the first IBM PC and Mac systems, and with good reason. It has the potential to change how you work with and think about PCs.

Intel and other manufacturers of 80x86-class CPUs are not going to stand still in the meantime, of course. By midyear, Intel will introduce the next Pentium, known as the P54C. In addition, Intel says it has accelerated its development schedule for its next-generation processor, code-named the P6. Intel will release no information on the P6 other than to claim that it will deliver 300 MIPS, or performance that's about three times faster than that of today's Pentium processor.

The price/performance ratio on Pentium-class processors is dropping, too. Intel recently lowered the price of the Pentium by 15 percent. Cyrix's 80x86-class M1 processor is expected to deliver somewhat greater performance than the Pentium at a lower price when it debuts later this year. These trends, plus the enormous installed base of 80x86 PCs, guarantee an uphill battle for these PowerPC desktop systems.

Power Personal and Power Mac systems will try to make inroads against formidable competition from 80x86-based PCs. Potential customers have been hearing about the benefits of the PowerPC and RISC for years, but many remain skeptical. "What's going to be real?" asks Steve Lassagne, an information-systems architect at Syntex (Palo Alto, CA). Before Lassagne considers any RISC PC, he wants to see it work successfully in other businesses. Still, he sees the potential for PowerPC systems to eventually replace his company's existing high-end Intel-based PCs and Macs.

Apple and IBM and their partners will have to convince the world that the long-term advantages of RISC processing power, compatible differentiation, and new paradigms for interacting with computers are worth the short-term pain of emulation and platform upgrades. RISC is on the desktop. ■

CONTRIBUTORS

BYTE senior technical editor Dave Vislosky and senior news editor Tom R. Halfhill also contributed to this story.

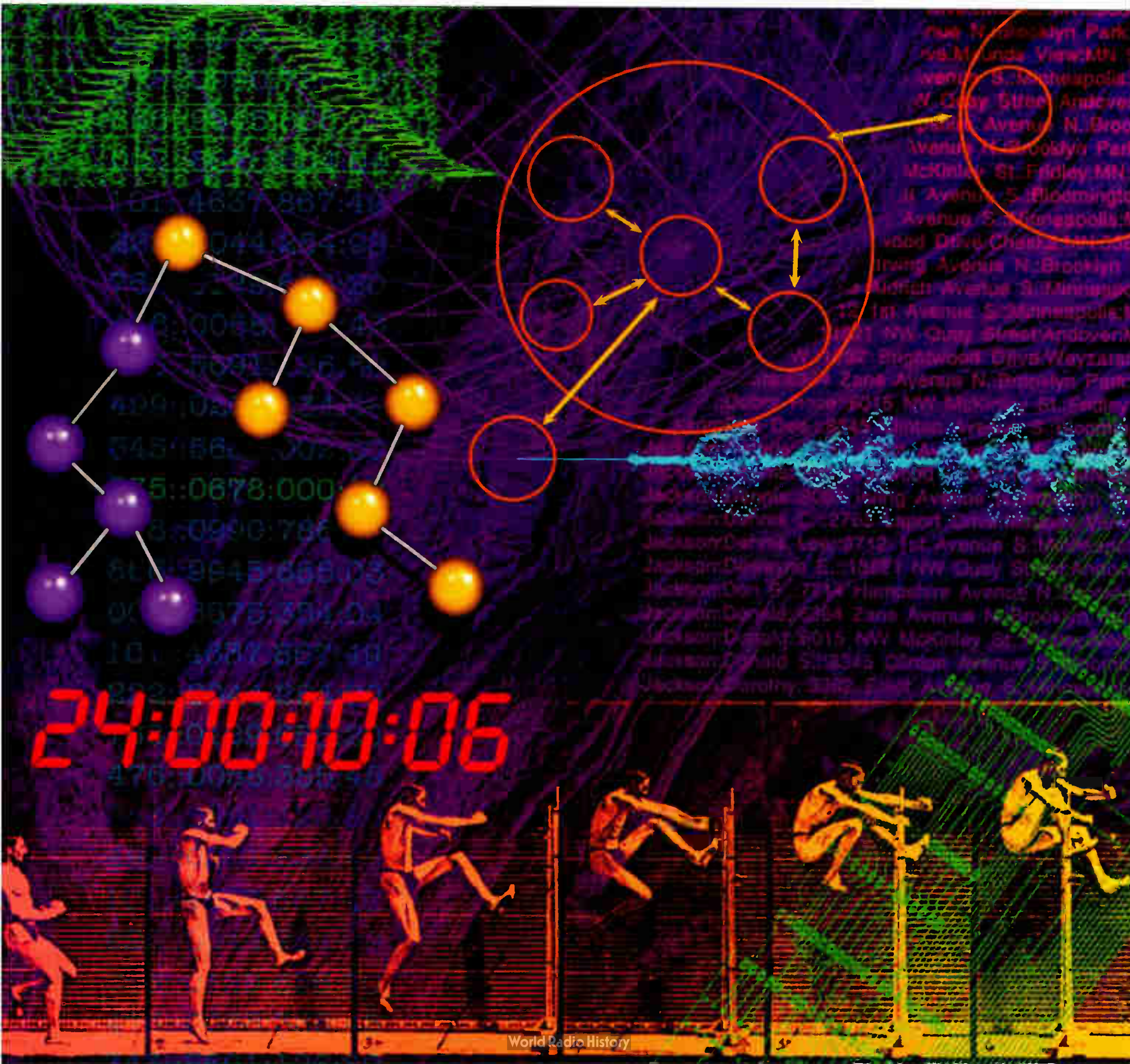
Tom Thompson is a BYTE senior technical editor at large, and Bob Ryan is a BYTE technical editor. They wrote the first in-depth look at the PowerPC in the August 1993 issue of BYTE. You can reach them on the Internet or BIX at tom_thompson@bix.com and b.ryan@bix.com, respectively.

State of the Art

OBJECT DATABASES

The best way to store the complex data used in object-oriented systems is with a DBMS that understands objects—something that relational databases don't do well

RICHARD MARLON STEIN



Object-oriented database management systems, or ODBMSes, represent the latest addition to the modern software engineer's toolbox. So many new applications are being designed with object-oriented techniques and programming languages—primarily C++ and, to a lesser extent, Smalltalk. These applications get much of their power from manipulating objects that include multiple, complex data types and associated methods and functions.

But what happens to that data when the application is not running? Only the ODBMS knows for sure. The synergy between OOP (object-oriented programming) and ODBMS interfaces generates a powerful and expedient mechanism with which to express, manipulate, and store—in what can be called an *objectbase*—the complex objects that are routinely created today. (A sampling of object-based applications using ODBMSes is presented in "Objects in Use" on page 99.)

Why Objects?

One of the principal reasons developers are turning increasingly to the object approach is that older techniques—procedural languages and relational databases—simply can't handle complex data very well. Developers have long recognized the shortcomings of the relational data model and commercial RDBMS (relational database management system) products with multimedia applications; economic models; document management systems; cooperative groupware products; client/server systems; and CAD, engineering, and manufacturing systems. These applications require the definition and manipulation of complex, abstract, articulated entities that defy representation with the relational data model.

RDBMSes lose their efficacy as storage systems when objects must be explicitly and tediously transformed (often losing some of their attributes and certainly their methods) before an object-oriented application program can store or retrieve them. (See reference 1. Also, for more information on the problems of mapping object data onto a relational database, see "The Great Debate" on page 85.)

ODBMS technology has gained momentum with the industry's recent adoption of the ODMG-93 standard (see the text box "The Object Database Standard" on page 82). The existence of an ODBMS standard simplifies the process of making applications portable, much as the SQL standard has let software developers migrate many applications between platforms without having to rewrite them.

Integrity, Reliability, and Consistency

Integrity and reliability are important concerns for any database user. Commercially available ODBMS products satisfy these needs, though sometimes with a reduction in overall performance. But the advantages of the object approach mean that both mission-critical and noncritical applications of ODBMS technology frequently pay a small performance penalty in return for reduced application engineering and maintenance costs.

The integrity of ODBMS transactions is essential. A transaction here is characterized as an inviolable sequence of operations—that is, all the operations that constitute a transaction either execute completely or not at all. An ODBMS transaction implies that an object is committed to storage and confirmed as stored.

Reliability refers to how the storage system retains objects in the event of computer malfunction. Under some high-stress conditions, an ODBMS may degrade unpredictably. In a multimedia system, the component object attributes (e.g., sound, video, graphics, and text) may differ substantially in their respective extents; one attribute stream may be much larger than the others. For a synchronized playback to occur, all media streams must be uniformly retrieved and recorded. Reliable ODBMS storage operations ensure that objects reach the storage system even if an error condition interrupts normal services.

ODBMSes store objects' attributes, not the methods that affect object state. Executable images for object methods are typically loaded by an ODBMS client, which retrieves ODBMS objects from the server through a tightly coupled network protocol, similar to an RPC (remote procedure call). The server provides lock management to prevent object inconsistencies from contaminating the objectbase. Access to an object's attributes is afforded by its methods. Each method possesses a *signature* that identifies the names and types of the arguments, as well as the names and types of any return values. Method signatures are specified for objects by the ODBMS's object definition language.

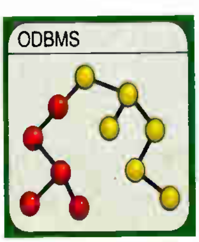
Persistence

ODBMSes implicitly support the notion that objects have a definable lifetime that can extend beyond an executing program (see reference 2). This persistence characteristic is important for applications that may interact with objects over varying spans of time.

For example, an economic forecasting model may require objects that reflect instantaneous stock-market conditions. The state of a stock-market object, as described by its attributes (e.g., the Dow Jones or Wilshire 5000 indexes), may persist for a few seconds at most before being superseded. But monthly economic indicators, such as the consumer price index and number of housing starts, have much greater longevity. Fundamentally, persistent objects outlive the procedures and processes that create them.

Object persistence is declared as part of the ODBMS schema. The ODMG-93 standard specifies three types of persistence attributes, one of which is assigned to an object when it is declared, and this persistence attribute is immutable during the object's lifetime.

The most ephemeral persistence type, or lifetime, is called *coterminous with procedure*. Object storage for this lifetime is obtained from the run-time call frame stack and is similar to an automatic variable. When the procedure returns, the object



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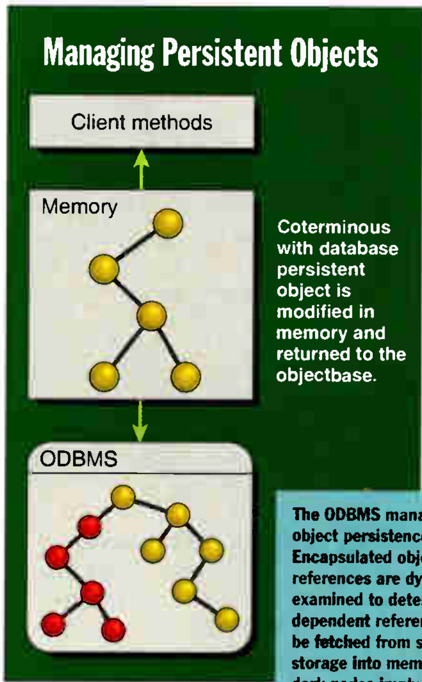


The ODBMS manages object persistence. Encapsulated object references are dynamically examined to determine if dependent references must be fetched from secondary storage into memory. The dark nodes imply recently modified object attributes; the clear nodes imply no changes to other objects.

passes out of scope and is deleted.

The next type of lifetime is *coterminous with process.* The application assigns memory resources for a particular object instantiation and returns them to the heap when the process exits.

Last, objects that have *coterminous with database* lifetimes are stored on disk under ODBMS run-time control. These tenacious objects remain in the store until the database is deleted.

An ODBMS can implement object persistence with a file system, although accessing disk media is far slower than reading memory. Also, a persistent object may contain references to other objects through a pointer. This is typical for a complex model that represents a highly articulated system or a collection of behaviors inherited from multiple objects. For optimal performance in accessing attributes, therefore, an object and any references it possesses must be resident in memory (see the figure "Managing Persistent Objects").

An efficient ODBMS will fetch the entire object, including dependent references, from secondary storage and place it in a cache; RDBMSes perform an analogous operation by loading whole tables in response to certain queries. Persistent-object cache management is partially controlled by the particular object's lifetime as declared by the ODBMS schema definition. The host operating system lies underneath any cache management strategy.

Keeping Track of Objects

Each time an object is created, a unique OID (object identifier) is added to the ODBMS identifier table. The OID is independent of the object's state. Coherent operation of the ODBMS hinges on the maintenance of this table, which retains and tracks OIDs as objects evolve. Currently, the ODMG-93 standard specifies that the OID table is a single flat structure that precludes, for the time being, any extensions into distributed tables. Future generations of the ODMG-93 standard will eventually support distributed ODBMS structures.

When an application references an object via its OID, the ODBMS must convert this into a virtual memory address before any object attributes can be modified. This conversion of OID to a memory address or address to an OID is called a *swizzle* (see reference 3).

Swizzle operations are important for efficient storage and application access. An ODBMS swizzles object pointers to speed access to data in memory. Because an object hierarchy includes pointers to other objects, the use of swizzles speeds retrieval and facilitates the update of object attributes.

Object Locks and Concurrent Use

As with any database system, sharing objects by multiple users raises the important issue of maintaining consistency among the user copies. If two or more users simultaneously access an object and add to or alter any of the object's attributes, inconsistencies will arise unless the transactions are serialized, ensuring that a consistent, predictable order is applied to the modification of stored objects. Concurrency control mechanisms prevent interleaved transactions to the same object. Exclusive write-lock mechanisms are applied to object storage and usually suffice to prevent changes by more than one person at a time.

Unfortunately, locking mechanisms can also impede the normal use of a database for which long-duration transactions dominate. In many cases, a transaction consists of a short sequence of operations that are completed in a few seconds or less. This is typical of automatic teller machines or credit-card authorizations.

But not all applications are so short and sweet. For example, CAD applications in IC manufacturing may involve several

teams of engineers working simultaneously on different parts of a chip design. Some of the chip's cells will undoubtedly cross workgroup boundaries, and it may take weeks for the different teams to figure out how to route wires and position the cells to minimize signal propagation delays, power dissipation, and electrical impedance.

During this protracted development period, other groups of engineers may need to update their design data for a write-locked cell held by a particular user. In this case, the ODBMS must provide the capability to queue up a lock request—and perhaps notify the current lock holder to allow the current changes—or provide the option to abort the lock-request operation. The ODMG-93 standard is silent on the object-locking issue; each ODBMS vendor furnishes its own set of locking options and capabilities.

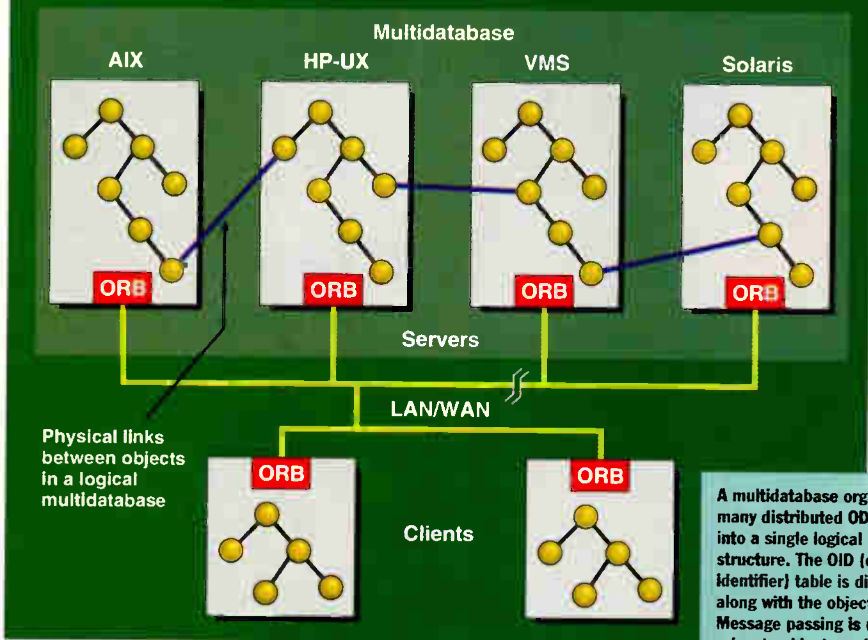
Distributed Objects—Data in ORBit

Another goal of most ODBMS technology is the notion of a multidatabase (see the figure "Inside a Multidatabase"), which can transparently integrate physically distributed ODBMSes into a single logical structure. To achieve this, the ODBMS must maintain the OID table as a distributed entity (see reference 4). Message passing is used to convey OIDs between peer tables to ensure consistency and to exchange objects between processes for distributed processing. The system addresses the multidatabase as a logical, global entity; the user has no knowledge of the underlying object distribution.

What makes the multidatabase concept work is the ORB (object request broker), which mediates client access to distributed objects. The ORB must perform many of the functions and capabilities found in current operating systems, in addition to network administration and communications, object format conversions between different processors, heterogenous access control, native memory access, security via encryption and decryption, and memory allocation (see the figure "Object Request Brokers").

An ORB executes a client request by effectively trapping all references to an OID issued by a method or ODBMS primitive (i.e., function). If the object is local, the method will operate on a cache-local object; a remote object will force the process to suspend until the object is relocated to the client's address space. Since network messages are generally slower

Inside a Multidatabase



A multidatabase organizes many distributed ODBMSes into a single logical structure. The OID (object identifier) table is distributed along with the objects. Message passing is used to relocate objects under control of an ORB (object request broker).

than local memory accesses, large objects will require more time to relocate than smaller ones. One way to minimize a process's latency is to organize multiple client threads. If the object possesses many attributes, you could dedicate separate threads to fetch each of the object attributes simultaneously. By overlapping computation with communication, the process idle time is reduced and a better load balance is achieved.

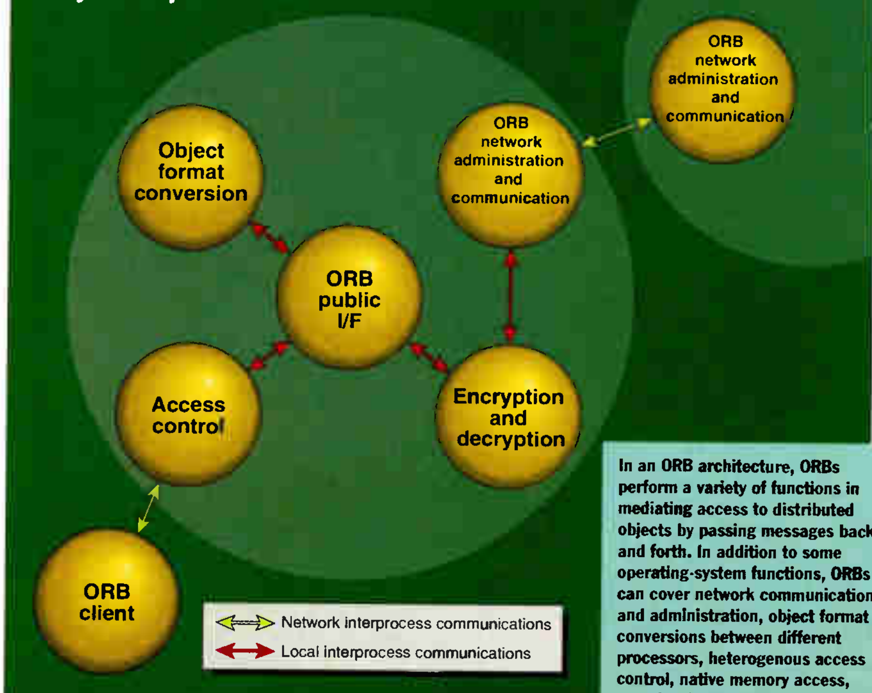
Client/servers operating over WANs, such as airline and hotel reservation systems, may be among the first types of applications to avail themselves of the multidatabase/ORB mechanism. Here, relatively fine-grained objects will be communicated between ORBs located on separate processors interconnected by a network. The amount of information needed to represent a single hotel or airline reservation is quite modest. A customer who phones to inquire about a reservation will then wait for the reservation object to move from some host computer system to the clerk's workstation.

Once at the workstation, the clerk may alter the reservation object by changing, say, the time-of-departure attribute for the customer's outbound flight. When completed, a local transaction will confirm the reservation object. Another workstation or mainframe might request all reservation objects periodically—say at the end of each business day—to compute daily income or other corporate measures.

The ORB model mimics the dynamic load-balancing techniques already familiar to practitioners of massively parallel computing. The principal difference is that an ORB facilitates the relocation of coarse-grained objects—instances that consume several megabytes of storage—whereas massively parallel systems are better suited to finer-grained messages—10 to 100 KB. ORBs are clearly better suited to highly asynchronous application domains, where object relocation is either infrequent—less than 10 object relocations each second—or the object attributes are divisible into smaller chunks and can be retrieved by multithreaded client ORB recipients. The message traffic associated with object relocation will subside after it arrives in the requesting ORB's address space.

NASA plans to incorporate ORBs into its Earth Observing System Data and Information System, or EOS-DIS. This data archive and distribution system will be used by space and environmental scientists to access and analyze the 300 GB per day expected from 18 satellites examining global warming, greenhouse gases, ozone depletion, and natural resource exploitation (see reference 5). Several DAACs (distributed active archive centers) will be established to serve scientists and provide data to public

Object Request Brokers



In an ORB architecture, ORBs perform a variety of functions in mediating access to distributed objects by passing messages back and forth. In addition to some operating-system functions, ORBs can cover network communications and administration, object format conversions between different processors, heterogenous access control, native memory access, security via methods for encryption/decryption, and memory allocation.

The Object Database Standard

To minimize cross-platform migration costs, software developers require some degree of feature standardization across ODBMSes (object-oriented database management systems), just as with operating-system interfaces, network protocols, or compilers. To foster this capability, the OMG (Object Management Group), an organization dedicated to the creation and promulgation of a standard for ODBMSes, started the ODMG (Object Database Management Group) during the summer of 1991. ODMG participants include representatives from the workstation and object-oriented database industries. The participating ODBMS vendors represent over 80 percent of the total marketplace.

This group has developed ODMG-93 1.0, the Object Database Standard. Although the ANSI standards committee does not endorse ODMG-93, ANSI has efforts directed at object-information systems (ANSI X3H7) and managed objects (ANSI X3T5.4). The ODMG will propose the adoption of ODMG-93 as an ANSI/ISO standard in the near future.

What's in the Standard?

This current object-database standard proposal specifies an ODM (object data model), ODL (object-definition language), OQL (object-query language), and C++ and Smalltalk language bindings for an ODBMS API. An ODBMS that conforms to ODMG-93 must supply tools that implement the ODM, ODL, and OQL.

While not yet an official part of the standard, the OMG sponsors the CORBA (Common Object Request Broker Architecture), a service that provides a platform-independent mechanism for transparent access to distributed objects. To supply this capability, CORBA implementations must harness communications protocols and a scheme for portable object representation similar to Sun Microsystems' XDR (External Data Representation) library.

Further, the ORB (object request broker) must also mediate concurrent read and write access among competing clients. Coherent maintenance of any distributed entity is not a trivial task; these systems exhibit nondeterministic behaviors that compromise reliability. Despite these potential obstacles, CORBA is a fundamental technology for the next-generation, object-oriented operating systems currently under development (see "Objects on the March," January BYTE).

The principal feature of the ODM is that it establishes the object as its basic primitive. The ODMG-93 standard defines a built-in set of types that can be used to create and instantiate composite structures that mirror real-world entities. The ODM permits the definition of arbitrary objects, an advantage that the relational data model does not expediently afford. The ODM furnishes an abstract and powerful semantic structure for representing complex systems.

Constructing an Object Database

An ODBMS schema is created with an ODL specification. The ODL specification is based on a Backus-Naur Form grammar that is similar to OOP language constructs. The ODL is used to define objects and create interfaces to them. The ODBMS furnishes an ODL precompiler that translates this specification into source code (either C++ or Smalltalk) for subsequent compilation by the platform compiler. The ODL precompiler also generates an `include` specification that lists data structures, class definitions, and method signatures identified by the input ODL specification. However, it is up to the ODBMS developer to furnish the source code to implement the method definitions that the ODL precompiler generates.

The method body will contain ODBMS API primitives for setting and getting object attributes, in addition to any logic needed to implement specific data model behavior. In the case of a multimedia application, for example, methods for accessing audio, video, graphics, and text streams will most likely invoke the standard ODBMS `select` operator to retrieve these items from object storage. When the multimedia document is first created, the ODBMS `create` primitive is used to insert the various streams into the object store.

Unlike the relational data model, an ODM has no rigorous mathematical underpinning. `Join` and `sort` operations are not strictly defined for an object, but an object's attributes can be subjected to relational semantics. In other words, you can't sort objects, per se, but you can sort them based on the value of an attribute.

Querying the Database

OQL furnishes a SQL-like query mechanism for operating on objects and their attributes. You can join and sort objects of different types with the set operators `intersect`, `union`, and `except` by accessing an object's attributes. You can also compare object attributes with =, <, >, and other Boolean operators.

OQL is designed to execute queries on articulated models that can only be represented via objects. Unlike SQL, which is restricted to tabular organization of tuples and that often requires a substantial number of join operations to reconstruct or extract data from a "flattened" object model, OQL primitives operate directly on objects and their attributes. Relational inferences between literal data item (e.g., floats, integers, and so on) attributes are obtained with standard mathematical methods.

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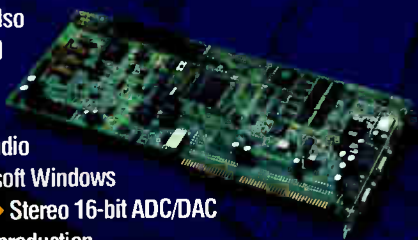

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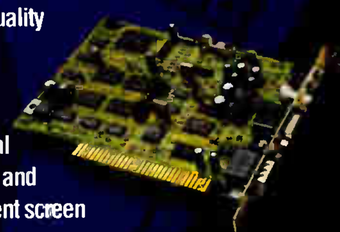

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and private interests. The gigantic volumes of data, expected to reach petabytes (10^{18} bytes) by mission completion, will most easily be accessed from DAACs via computer networks aided by ORB agents.

The trickiest aspect of CORBA (Common Object Request Broker Architecture) lies in assuring the delivery of all messages that describe objects. Nondeterminism arises from the asynchronous nature of communicating sequential processes; two communicating ORBs exemplify this configuration. But interspersed between the processes' network I/O connections are additional processes dedicated to encryption, access control, accounting, and so on. Each process has the potential to interject an exception condition between the two ORBs, and this exception may corrupt the data transmission or force one of the peer ORBs to terminate, thereby creating a state of unrecoverable deadlock.

Tomorrow's Objects

ODBMSes possess a rich set of operations and primitives that couple seamlessly into the semantics of OOP languages. ODBMSes simplify the design process through their enhanced modeling capability. Developers who incorporate an ODBMS into their products are likely to realize substantial savings from reduced software maintenance and engineering costs.

ODBMSes and their ORBs can produce scalable, reusable architectures that map easily onto client/server topologies, where enterprise-wide multiprocessor object servers distribute and manage objects over a LAN. However, the ORB mechanism may impede ODBMSes from efficient exploitation by message-passing parallel computer systems such as the Cray T3D, KSR1, or nCUBE-2. Background message traffic is required to maintain a coherent OID table for distributed environments.

Nonetheless, these computation systems will inherit a leadership role in information commerce. ODBMS vendors should recognize this important opportunity and begin to engineer CORBAs that minimize message traffic. ■

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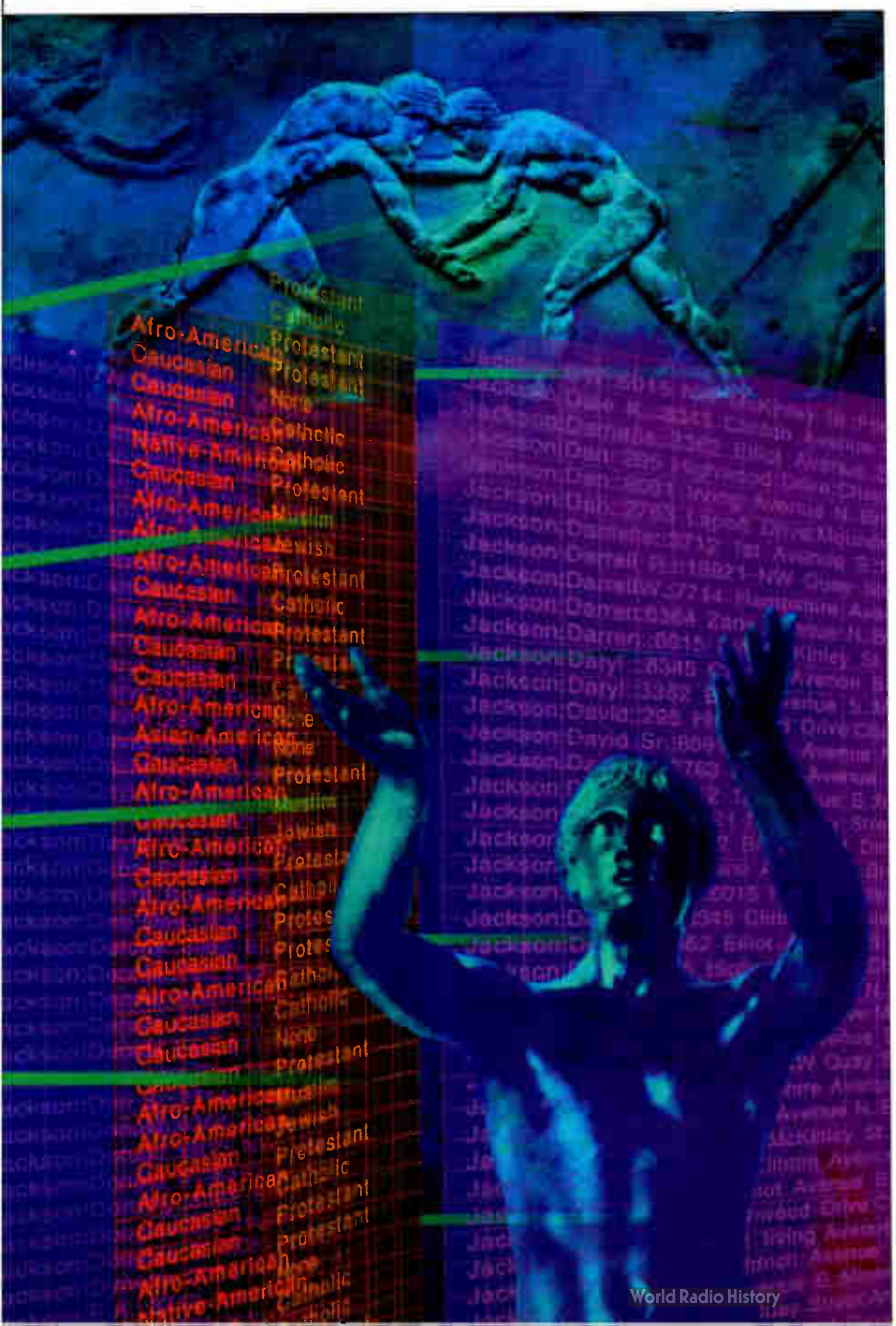
Richard Marlon Stein is a freelance writer and multicomputer systems technologist with the Parallel Software Group of Santa Clara, California. You can reach him on the Internet at rms@well.com or BIX c/o "editors."

State of the Art

THE GREAT DEBATE

Force-fitting objects into a relational database just doesn't work well. The impedance problem is at the root of the incompatibilities.

CRAIG S. MULLINS



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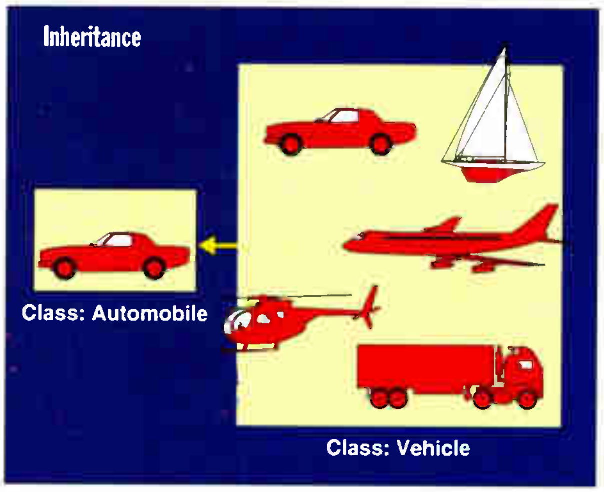
The relational model has been king of the database hill for the past 10 to 15 years. During this period, few development projects that required a database used anything other than a relational system. But the times they are a-changin'. Object-oriented DBMS products are gaining wide acceptance for their ability to handle complex data in ways that relational products simply can't.

Defining the Paradigms

By definition, a *paradigm* is an example that serves as a pattern or model. A *paradigm shift*—a term increasingly seen in the computer trade press—refers to a fundamental change in the basic methods used to accomplish a task.

Most people connected with computer systems realize that the industry changes daily. New technologies are constantly being developed, but most of these merely provide better ways of doing something you have always done. When a paradigm shift occurs, what changes is the essential core of how a task is performed—and perhaps defined.

The object-oriented model represents the latest paradigm for computer programming, after procedural languages and rule-based programming (e.g., in languages such as Prolog). Object-based languages—including Smalltalk, Eiffel, and C++—are based on manipulating objects, which encapsulate complex data structures and processes (usually called *methods*) for manipulating that data. To invoke a method, a message must be sent to the object in which the method is encapsulated. Because each object contains its own methods, most procedural code is eliminated. The object-oriented paradigm, while currently a hot topic in the computer world, is hardly new. The first OOPL (object-oriented programming language), Simula-67, arrived on the scene in 1967. *continued*



The class Vehicle can include objects of many different subclasses, each with its own special data attributes and methods. Automobile is only one subclass of Vehicle.

Object Database Management Systems

To handle the data that OOPLs create and manipulate and to provide all the fundamental benefits of a DBMS to object-oriented applications, ODBMSes (object-oriented database management systems) were introduced. Benefits of an ODBMS include persistent data, data sharing, concurrent data access, and recovery control.

ODBMS products are designed to supplant relational DBMS products within an object-oriented development environment. Their architectures are designed to understand and utilize object-oriented techniques such as complex objects, abstract data types, encapsulation, and inheritance.

Object vs. Relational

What is the difference between an ODBMS and an RDBMS (relational database management system)? The primary difference is the ability of an ODBMS to support complex objects in an efficient and easy-to-manipulate form. A complex object consists of data and processes that manipulate that data. In contrast, RDBMS products provide access to their data only in terms of rows and columns. And, other than triggers, an RDBMS can't store processing logic at the table level.

Other examples of complex objects include bill-of-materials hierarchies, CAD diagrams, and multimedia BLOBs (binary large objects). An ODBMS is ideally suited to store and manipulate these types of objects. Although some relational databases can process these types of objects, it is seldom easy or efficient to do so. Imagine using SQL Server to explode a bill-of-materials hierarchy from a fully normalized table. While technically possible, it is not truly feasible in terms of ease of use or performance.

Greater Abstraction

Abstraction is a key component of everyday life. People understand concepts such as an automobile, a light bulb, freedom, and trouble. Automobiles and light bulbs are concrete things, but you need not have them physically present to visualize them. Freedom and trouble are concepts that you can't see or touch, but you understand them in the abstract.

An ODBMS raises the level of abstraction. Objects stored in an ODBMS are organized more closely to the way in which you view and use them in the real world. For example, consider the objects vehicle and automobile. All automobiles are vehicles, but not all vehicles are automobiles. In an ODBMS, you can implement an object of class Vehicle and subclass Automobile that inherits the methods and structure of Vehicle (see the figure "Inheritance"). Using an RDBMS, you would have to implement two separate tables, one for Vehicle and another for Automobile. The Vehicle table can't be used to define Automobile because an RDBMS lacks inheritance. In addition, different algorithms would have to be coded to access each subclass.

The Impedance Mismatch Problem

ODBMS products are sometimes touted as a solution to a problem encountered with RDBMS products. The problem is called *impedance mismatch* and refers to the difference between the declarative, set-level operation of relational-database query languages and the procedural, record-level operation of a typical 3GL (third-generation language). There are two components to impedance mismatch:

1. The difference between the set-at-a-time data manipulation language of the DBMS (e.g., SQL) and the record-at-a-time programming language (e.g., C or COBOL). When the declarative database language is embedded within the procedural language, the system can return multiple rows to a programming language that is not equipped to operate on sets of data (see

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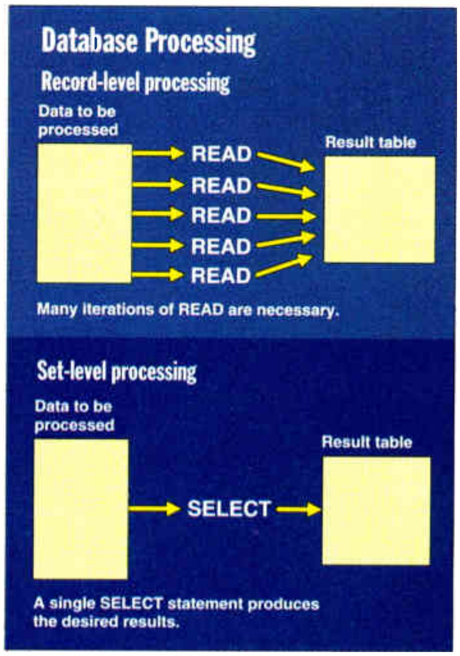

When you access a database one record at a time (top), it takes many READ operations to produce reports or result tables. If the DBMS operates at the set level, it can get the data it needs in one SELECT operation.

the figure "Database Processing").

2. The difference between the typing systems that the DBMS uses and the general-purpose programming language used to develop the rest of the application. For example, many RDBMS products support date types and date arithmetic, but most programming languages don't support them. Therefore, data returned from the DBMS must be transformed into a form that the programming language understands (e.g., by converting a date to a character string).

Typically, when accessing a relational database, you must embed a SQL query within a 3GL program. Because the two languages operate at different levels and some mechanism must resolve the differences (i.e., by copying data from the database language to the programming language and back again), the system incurs extra overhead. On the other hand, you normally access data in an ODBMS by using an OOPL, so no impedance mismatch is encountered. All operations are at the record level.

Why do you need to use two languages? For one thing, the DML (data manipulation language) of the DBMS generally lacks computational completeness and can't handle the nondata manipulation components of an application. On the other hand, most

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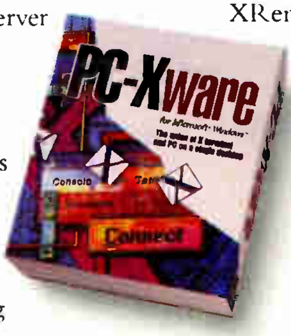

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programming languages lack the facility to handle persistent data other than in the form of files. They also typically lack abstract or high-level data types, constraints, and query capability. To enable the two languages to perform the tasks that each is ideally suited for, they must be able to communicate with each other. This, in a nutshell, is the impedance mismatch problem.

Resolving the Impedance Mismatch

Several different techniques have been tried, with more or less success, to overcome the impedance mismatch:

Query Download. Using this approach, queries are developed that retrieve all objects that the process can require to be executed. The data is translated to a format that the process can read before accessing the object. After execution, the objects are copied back into the ODBMS. This approach results in very efficient program execution at the expense of significant start-up and exit overhead, limited (or no) concurrent data access, and the inability to use the ODBMS during program execution.

BLOBs. Another solution is to store objects in the ODBMS as BLOBs. Instead of identifying each field (i.e., column) and its attributes to the ODBMS, you can store the entire object in a single large field. Once again, the major benefit of this approach is efficiency, but the drawbacks are usually unacceptable. Because the ODBMS is unaware of the object's internal structure, querying is impossible—access requirements can't be coded against individual components (i.e., fields) of the BLOB. Also, the ability to allow concurrent access is problematic.

DBMS/Program Affinity. Defining the program's level of interaction with the DBMS to be at a field-by-field (or object-by-object) level removes the set-level versus record-level processing mismatch. However, it also reduces the effectiveness of database access, because all access is one record at a time, thereby crippling the system's ad hoc query capability.

Procedural Database Language. One of the most elegant solutions to the impedance mismatch problem is to augment the database's query language with procedural flow-of-control operations (e.g., WHILE loops and IF...ELSE constructs). Using this approach, more of the application can be written in the query language. A number

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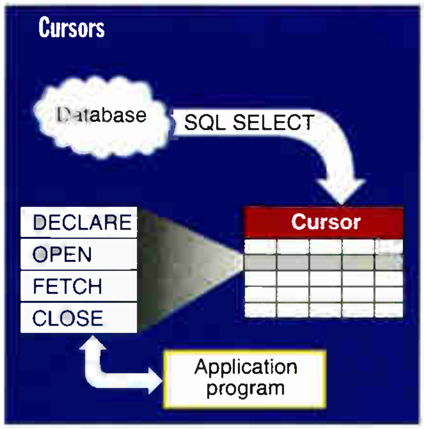

In a relational schema, a cursor is a data structure used to hold multiple rows of data returned by a SELECT statement. The application program can then read data from the cursor, accessing it a row at a time as if it were a sequential file, using the DECLARE, OPEN, FETCH, and CLOSE functions.

of RDBMS products, such as Oracle's PL/SQL and Sybase SQL Server's Transact-SQL, provide procedural extensions to SQL.

The coupling of program logic and data into a set-level procedural language is an attractive benefit of this approach. Likewise, performance is usually enhanced because network traffic is reduced. There are, however, some drawbacks; forcing a programmer to write the application using the database language instead of the general-purpose language limits the options and may pose difficulties. Finally, query languages often lack important computational powers and other important features, such as the ability to define and interact with the user interface.

Persistent Programming Languages. We call programming languages *persistent* when they can specify objects to "keep around" when the program is not executing. However, the ability to make program objects persistent still fails to address the interaction of the program with an ODBMS. Impedance mismatch will still occur because the DBMS's retrieval and data-typing scheme won't match those of the program.

Extended Data Types. Support for handling user-defined, extended data types is another approach. But unless both the DBMS and the programming language can define extended data types using the same methods, impedance mismatch is still inevitable.

Integration. In the end, the most workable solution is to simply remove the mismatch entirely. Integrating ODBMS products and programming languages so that they operate at the same level and use the same data model will eliminate the impedance mismatch problem. Implementing this approach, however, takes much effort. You must consider the following problems:

- the lack of a formal, standard object model
- an apparent compatibility conflict between encapsulation and database query languages
- the difficulty of providing standard interfaces and data models given the reality of different commercial implementations

RDBMSes and Impedance Mismatch

Many RDBMS products handle impedance mismatches through two primary mechanisms: cursors and type translation. You can think of a *cursor* as a kind of pointer (see the figure "Cursors"). The programmer declares a cursor and defines a SQL SELECT statement for that cursor. An application program accessing that RDBMS can navigate, one row at a time, through the set of rows returned by the SQL statement. In essence, the program uses the cursor much like a sequential file. It opens the cursor, fetches one row at a time from the cursor, and then closes the cursor. When processing with cursors, a SQL statement can return zero, one, or many rows. Four distinct operations are available for cursors:

DECLARE. Defines the cursor, gives it a name unique to the program in which it is embedded, and assigns a SQL statement to the cursor name.

OPEN. Readies the cursor for row retrieval. OPEN reads the SQL search fields, executes the SQL statement, and builds the result table. It does not assign values to host variables, however.

FETCH. Returns data from the result table one row at a time and assigns the values to specified variables. If the result table is not built at cursor OPEN time, it is built fetch by fetch.

CLOSE. Releases all resources that the cursor uses.

Type translation occurs when the program attempts to retrieve a column that has been defined as a data type that the

programming language doesn't support. Consider dates. For the program to access a date column, the data must be converted to a form that the programming language understands. For example, DB2 converts a date column to a `PIC X(10)` field in COBOL. Of course, some functionality is usually lost after this translation. The RDBMS can perform date arithmetic directly (e.g., calculating the number of days between two dates by simple subtraction), but the programming language cannot.

Object Databases Meet Their (Mis)match

ODBMS products manipulate data using the methods defined in object classes and via the programming language used to define the classes. This language is usually an extension of an OOPL and therefore will operate at a record-by-record level. The ODBMS's DML (data manipulation language) has no impedance mismatch problem because it can access entire objects and is tied to the type-checking mechanism of the ODBMS.

Having the DML and the general-purpose programming language so tightly intertwined avoids the data-typing mismatch. Even in this scenario, however, access to database records is still row-at-a-time. Is this really a solution to the set-level component of the impedance mismatch problem? By moving back in time (i.e., prerelational) to record-at-a-time processing, you lose the benefits of set-level database access, such as eliminating the need for looping constructs (WHILE, FOR, and DO) for selecting, updating, deleting, or modifying multiple rows. A set-level language like SQL also makes ad hoc querying and report writing much easier.

Also, OOPLs came into use before ODBMSes were developed and widely available. Many object-oriented development projects have used proprietary file structures or a SQL interface to a RDBMS. In this situation, the impedance mismatch problem looms as large as ever.

The Future

One thing you can expect to see in the future is that the rules that define and maintain the integrity of the database can be stored as methods in a reusable class library, along with the business rules that guide the way a company performs its day-to-day operations. Also, since the user interface, network interface, and procedural logic are increasingly being written in an OOPL, it will be necessary to couple the OOPL and the ODBMS more tightly together.

A DBMS can attempt to resolve the impedance mismatch by extending its DML so that more of the application can be written with the DML directly. Consider Sybase SQL Server and its extended SQL offering, Transact SQL. This is a product in which looping and IF...ELSE constructs can be used within SQL. Additionally, user-defined data types, rules, defaults, and triggers can be attached to tables and columns, and stored procedures can be housed in the DBMS. Of course, Sybase is not an ODBMS: It lacks complex object support, inheritance, and many other object-oriented features.

A computationally complete DML will not, by itself, enable an entire application to be written in the ODBMS's language. Without programming constructs that control external resources, such as the user

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interface and hardware, the application cannot be successfully completed.

At present, ODBMS products are maturing and will inevitably eat into the huge market share enjoyed by RDBMS products. Nonetheless, RDBMSes will continue to prosper and thrive in the world of business data processing, where applications such as payroll and accounting do not generally require complex objects. Use of ODBMSes will continue to grow in those fields that require complex objects, such as CAD and manufacturing. There will always be true RDBMSes and true ODBMSes.

Successful RDBMS products will seek to incorporate the best components of object-oriented technology without compromising the relational model. Likewise, successful ODBMS products will seek to incorporate the best features of the relational model, without compromising the benefits derived from classes, inheritance, and encapsulation. This will likely lead to a marriage of the two technologies into a hybrid technology—object relational—that builds on the strengths of both relational and object-oriented concepts.

But—and this is no small matter—until the impedance mismatch problem is resolved, inconsistencies will continue to exist between the ways in which the DBMS and the programming language handle data items. ■

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Craig S. Mullins is a technical researcher in database design, client/server technology, object orientation, and relational technology at Platinum Technology (Oakbrook Terrace, IL). He is also the author of DB2 Developer's Guide *(Sams, 1992). You can contact him on Prodigy at WHNX44A, on CompuServe at 70410,237, or on BIX c/o "editors."*

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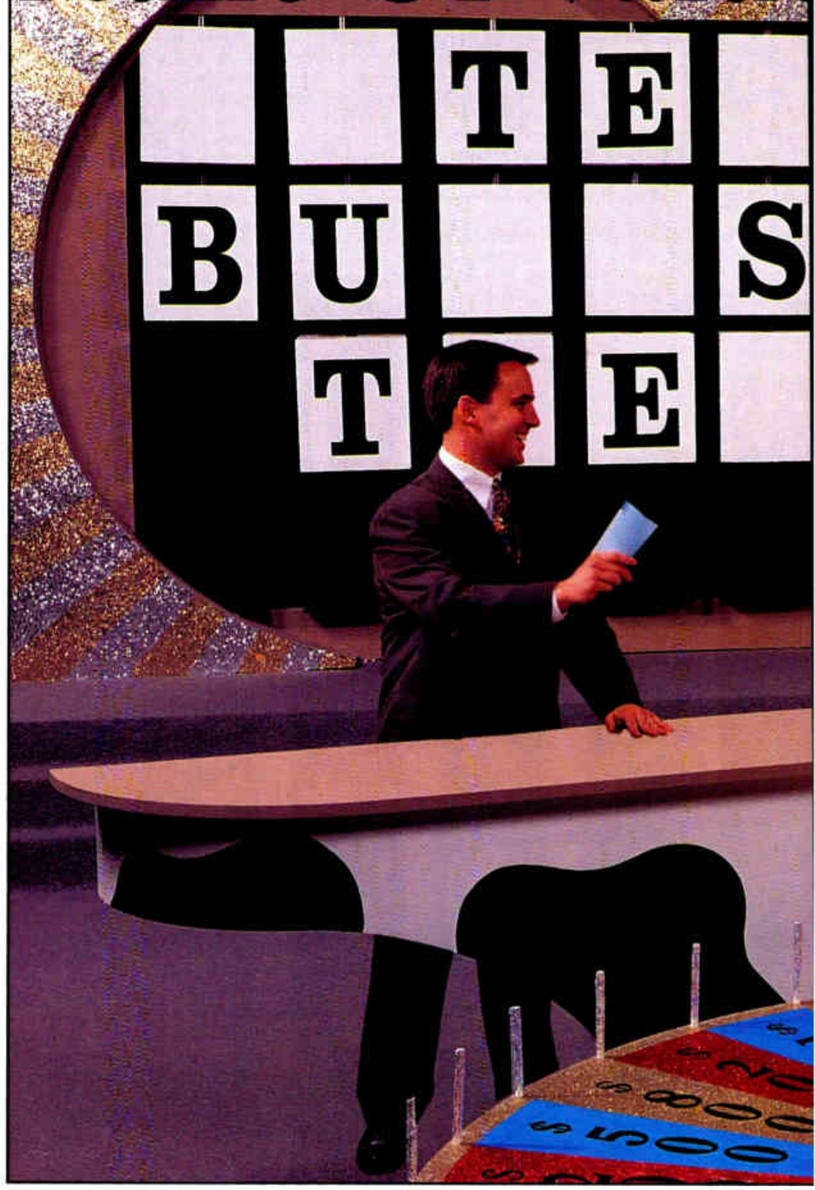

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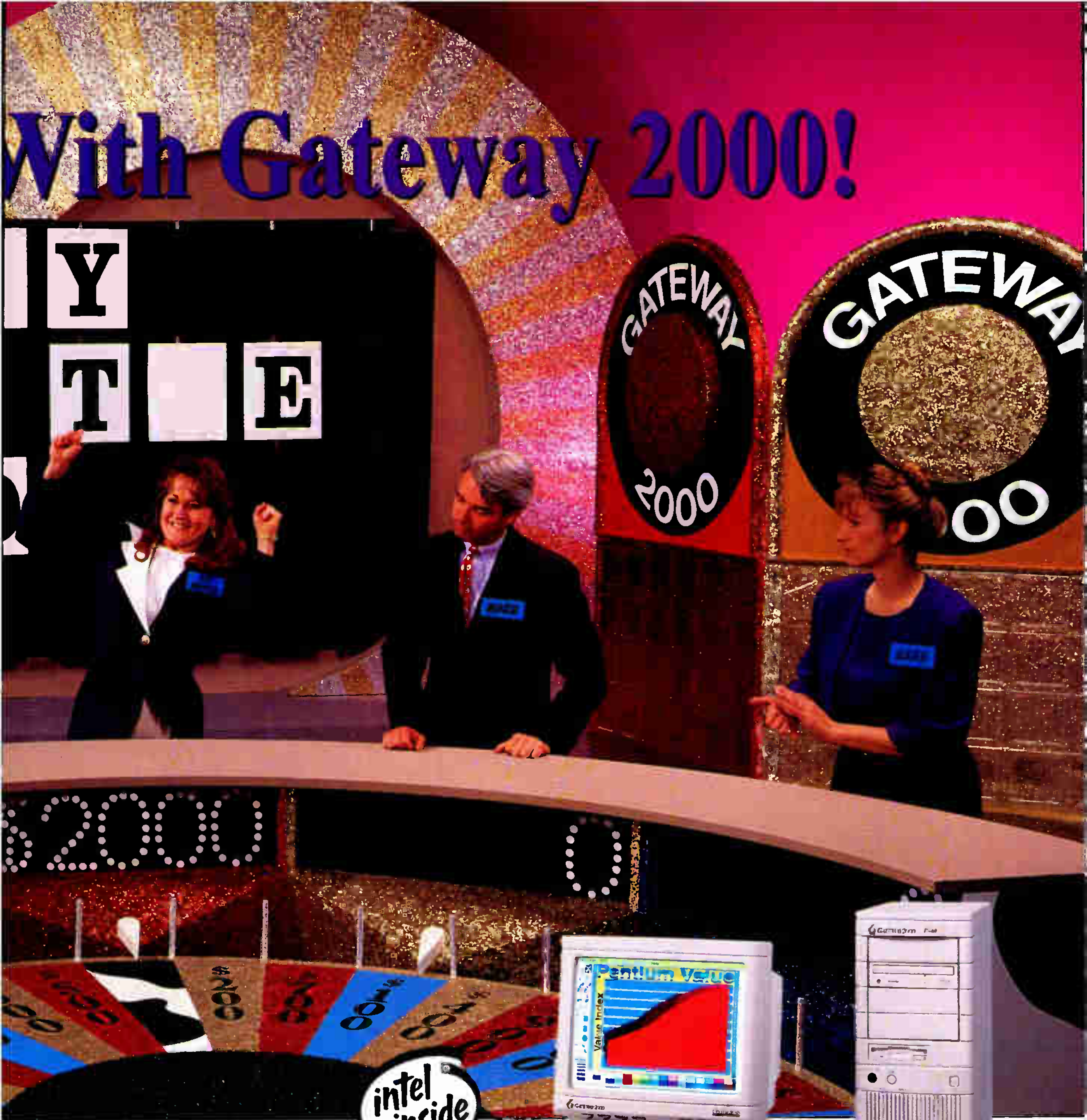

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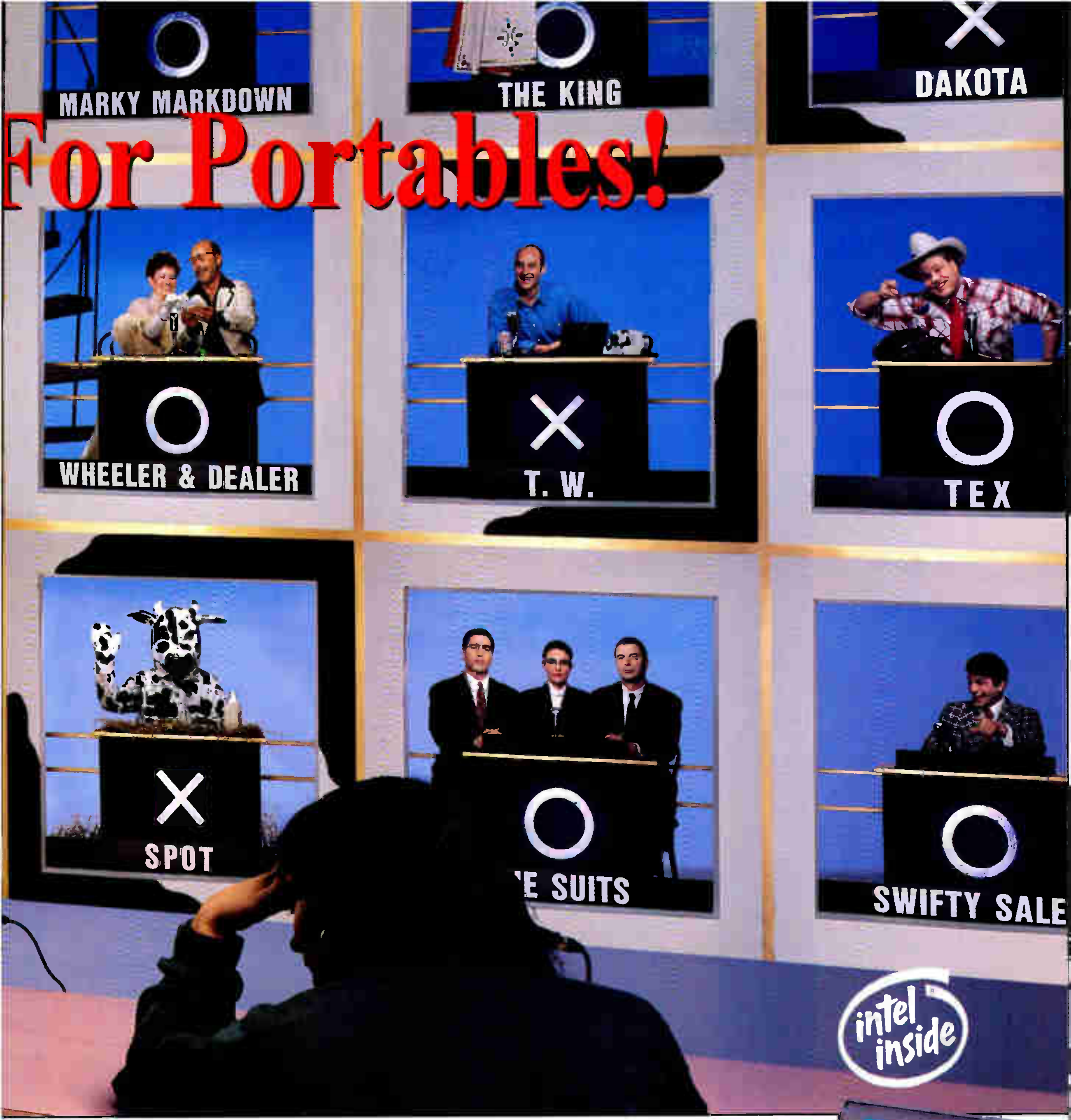

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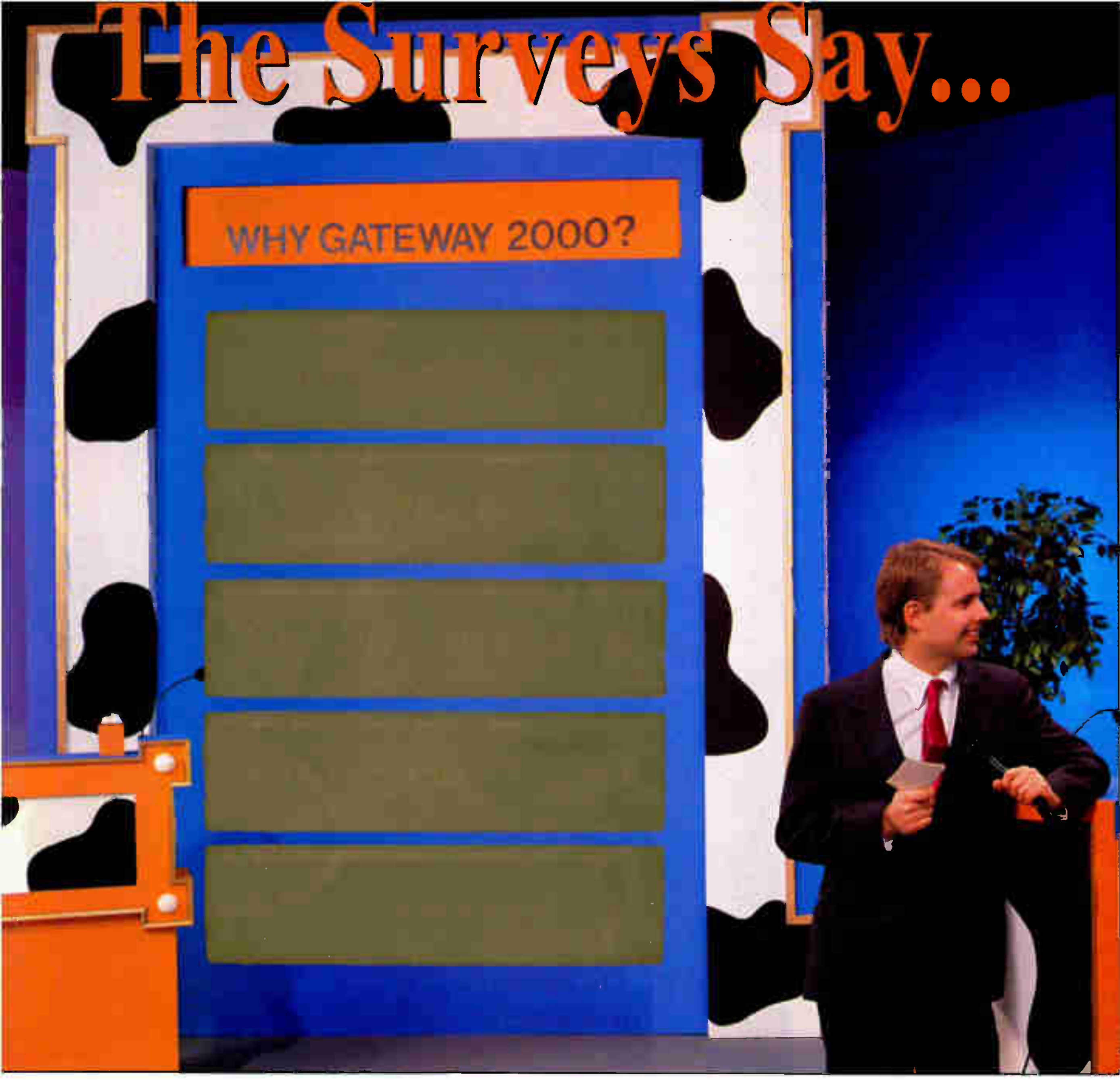

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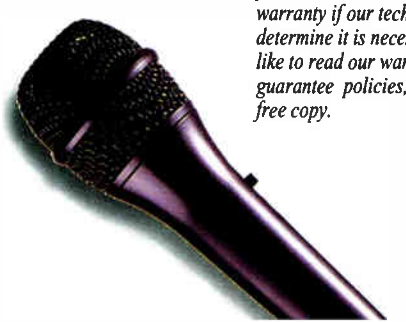

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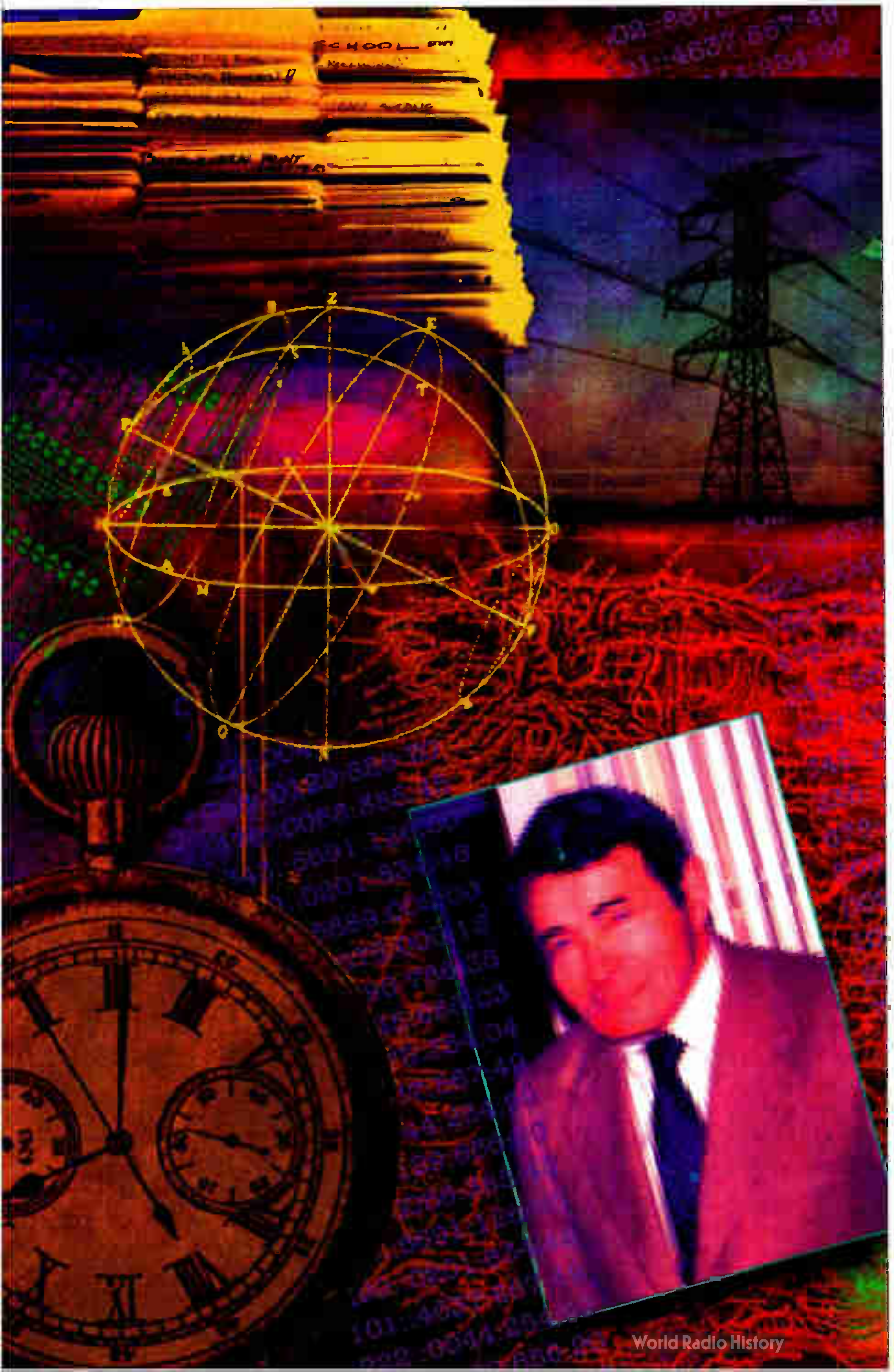
State of the Art

OBJECTS IN USE

Real-world applications of commercial ODBMSes show performance and development advantages

RUSSELL KAY



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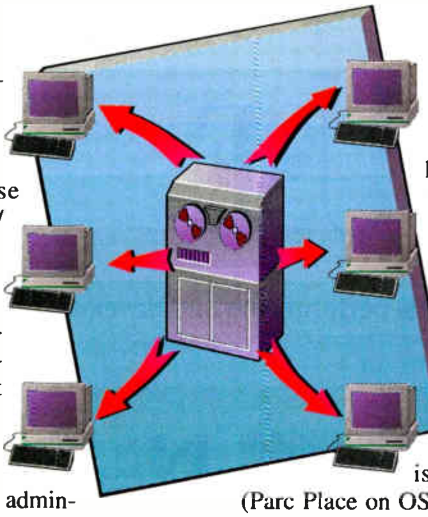
Not too long ago, DBMSes were complex pieces of mainframe software that only people with long experience could begin to comprehend or use. When microcomputers came along in the late 1970s, the first databases oriented toward end users were developed and marketed. Using these products, a whole new class of user-programmers began to create their own database applications. This was such a radical development that it marked a turning point in database computing.

Now, another shift is at hand. A whole new class of ODBMSes (object-oriented database management systems) has since been added to the wide variety of powerful and relatively inexpensive flat-file DBMS and RDBMS (relational DBMS) products on the market. To find out how these new products are being used in the real world, BYTE talked to a number of end users and systems developers about their experiences with object databases. We asked why they had chosen to go the object-oriented route, how they had evaluated and chosen the particular ODBMS product(s) they use, and what's still on their wish list—that is, what they would like to do but cannot at present. We found that most users began using object databases because, quite simply, they had complex data objects that needed to be stored. Here's a look at a few of these situations.

Betting on an ODBMS Is No Gamble

The Austin, Texas–based company Continuum is a vertical marketer of software to the insurance industry. The company's products help insurance companies—which until very recently were strictly large mainframe shops—move much of their processing onto workstation-based systems. Of course, the existing data and legacy systems are still important considerations. Continuum has two major products: Continuum Workstation Platform/Enterprise Solution, or CWP/ES, which helps



insurers manage distributed transaction systems; and Business Process Management/Enterprise Solution, or BPM/ES, which manages work flow and resource allocation.

According to Kenneth Schoff, a manager/consultant at Continuum, a typical insurance company can have as many as 15 different administrative systems, mostly mainframe-based, that might be up to 30 years old. But such a company wants to be able to present a single view of data to its internal users; for example, a user should be able to update an address change just one time and have it applied to all systems.

This type of system has to be transaction-oriented so that if a transaction fails for some reason, the data is current to the point before the failure. "We use Ontos ODBMS on OS/2 to maintain the persistence of all data that the user enters onscreen," says Schoff. Once the entry is completed on the PC, a local server submits the transaction to the mainframe, which handles validation, verifying that there is no conflict with another transaction. The local server resubmits the transaction later on if the system happens to be down.

This particular application didn't have to use an ODBMS, Schoff notes. "But everything else about the systems was object-oriented, so we tried to present an object view to the users. Then we translate that onto legacy systems," he adds.

Continuum's work-flow management system is a true object-oriented system, where the objects are distributed. BPM/ES works by defining available resources—equipment, people, and so on—as one type of object. The system also defines work to be performed in terms of work-flow objects, which Continuum calls "case objects." These can be nested with subcases to any depth, down to the level of individual tasks, which is where the work gets done. The system also uses a bidding/assignment algorithm to assign the work to the resources. It uses a best-skills match and also balances work flow—so it doesn't overload one person while others are idle, for example.

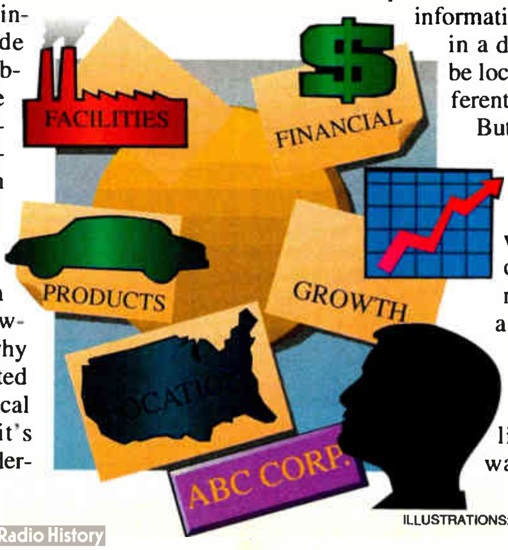
An object-oriented database works so well for Continuum because it provides all the data that the company needs in one call, according to Schoff, who adds that "with a relational DBMS, we might have to do a series of joins to get all the information we need."

For both Continuum products, the processing engine is written in Smalltalk (Parc Place on OS/2, Digitalk on Unix). A database interface-process module acts as a layer between Continuum's object model and the operating system. The company developed the products on a SparcStation and is currently porting both BPM/ES and CWP/ES to Hewlett-Packard's HP-UX. A client interface layer, also written in Smalltalk, allows a customer to mix and match workstations and data-bases; for example, an OS/2 engine can talk to an AIX database or vice versa.

Continuum selected the Ontos ODBMS as the basis for its systems in 1991. "We had a requirement from our customers, who were underwriting the development," says Schoff, "that the systems had to run on OS/2. We knew ourselves that they also had to operate on Unix." Support for those two operating systems was the deciding factor in Continuum's picking Ontos. At that time, Schoff comments, "Ontos was the only vendor whose development schedule matched our needs." He adds that Continuum also evaluated GemStone, ObjectStore, and Versant before deciding on Ontos.

Objective: Exploring Relationships

Analyzing and integrating a wide variety of distributed data is the function of InfoPower, a product from Delfin Systems of Arlington, Virginia.



To get an idea of how InfoPower works, and why an object-oriented database is critical to its success, it's necessary to understand how the intelligence community works—how it gathers data and pulls information out of it. Traditionally, says Delfin marketing manager Kent Potter, "in the intelligence arena, you're confronted with [not only] huge quantities of complex data, full-text databases, and traditional structured databases, but also image databases and lots of other things—and you've got to bring all this together in a way that makes sense."

Most systems designed for intelligence analysts and for the command-and-control community began with existing databases; applications were built to access them. But pulling together very different kinds of data poses real problems. For instance, you may have one database of locations and another of relationships (e.g., subordinations, who reports to whom, who talks to whom, who controls what, and what facilities control what products). Yet another database may store other attribute information, such as what quantities of a product are produced, how many of what model tank the Italian government possesses (not just where they are located), and trends.

Particularly in the intelligence field, Potter comments, "you're never going to find all the information you need about an entity of interest in one database; [such a situation] doesn't exist, because some data collectors must collect information in specialized ways, and their needs can only be met by building a database that supports them directly."

The information analyst must break down the walls between different databases. He or she may begin with little glowing dots on a map and then want to see the facilities that, say, produce nuclear weapons or drugs and then uncover any relationships between these facilities. This information could be buried in a database, or it may be located in a set of different data sources.

But what if you think of a new question or acquire some new data? Say you want to click on one of those on-screen map nodes and look at a picture of it. How about recovering the full text? What about a time line? What if you want to include a

ILLUSTRATIONS: ANDREW EDWARDS © 1994

group of facilities on a chart and add the amount of a particular chemical or the quantity of a piece of equipment each one produced in a given time frame?

One of InfoPower's modules is designed specifically to allow you to look at relationships. It has an auto-investigate function that starts at one node and goes out and looks at all the available relationships, explains Dan Stickel, Delfin's director of decision systems in Santa Clara, California. "Say it started with me; it could find out where I work, my religious preferences, and where I've traveled in the last few weeks."

In its original government-sponsored work, Delfin used a relational database. Stickel comments that "we were trying to look at the relationships between real-world things; we're really strong on relationships. So, what we thought was that doing relationships in a relational database... the name sounds like it should work."

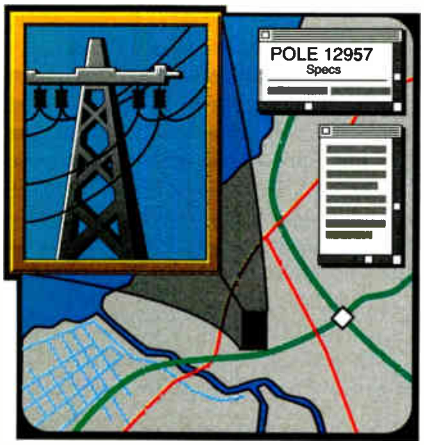
Experience proved otherwise, however, because exploring relationships with an RDBMS involves doing a lot of joins, and performance drops off steeply. Stickel found that using an object database really sped things up: "We were able to keep reference pointers instead of doing joins over and over again. Using the object database was definitely two orders of magnitude faster," he notes.

Expanding on the differences between the two approaches, Stickel notes that the RDBMS the company first used—Sybase—is a fine product. "If all you want to do is pull back lists of things, with filters, it's fast; there's no question about it. And going to an object database wouldn't make things faster. A lot of the time, the whole object-design methodology is more elegant and more extensible, but a little slower," he says.

Picking the right ODBMS product from the few that were available two years ago was no simple task. Stickel says that the company went through an extensive evaluation of several products, including Versant and Itasca, "to the point where we were actually using them." ObjectStore gave good performance, and at that time its technical support and documentation were deemed to be far superior to those of similar products that offered the features the company needed. "When we started [evaluating ODBMS products]," Stickel continues, "they were all really flaky—although reading about them in the press wouldn't have told you that. But trying to use them for real, we ran into one bug after another. Thankfully, that's no longer the case."

Delfin's Potter thinks that the advent of object databases has made a significant change in what's feasible. With more and more power becoming available on the desktop, and with vast amounts of data—of all types, not just rows and columns—proliferating, users need to access it in a fused, integrated way. You don't want to force people to learn multiple interfaces. "Now it is possible to put an object-oriented database in there as the hub; map those other, different databases to it; and then link out to whatever tools you need for visualization/analysis," says Potter. "In our view, that is a new category of product made possible by object databases. It's a brand new kind of product."

continued



Power Play

Florida Power and Light provides electricity to millions of people in the Sunshine State. Part of this job includes the maintenance of existing facilities and the design of new power-distribution channels. A spokesperson for the utility, who asked not to be identified, told BYTE that in the late 1980s it had developed a pilot version of a generic AMFM (automated mapping/facility management) application using a FORTRAN toolkit and mainframe-based technology.

Called the Facilities Graphics Management System, the application allows Florida Power and Light distribution engineers, designers, and service planners to bring up on a computer screen a picture of the geography of a given area, including streets, canals, other waterways, and buildings. It even locates poles, transformers, and switches. And it's not just pretty graphics; the system presents an intelligent map where supporting information is tied to parts of the picture. Place the cursor on a utility pole, for instance, and you can bring up information about the pole's size, class, and ownership.

Although this pilot application started out on mainframes, by the early 1990s the developers knew it was a natural for implementation via an object-oriented system. There was also a desire to move it to desktop platforms. The developers looked at Unix workstations and also considered several object-oriented databases, looking for one that was flexible and still had the "usual" DBMS functions one would expect in a mature relational database (e.g., backup and recovery). And since the application was object-oriented, there were naturally many advantages to using an object database. Also, they were concerned that using a relational database might tie their hands and have an impact on the design of the object model itself. Finally, performance and cost were important factors to consider.

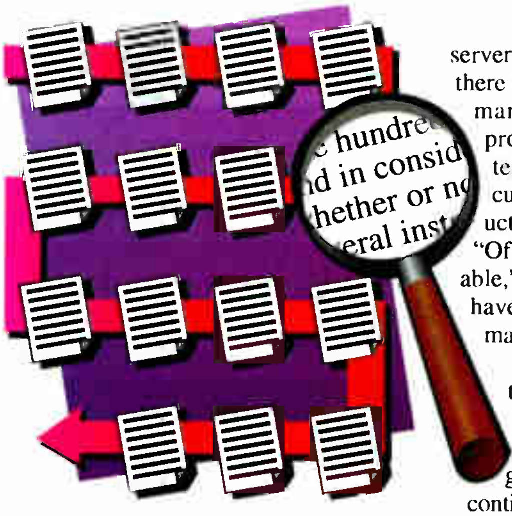
The developers decided to create the new system using a Smalltalk-based, object-oriented toolkit called Objective Facilities Management, which was developed at the University of Florida. Unfortunately, the toolkit provided no means of making objects persistent, so Florida Power and Light opted to use Servio's GemStone. The redone system, which was first implemented in Dade County, uses a master GemStone database on a central server, with local servers (which also run GemStone) at the various usage sites. Actual design work is done on IBM-compatible 486/33 PCs.

One interesting aspect of the system is that it typically encounters the "long transaction" problem. In other words, a single user can tie up a large area or block of data for a long period of time before it gets completed and returned to the server. However, there's not too much of a problem with different users trying to work on the same area at once.

Documenting the Advantages

PassagePro is a recently released document management and production system from Passage Systems. The object-oriented system runs on Silicon Graphics workstations and provides document check in/check out, configuration management, work-flow management, and workgroup notification, with automatic production of both on-line and hard-copy information.

According to Vance Nakamoto, president of the Mountain View, California–based firm, "the object-oriented paradigm fits our problem space very well." He adds that the company expects to ultimately be able to use relational databases as well, "but we figured the best way to start was with an object-oriented DBMS," he says. "We wanted to create an API from an object-oriented perspective rather than having relational technology affect our implementation." To do this, Passage Sys-



tems built its API with a database transaction layer beneath it. "Now we're doing a Sybase port," Nakamoto says, "and it will have a new binding layer to the relational database."

Passage Systems decided about two years ago to use Versant as its ODBMS. Reasons for the choice included the fact that Versant was more focused on client/server and multiserver solutions and that there was already a lot of configuration management built into the ODBMS product itself. Finally, Passage Systems was attracted to the proactive, customer-oriented attitude of the product's company and its nearby location. "Of the few object databases then available," says Nakamoto, "they seemed to have the best performance for the data management scenario we were facing."

He adds that using relatively new technology carries its own price and that the early versions of the ODBMS software were quite buggy. Things are much better now, he continues, adding that PassagePro stresses the Versant system more than most and that Versant has been quite responsive. At the time BYTE talked with Nakamoto, he was about to begin the process of porting the product to Versant 3.0 on a Sun workstation.

Nakamoto is not clear whether the capabilities and performance of object databases will scale up effectively for large installed databases that have gigabytes of data and thousands of objects. However, he might be encouraged by the positive experience at Florida Power and Light, whose database for Dade County alone is several gigabytes in size.

No Objections Here

Although this article takes a look at only a small sampling of how object database systems are being used in the real world, it seems clear that for a number of applications the promise of improved performance and added functionality has indeed been realized.

Clearly, ODBMS technology is not appropriate for many situations. However, where data is generated by object-oriented applications that are written with object-oriented programming languages, using an ODBMS to store persistent data is a win-win situation for systems developers and end users alike. ■

Russell Kay is a technical editor at BYTE. He can be reached on the Internet or BIX at russellk@bix.com.

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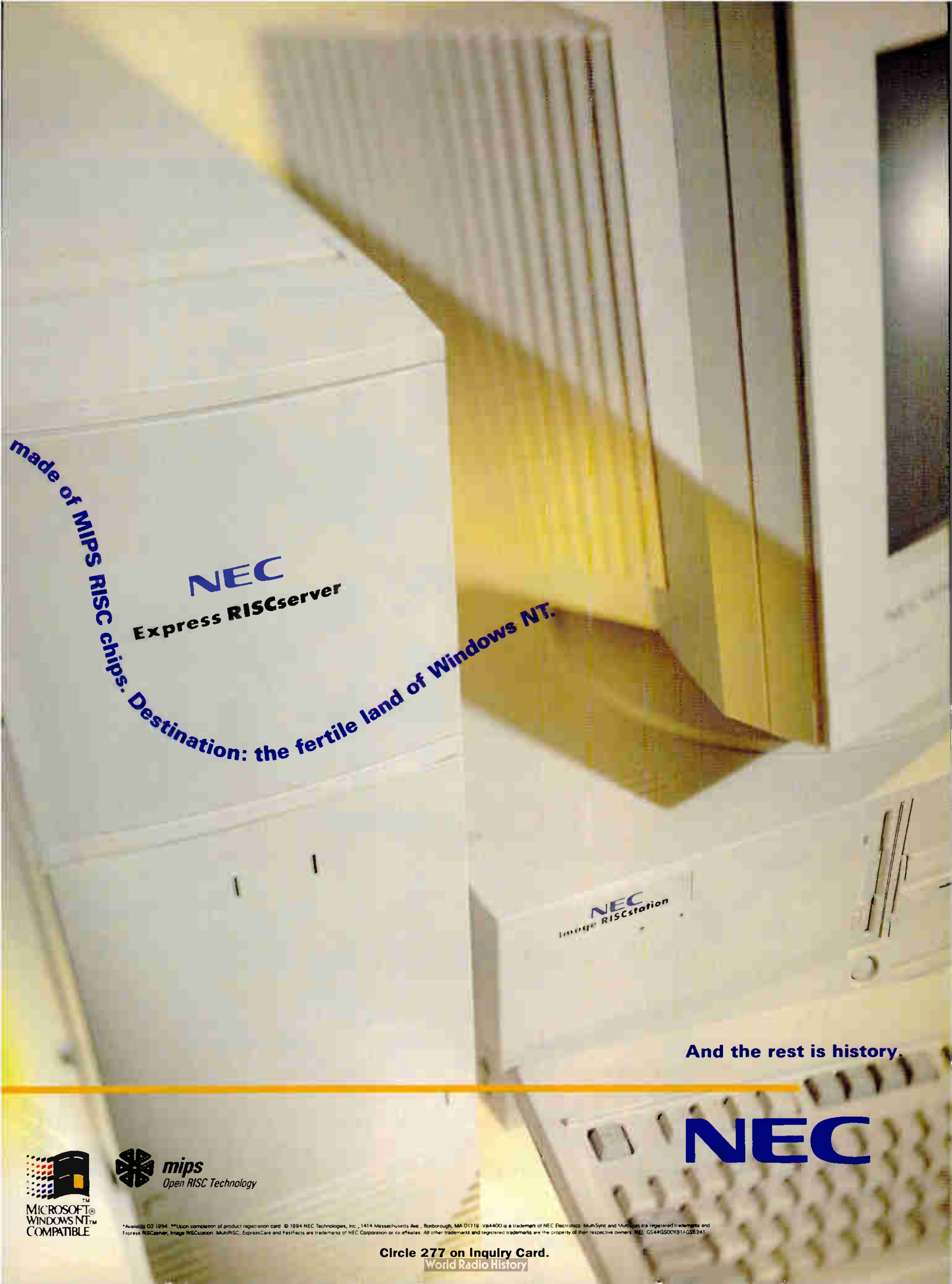
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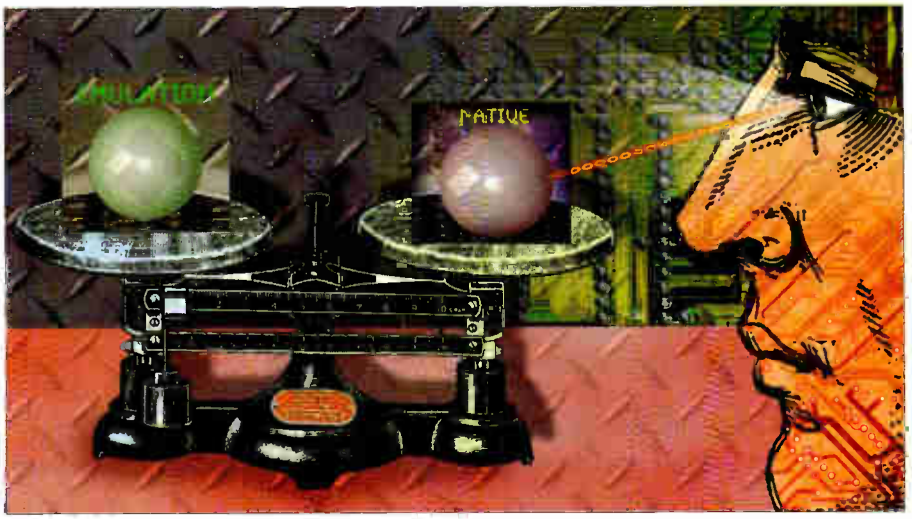

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Windows PCs are no RISC workstations, but then, RISC workstations are no Windows machines, either. Workstations may make the perfect platform for core business activities, such as hosting corporate databases or serving as development or engineering systems. But traditionally, RISC workstations have provided a poor environment for running the kinds of tools that most *individuals* in a business need daily—the humble word processors, spreadsheets, and small-scale databases for which Windows excels.

By making workstations capable of directly running 16-bit Windows applications, emulation technology promises to bring to the workstation desktop the rich selection of commercial and in-house applications that Windows users now enjoy. SunSelect's Wabi, Insignia Solutions' SoftWindows, and Microsoft's Windows NT emulation support are examples of this technology, supporting Windows binaries on Hewlett-Packard's PA-RISC, Sun Microsystems' SPARC, DEC's Alpha, the PowerPC, and Mips systems (see "Emulation: RISC's Secret Weapon" on page 119).

Pure instruction-by-instruction emulation exacts, of course, a severe performance penalty; so each of these technologies combines emulation with various native Windows components to provide speeds closer to those expected of the underlying machine (Insignia Solutions' SoftPC and sibling SunPC from SunSelect more closely match the pure emulation model). And performance can be a critical issue, especially since the Windows applications that users will likely run under emulation will be highly interactive.

BYTE tested the performance of Windows applications, running through emulation, on workstations built on each of the processors listed above. There is noticeable variance among machine and technology combinations, but on balance, RISC workstations will not deliver the Windows performance to which you are probably accustomed: Current workstations and emulation technology provide only about 20 percent the speed of a good native Windows platform (e.g., a 66-MHz 486DX2 with accelerated graphics). While this performance might be adequate for many common office applications, tasks that require moderate to heavy computation will suffer under emulation. This includes applications such as data analysis, imaging, and CAD.

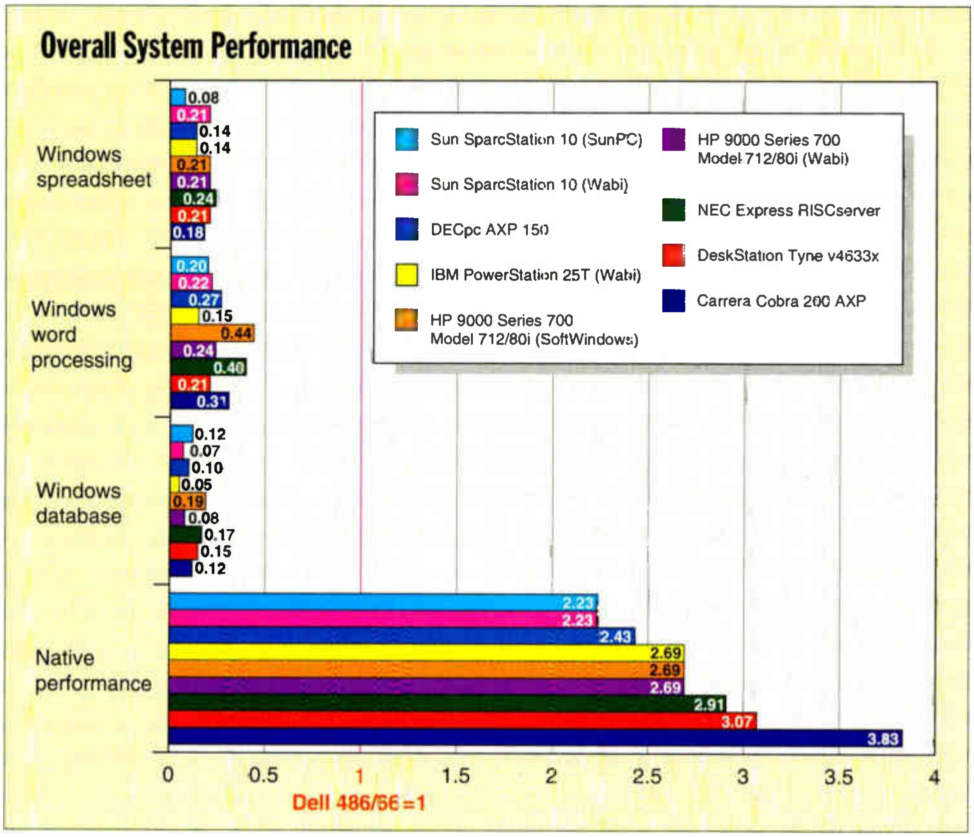
Wabi, Windows NT, or SoftWindows: Whichever way you run Windows on a RISC workstation, CISC is better

Testing Details

I tested seven systems: Carrera Computers' Cobra 200 AXP (Alpha), Desk-Station Technology's Tyne Series v4633x (Mips), DEC's DECpc AXP 150 (Alpha), the IBM RS/6000 PowerStation 25T (PowerPC), the HP 9000 Series 700 Model 712/80i (PA-RISC), the NEC Express RISCserver (Mips), and the Sun SparcStation 10 Model 512 (SPARC). The PowerStation 25T, HP 712, and SparcStation 10 are Unix systems; the other machines run Windows NT. The configuration details for each system are given in the "System Features" table on page 114.

The Windows NT machines all run 16-bit Intel Windows binaries through Windows NT emulation, but the Unix systems exploit a few different technologies. I tested each running Wabi 1.0. I also tested the HP 712 with SoftWindows, and the SparcStation 10 using SunPC, Sun's emulation offering. Sun offers a hardware accelerator for SunPC (an actual 486 on an SBus card), but I didn't test that option because its software-emulation component accounts for only a small part of its performance.

For each of these combinations of system and emulation



Summary benchmark results for RISC workstations running 16-bit Windows applications. Systems are listed in order of native processing speed, as determined by BYTE's portable benchmarks. For each test, a score of 1 represents the performance of a typical Windows configuration, a 66-MHz 486DX2 PC with accelerated graphics. Although these systems average just under three times the speed of a 486DX2/66 running native code, the average speed for these RISC machines running Windows is only one-fifth that of a 486DX2/66.

technology, I ran four suites of tests. The first, BYTE's portable benchmark suite, is a collection of low-level synthetic benchmarks written in C. The portable benchmarks evaluate native processing performance for each of the systems, providing a yardstick against which to measure the performance of Windows applications running under emulation; they are a mixture of memory access, integer, and floating-point tests.

The other three suites are NSTL's Windows application performance tests. These test spreadsheet, word processing, and database performance using off-the-shelf applications. The suites test a mixture of operations appropriate for each application category, like charting for spreadsheets or updating a database. I used Microsoft Excel for spreadsheets, Microsoft Word for Windows for word processing tests, and either Borland's Paradox for Windows or Software Publishing's Superbase (depending on circumstances described below) for testing database management.

Testing Changes

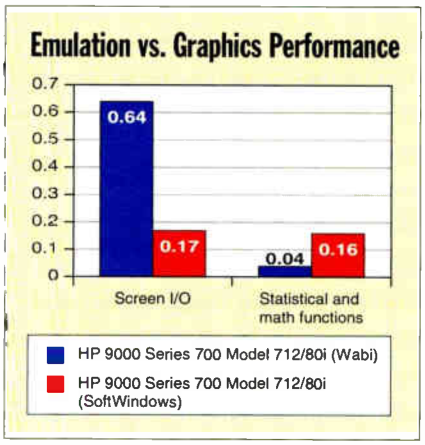
I had to make a few minor modifications to the standard test suites. First, these tests do not include printing performance, as these workstations' print emulation mechanisms are so different from one another that it would have made a fair comparison impossible. Second, some of the interactive tests for the database suite aren't counted, because they run too quickly on some of these systems to time accurately. Third, the word processing tests don't include some tests that are very dependent on screen size, since I couldn't normalize display modes across systems.

In addition to the systems under test, I also ran each suite on a Dell Dimension 486 to serve as a baseline for comparison. The Dimension includes a 66-MHz 486-DX2 processor, 24 MB of memory, and a Number Nine GXE graphics card, a PCI (Peripheral Component Interconnect) video accelerator. The Dimension is a fast machine, one that approximates the state of the art for Windows 3.1 desktop systems. All the test results are reported as indexed against this baseline; that is, a score of 1 on a test indicates performance equal to that of the Dimension.

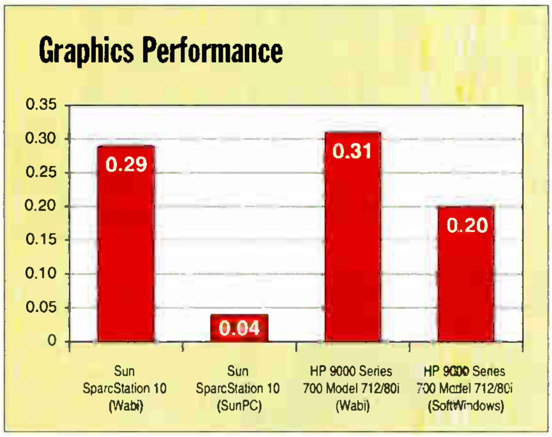
The only Wabi-certified Windows DBMS is Paradox for Windows. However, Paradox for Windows requires 386 support, so it can't be run on any of the other emulators, which supply only 286 emulation. Therefore, I ran Paradox for Windows on all the Wabi systems, and I ran Superbase on all non-Wabi systems. I ran both packages on the Dimension, and, again, all results are reported in comparison to that system.

Comparing Performance

The figure "Overall System Performance" shows the results for each tested system. Results are listed in order of native performance, according to the BYTE portable benchmarks. Native performance ranged from a high of 3.83 times the performance of a 486DX2/66 (for the Carrera Cobra's 200-MHz Alpha) to a low of 2.23 for the Sun SparcStation 10. Note that the BYTE portable benchmarks do not take advantage of the second processor in the SparcStation 10, so, for the purposes of this comparison, that system is effectively running on a single 50-MHz SPARC. On the average, these worksta-



Wabi is better when it comes to pure graphics tests, but it falls behind the superior emulation and native DOS support provided by SoftWindows on more floating-point- and processor-intensive tasks. These two tests, from the Windows spreadsheet benchmark, show a dramatic difference between graphics operations (screen I/O) and floating-point processing (statistical and math functions).



SunPC is a pure virtual PC environment; both Wabi and SoftWindows include components of Windows compiled natively. The difference is obvious when making heavy use of Windows graphics calls, as when drawing charts in Microsoft Excel.

tions are 2.75 times as fast as the Dimension running native code.

Emulated performance, however, is a significantly different story. For all three applications and all workstations, the mean workstation performance is only 0.19 times that of the Dimension.

Each application puts different demands on a system. All the applications consist of a variety of operations with different requirements, but they can be roughly broken down as follows. The database benchmarks are most affected by fast hard disk performance and processing speed; these are the least affected by the performance of Windows itself. The spreadsheet benchmarks are heavily influenced by Windows performance and vary primarily according to video display speed and floating-point performance. Word processing tests are about an even mix of display, processor, and disk performance and, again, are strongly dependent on Windows performance.

Separate Strengths

Similarly, each emulation technology has strengths of its own. Wabi, through its use of calls to the underlying X Window System manager, makes the best use of workstation graphics performance; however, when Wabi systems must emulate rather than make native calls, they are apparently weaker than SoftWindows or Windows NT systems. SoftWindows, with native versions of DOS and Windows, takes good advantage of underlying hardware and also offers very good emulation. Windows NT's emulation is similar to that of SoftWindows (as far as emulation on RISC goes) and presents the same strengths. SunPC, SunSelect's fully emulated PC environment, has excellent emulation but very poor display speed relative to the other technologies.

Test results suggest that the emulation provided by Wabi is not as good as that provided by SoftWindows. On the spreadsheet screen I/O tests, Wabi again takes better advantage of underlying graphics performance and outruns SoftWindows almost four to one on the same machine (the HP 712). However, the results are completely reversed for the floating-point- and processor-intensive statistical and math functions test, where SoftWindows' better floating-point support and processor emulation appear to make the difference.

Both SoftWindows and Wabi make use of the underlying X Window System, although Wabi's more complete exploitation of that system makes it the faster graphics platform. But any use of X makes an enormous difference over pure bit-map-oriented screen emulation. On the spreadsheet chart tests for SoftWindows, Wabi, and SunPC running on the HP 712 and the SparcStation 10, the Wabi systems performed better than the SoftWindows system.

The most obvious disparity, however, is between SunPC, which emulates the screen completely in software, and the other three systems, which make use of native graphics calls. On the SparcStation, Wabi is 6.5 times faster than SunPC on this test.

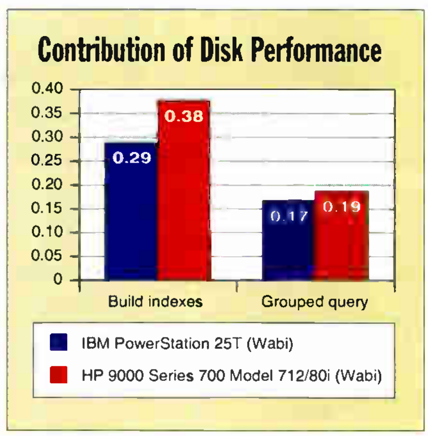
Component Factors

Emulation performance isn't the only thing that affects the performance of Windows applications—sometimes it's just old-fashioned component speed. One test measures Windows database indexing and multiple-table queries under Paradox for the PowerStation and the HP 712. Although the PowerStation's PowerPC 601 and the HP 712's 80-MHz PA 7100LC are evenly matched on the portable benchmarks and both systems are running Wabi, the HP 712 easily outperforms the PowerStation while indexing, on the strength of a faster disk subsystem.

There's little correlation between operating system and emulation performance, as you might expect; the Windows NT systems performed primarily according to processor and component speed and were mixed with the Unix systems for overall results. Among the Windows NT systems, the Mips workstations and Alpha machines (the DECpc AXP 150 and the Carrera Cobra 200) present similar emulation performance despite a significant difference in raw CPU power.

Current Limitations

Emulation for Windows applications on RISC systems is still in its early stages, and I expect that performance results will change with pending releases of upgrades to these technologies. At the moment, working with these systems presents a challenge that goes beyond mere performance, as they are still unstable to some extent.



Emulation capability isn't the whole story when comparing Windows performance; sometimes it just boils down to faster components. The PowerStation 25T's PowerPC 601 runs exactly as well as the HP 712's PA 7100LC on BYTE's native processor benchmarks and is very close on the memory-intensive database query in Paradox for Windows. However, the HP 712 pulls ahead on the disk-intensive index test purely on the strength of better disk performance. Such component differences can mask the effects of emulation when comparing RISC systems.

In general, the Windows NT systems proved to be more stable than the Unix workstations when running 16-bit Windows applications. SunPC had some problems unrelated to performance. Running the Word for Windows test, for example, twice generated an error message from SunPC for an unsupported instruction. But attempting to dismiss the error message box locked the console. The Excel spreadsheet tests also generated an exception (a plain old GPF, or general protection fault), but only on the first run; the second run worked fine.

I tested with beta versions of Wabi, so a

SPECIAL The RISC Decision REPORT

SYSTEM FEATURES

System features that contribute to performance, and system pricing.

			
SYSTEM	**COBRA 200 AXP**	**TYNE SERIES V4633X**	**DECPC AXP 150**
Processor			
CPU	Alpha AXP 21064-200	IDT R4600	DECchip 21064
CPU speed (MHz)	200	133	150
Primary cache (KB, instruction/data)	8/8	16/16	8/8
Secondary cache (KB)	2048	512	512
RAM (as tested, MB)	64	64	64
Memory width (bits)	128	128	128
Graphics			
Graphics card	ATI	Appian Renegade 1280V	Compaq QVision SVGA
Graphics processor	ATI Mach 32	Appian AGC98032	Compaq
Resolution tested	1024 × 768	1024 × 768	1024 × 768
Graphics bus	PCI	VESA	EISA
Hard drive			
Hard drive tested	525-MB SCSI	540-MB IDE, 1080-MB IDE	1-GB SCSI (2)
System software			
Native operating system	Windows NT 3.1	Windows NT 3.1	Windows NT 3.1
Windows emulation	Windows NT 3.1	Windows NT 3.1	Windows NT 3.1
Other components in tested system	PCI SCSI, PCI Ethernet, PCI Video, 17-inch monitor, mouse, keyboard, serial/parallel ports, 1.44-MB floppy drive, CD-ROM	Ethernet, 17-inch monitor, mouse, keyboard, serial/parallel ports, 1.44-MB floppy drive, CD-ROM	17-inch monitor, Ethernet, mouse, keyboard, serial/parallel ports, 1.44-MB floppy drive, CD-ROM
System price			
As tested	$8995	$10,729	$13,012
Base configuration	$6995	$3995	$8495
Contact	Carrera Computers, Inc. 23181 Verdugo Dr., Suite 105A Laguna Hills, CA 92653 (800) 576-7472 or (714) 707-5051 fax: (714) 707-5053 carrera1@delphi.com **Circle 1078 on Inquiry Card.**	DeskStation Technology 13256 West 98th St. Lenexa, KS 66215 (800) 793-3375 or (913) 599-1900 fax: (913) 599-4024 **Circle 1079 on Inquiry Card.**	Digital Equipment Corp. 40 Old Bolton Rd. Stow, MA 01775 (800) 722-9332 **Circle 1080 on Inquiry Card.**

[1] Prices reflect two processors (price with one CPU: $22,495).
[2] Price with two CPUs is $15,000.

little instability is to be expected there. However, some of the difficulty in working with Wabi goes beyond its beta status. Getting Paradox for Windows to work, in particular, required a day of tweaking configuration files, even given that the file-locking limitations of Wabi were well-documented. Unfortunately, this is the only Windows DBMS that is currently certified to run on Wabi 1.0.

Trends

The benchmark results lead to a few conclusions: Wabi is the best technology for graphics applications, but it is somewhat lacking in emulation for code that doesn't run through supported Windows components. SoftWindows is surprisingly strong in all areas, although Wabi is still better on graphics. SunPC has excellent emulation and a good DOS platform but is not as fast a platform for Windows as the other two technologies available on SPARC (Wabi and SoftWindows). And Windows

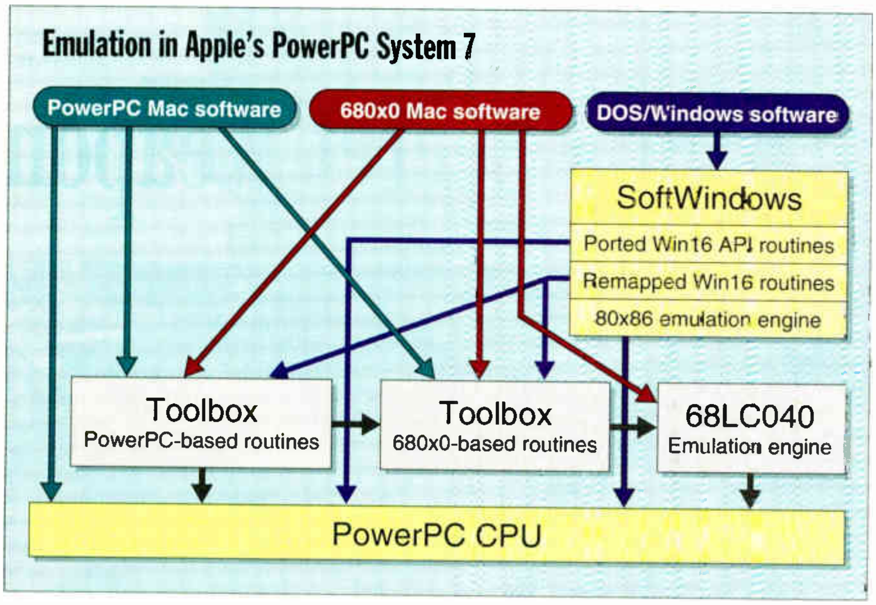
			
RS/6000 POWERSTATION 25T	**HP 9000 SERIES 700 MODEL 712/80I**	**NEC EXPRESS RISCSERVER**	**SPARCSTATION 10 MODEL 512**
PowerPC 601	PA 7100LC	NEC VR4400SC	SuperSPARC (2)
66	80	150	50
32	256	16/16	20/16
None	None	1024	1024 per CPU
64	64	32	64
64	64	128	128
GXT150	Integrated	64-bit Jaguar VXL	Turbo GX Plus
IBM	Integrated	Jaguar	Turbo GX chip
1280 × 1024	1280 × 1024	1200 × 1600	1152 × 900
Local bus	Proprietary local bus	64-bit VXL	SBus
1-GB SCSI	1-GB SCSI	1.3-GB SCSI, 520-MB SCSI	1.5-GB SCSI-2, 1.05-GB
AIX 3.2.5/AIXwindows 11.r5	HP-UX 9.03	Windows NT 3.1	Solaris 2.3
Wabi	Wabi 1.1, SoftWindows	Windows NT 3.1	Wabi, SunPC
17-inch monitor, Ethernet, Token Ring, FDDI, mouse, keyboard, serial/parallel ports, 1.44-MB floppy drive, CD-ROM	19-inch monitor, Ethernet, mouse, keyboard, serial/parallel ports, 1.44-MB floppy drive, CD-ROM	Local-bus Ethernet, mouse, keyboard, 1.44-MB floppy drive, CD-ROM (no monitor)	20-inch monitor, integrated Ethernet, ISDN, audio, speakerbox, 1.44-MB floppy drive, CD-ROM
$14,775	$20,576	$12,000	$27,995[1]
$9395	$8820	$11,000[2]	$25,995[1]
IBM Corp. Old Orchard Rd. Armonk, NY 10504 (800) 426-2255 **Circle 1081 on Inquiry Card.**	Hewlett-Packard Co., Direct Mktg. P.O. Box 58059, M/S 511L-SJ Santa Clara, CA 95051 (800) 637-7740 fax: (800) 333-1917 **Circle 1082 on Inquiry Card.**	NEC Technologies, Inc. 1414 Massachusetts Ave. Boxborough, MA 01719 (800) 632-4636 or (508) 264-8000 fax: (800) 366-0476 BBS: (508) 635-4706 **Circle 1083 on Inquiry Card.**	Sun Microsystems Computer Corp. 2550 Garcia Ave. Mountain View, CA 94043 (415) 960-1300 fax: (415) 969-9131 **Circle 1084 on Inquiry Card.**

NT emulation runs about as well on Alpha systems as it does on Mips systems.

Despite these differences in the performance of each technology, the results taken as a whole suggest that RISC Windows performance on 16-bit Intel Windows binaries is still well below that of solid Intel-based Windows machines. The very best overall application score for any RISC workstation was earned by the HP 712 running Word for Windows under SoftWindows, at less than half the speed of the Dell Dimension. Overall, any application for which you require 33-MHz 486 or better performance isn't a very good candidate for emulation on RISC. ■

ACKNOWLEDGMENTS *BYTE Lab technical director Rick Grehan and BYTE Lab assistant Selinda Chiquoine also contributed to this story.*

Steve Apiki is a BYTE contributing editor and senior developer at Appropriate Solutions, Inc., a consulting firm based in Peterborough, New Hampshire, and specializing in cross-platform development. You can reach him on the Internet or BIX at apiki@bix.com.



System 7 for PowerPC *relies on built-in emulation not only for backward compatibility with 680x0-based Mac software, but also for its own Toolbox routines that aren't yet ported. Even native PowerPC programs call some Toolbox routines that must be handled by the 68LC040 emulation engine. Also, due to the effect of call chains, some native Toolbox routines call 680x0-based routines. If Insignia's SoftWindows is installed, some Windows code passes through two emulation layers: the SoftPC 80x86 engine and the 68LC040 engine.*

unheard of in real-time emulation.

Designers are getting enormous help from recent trends in the evolution of system software. The API layers originally designed to shield applications programmers from the complexity of the underlying operating system are a boon to emulators, which can take advantage of the API to further their agenda of hardware/software abstraction. API calls made by the nonnative program can be translated to similar API routines on the native platform, thus bypassing the tedious steps of instruction emulation.

Taken together, these three developments—faster CPUs, refined emulation engines, and API translators—amount to a breakthrough in emulation technology. The first clue that a watershed was reached came last year, when Microsoft included an 80x86 emulator in the RISC versions of Windows NT. This lets computers with Mips R4000 and DEC Alpha AXP microprocessors run Windows 3.1 binaries compiled for Intel microprocessors.

Also last year, SunSelect (Chelmsford, MA) announced Wabi, an API translator that runs several of the most popular Windows 3.1 binaries on Unix workstations. Microsoft countered by licensing one of its greatest corporate treasures—the Windows API source code—to Insignia Solutions (Mountain View, CA), a leading company in emulation technology. The result is Insignia's SoftWindows, which runs Windows 3.1 on major non-Intel platforms.

This March, Apple (Cupertino, CA) took emulation technology still further—taking perhaps the greatest risk in its history. The new Power Macs (see "Apple, IBM Bring PowerPC to the Desktop" on page 44) run a PowerPC version of System 7 that includes a hybrid 68LC040/68020 emulator. The emulator provides backward compatibility with 680x0-based Mac software on the new RISC platform, much as the 80x86 emulator in the RISC versions of Windows NT provides backward compatibility with Windows 3.1 software. But Apple is also using the emulator to run portions of System 7.

Thus, System 7 becomes the world's first recursively emulated operating system, relying on its built-in emulator to run parts of itself as well as existing 680x0 programs and native PowerPC applications. In a real sense, Apple is staking its future on the viability of emulation (see "The Power Mac's Run-Time Architecture" on page 131).

API Translation

Operating systems have long provided services to programmers for handling some low-level tasks that are specific to the underlying hardware. For instance, an operating system might provide routines for printing characters on the screen, reading incoming bytes through a communications port, or writing data on a disk. All the programmer has to do is pass the appropriate arguments to the routine, and the operating system does the rest. But the shift to graphics-oriented computing that occurred in the 1980s caused an explosion in both the number and sophistication of services provided by the operating system.

When Apple introduced the Mac in 1984, programmers complained it was difficult to program. Suddenly, programmers were responsible for constructing a graphics front end replete with pull-down menus, windows, dialog boxes, and icons, all managed by a complex event loop. Everything had to conform to a series of rigid "guidelines" laid down by Apple.

To make the job a little easier, Apple equipped the Mac with the Toolbox, a rich library of operating-system routines that saved programmers from hundreds of the most onerous chores. Common Toolbox routines like NewWindow (draw a new window on the screen), FillRect (fill a rectangular area with a pattern), and CopyBits (copy a block of pixels from one screen location to another) isolate Mac programmers from many of the lowest-level tasks and are often highly optimized. In effect, the Toolbox imposes a thick abstraction layer between the programmer and the hardware. Apple strongly discourages programmers from bypassing the Toolbox because the program might break on future releases of the operating system.

This model has been adopted by all modern GUI-based operating systems. The various Windows APIs, X Window System, Motif, Open Look, NextStep, GEOS, and PenPoint all have API layers that simplify the task of programming for a GUI while standardizing the look and feel of the application riding above it. If the API is ported to another CPU, programmers writing in high-level languages may not notice the difference. The API calls look exactly the same, accepting the same arguments and returning the same results.

This trend plays right into the hands of emulators, which seek to impose another abstraction layer that isolates nonnative binaries from the underlying differences in hardware and system software. All APIs share a number of common functions, and an emulator can take advantage of that by mapping—or "translating"—API calls from one library to another.

Alternatively, an API can be natively

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ported to the target platform or completely rewritten. Whether the API is translated, ported, or cloned, as long as it accepts the same parameters and provides the same services, the differences are virtually invisible to programmers writing in high-level languages.

These approaches do not entirely eliminate the need to emulate binary instructions. There is always some code that doesn't call the API. Fortunately, the most time-consuming code (e.g., screen drawing) tends to rely heavily on API routines. Modern GUI applications spend enormous amounts of time redrawing the screen and performing other graphics chores, and almost all of that time is spent in the API.

Performance profiles reveal that a typical Windows program spends about 60 percent of its time executing API calls, while the average Mac program spends about 80 percent of its time in the Toolbox. Mac software tends to be more API-intensive since the Toolbox is significantly larger than the Win16 API: more than 4000 calls versus 800 to 1500, depending on which extensions are counted.

Look and Feel

When the routines of one API are substituted for the routines of another, a side effect is that the program may acquire the look and feel of the host API. For instance, if Apple's Toolbox call for displaying a pull-down menu is mapped to the corresponding routine in Motif, the result is a Motif-style menu, not a Mac-style menu. The Mac program adopts the appearance and behavior of a program that's written natively for Motif.

An example of this approach to emulation is the Equal Application Adapter from Quorum Software Systems (Menlo Park, CA). Equal allows you to run the Macintosh versions of Microsoft Word and Excel on a Unix workstation under Motif or Open Look. Quorum spent three years laboriously translating more than 4000 Toolbox routines into their Motif, Open Look, and X equivalents. A 680x0 emulation engine handles non-Toolbox code.

Equal makes no attempt to emulate the entire Mac OS. Instead, you launch the Mac applications directly from the Unix desktop. "People don't want to buy system software, middleware, because it doesn't do anything," says Nick Sturiale, Quorum's marketing director. "What they really want is an application that works." For this reason, Quorum has taken an application-based approach.

Depending on your point of view, this approach is either an advantage or a disadvantage. The emulated program looks and feels like a native port, integrating more smoothly with the host environment. Sometimes the emulated program runs even *faster* on the host than it does on its own platform, if the routines in the host API are more efficient than those in the original API. But some users don't want to lose the original look and feel of their applications, and they may also prefer to run the complete nonnative environment—operating system, GUI, and all. *continued*

COMPARISON OF SOFTWARE-BASED EMULATORS

	EMULATION SOURCE/TARGET	EMULATION ENGINE	LOOK AND FEEL	API TRANSLATION	SUPPORTED PLATFORMS
Equal Application Adapter (Quorum)	Mac on Unix	680x0	Unix Motif, Open Look (applications only)	Extensive mapping to Motif, Open Look, X	Sun SPARC, SGI Mips, HP PA-RISC
Liken (Andataco)	Mac on Unix	680x0	Mac System 6 (monochrome screen only)	Mac ROMs rewritten or mapped to Unix, X	Sun SPARC, HP PA-RISC, IBM RS/6000, DEC Alpha
Macintosh Application Environment (Apple)	Mac on Unix	68LC040	Mac System 7	Mac Toolbox natively ported and emulated	Sun SPARC, HP PA-RISC
Macintosh Application Services (Apple)	Mac on Unix	68LC040	Mac System 7	Mac Toolbox natively ported and emulated	IBM RS/6000 (PowerOpen Unix)
SoftPC (Insignia Solutions)	MS-DOS/Windows on Mac, Unix, NextStep[1]	286	MS-DOS, Windows 3.1	Minimal API translation	Mac, Sun SPARC, SGI Mips, HP PA-RISC, IBM RS/6000, NextStep Motorola, NextStep Intel
SoftWindows (Insignia Solutions)	MS-DOS/Windows on Mac, Unix, NextStep[1]	286	MS-DOS, Windows 3.1[2]	Win16 API natively ported, mapped to Unix or Mac OS, and emulated	Mac, Sun SPARC, SGI Mips, HP PA-RISC, IBM RS/6000, NextStep Intel
Wabi (SunSelect)	Windows on Unix	386/486	Windows 3.1 (applications only)	Win16 API rewritten or mapped to Unix, X	Sun SPARC, HP PA-RISC, IBM RS/6000, Novell UnixWare

[1]No CPU emulation necessary on 80x86 platform. [2] Future versions of SoftWindows for Unix platforms will allow users to select between the Motif and Windows GUIs.

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F780i-W	21"	0.26mm	H:45-100kHz V:55-120Hz	1600x1200
F760i-W	21"	0.28mm	H:30-78kHz V:55-90Hz	1280x1024
F560i-W	17"	0.26mm	H:30-82kHz V:55-90Hz	1280x1024
F550i-W	17"	0.28mm	H:27-65kHz V:55-90Hz	1024x768
F340i-W	15"	0.28mm	H:27-61.5kHz V:55-90Hz	1024x768

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For those users, there's Liken, a Mac-on-Unix emulator from Andataco (San Diego, CA). Liken strives to preserve the Mac's distinctive look and feel. It runs the Finder within an X window on the Unix desktop, and the Mac session works like a Mac in almost every respect. You can even launch multiple Mac sessions in their own independent X windows.

Liken takes a broad approach to API translation. First, it takes advantage of the fact that before System 7, Apple freely distributed copies of its system software through users groups, BBSes, Internet FTP sites, and other sources. Thus, Liken requires a copy of System 6.

However, large chunks of the Mac OS are also located in ROM, and you can't just plug Mac ROMs into a Unix workstation. So about 1500 ROM-based Toolbox routines were rewritten with more than 90,000 lines of code, mostly in C. Those routines include all or parts of the Mac's HFS, boot-up procedures, Resource Manager, and Font Manager.

Toolbox calls that aren't critical to look and feel are mapped to underlying routines in Unix's CLib and X's XLib. There is also a 68000 emulation engine that handles applications and parts of the Mac OS that Andataco didn't rewrite. As a result, Andataco says Liken runs as fast as a low-end Mac Quadra on a Sun SparcStation 10 and as fast as a high-end Mac Quadra on Hewlett-Packard's best PA-RISC box.

Preserving original look and feel was also a key goal of SunSelect's Wabi, a Windows-on-Unix emulator. Wabi has a 386/486 emulation engine to execute non-API code, plus a library of work-alike Win16 routines that bypass Motif. Thus, a Windows application retains its normal attributes under Wabi. Hundreds of those work-alike calls that don't affect look and feel are mapped to corresponding routines in CLib and XLib, letting some Windows operations run faster under Wabi than they do on native PCs.

To demonstrate this, SunSelect ran the Texas Instruments WinTach 1.2 benchmark program on two identical 50-MHz 486 PCs, one with Wabi and the other with Windows 3.1. Wabi scored an RPM (relative performance measurement) of 19 versus 12 for Windows, a difference of more than 63 percent. (One RPM equals the performance of a 20-MHz 386.) WinTach is highly API-intensive, so it's a good measure of relative API performance, although not necessarily a good benchmark of overall performance.

One drawback of Wabi is that it does not duplicate the entire Win16 API. Instead, it implements a core API—including some calls undocumented by Microsoft—required by thirteen "certified" Windows applications. Those programs include popular packages from Lotus, Microsoft, Borland, WordPerfect, Corel, Aldus, Software Publishing, and Datastorm. Wabi will run additional programs that aren't certified, but the results are unpredictable.

Wabi also doesn't include the Windows desktop (i.e., Program Manager and File Manager), although it can run PROGMAN.EXE and FILEMAN.EXE if you have a copy of Windows. SunSelect expects most Wabi users to manage files from their Unix desktops. Also missing from Wabi 1.0 are multimedia extensions, sound (except for simple beeps), and PC networking.

"Official" Emulators

Third-party products like Wabi, Equal, and Liken are prodding the operating-system vendors into action. Microsoft and Apple want to ensure that their competing operating systems will spread to non-native platforms on officially sanctioned emulators. Microsoft is largely delegating the job to Insignia Solutions, while Apple is readying its own emulation technology.

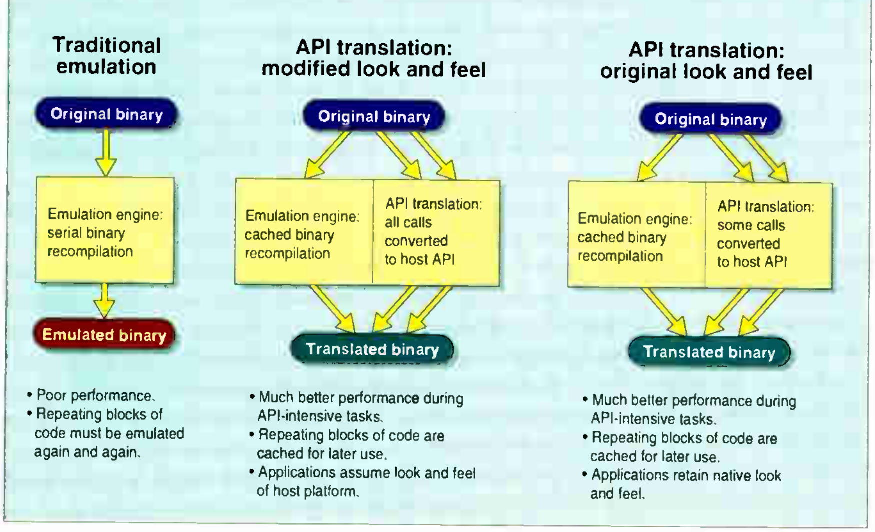
All this neatly dovetails with the cross-platform strategies of Microsoft and Apple. Windows NT is already spreading the Windows GUI to different CPU platforms—including DEC Alpha, Mips R4000, and PowerPC—with integral 80x86 emulation. Apple is working on Mac emulation for Unix and has decided, for the first time, to openly license the Mac operating system to PowerPC clone makers (see "Apple Opens the Mac OS" on page 24).

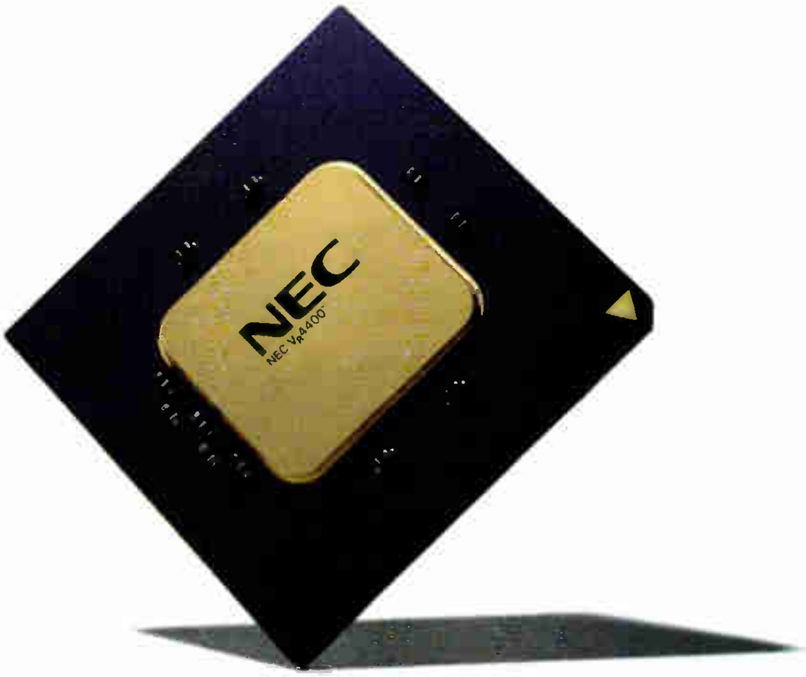
Microsoft wasted no time making its intentions clear. No sooner had SunSelect announced Wabi than Microsoft stole some of the thunder by revealing it had licensed the Windows API source code to Insignia. Insignia was already a major force in the emulation market, thanks to its SoftPC series of DOS and Windows emulators for Unix and the Mac. But SoftPC relies heavily on instruction-level emulation, and its performance is snail-like on all but the fastest machines. With access to Windows source code, Insignia can port or translate the API to run at native speeds on any RISC platform. Another bonus is that Insignia can ship its product with the latest versions of MS-DOS and Windows.

The result is Insignia's SoftWindows, the successor to SoftPC. SoftWindows began shipping late last year for some Unix workstations and debuted in March on the new Power Macs. Its performance approximates the feel of a fast 386 or a low-end 486, depending on the speed of the host CPU (see "Windows on RISC" on page 109). Naturally, SoftWindows does much better on API-intensive tasks, because those calls can either run natively or be mapped to host API routines that don't alter the look and feel of Windows. Non-API code is pumped through the same 80x86 emulation engine that's found in SoftPC.

Access to the Windows API source code isn't a magic bullet, however. Insignia

Three Approaches to Emulation





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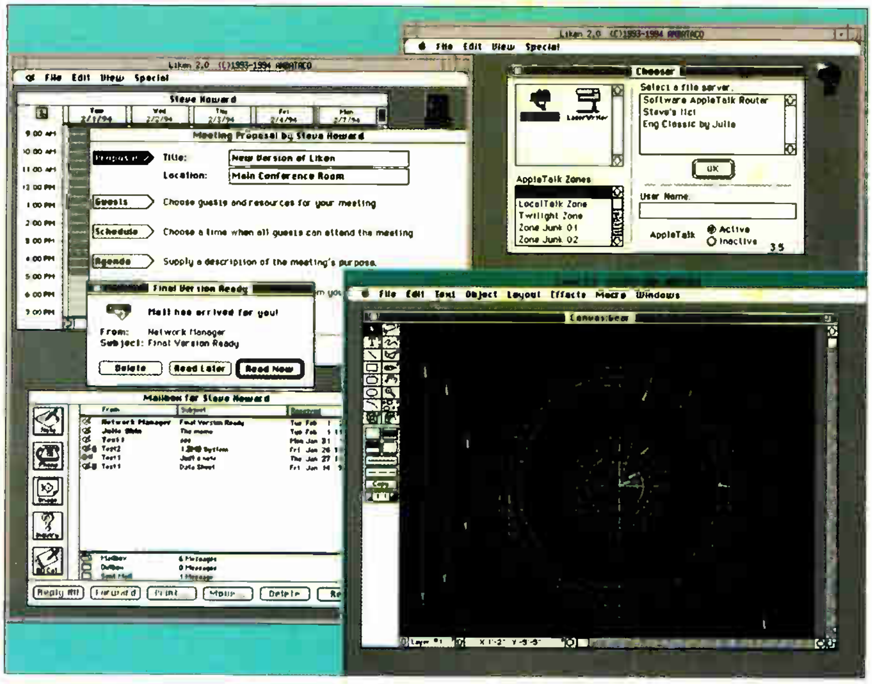


Andataco's Liken runs the *Mac Finder within an X window under Unix.*

faces a challenge similar to Apple's port of the Toolbox to the PowerPC—and for many of the same reasons. Both the Win16 libraries and the Toolbox trace their lineage back a decade or more, which means there's lots of old code written in mixed languages by long-gone programmers. The most recent parts of both are written in C, but older chunks were written in Pascal, and the most critical routines were hand-coded in assembly language. The assembly routines tend to be highly optimized, resorting to every trick in the book, including self-modifying code. And, of course, the documentation for this old code ranges from adequate to hopeless.

As with Apple's port of the Toolbox, therefore, Insignia's port of the Win16 API is not entirely native in the first release. In fact, much of Win16 in SoftWindows is emulated in the usual way. Porting this code (or remapping it to the host API) is an ongoing effort that over time promises to reap even greater gains in speed.

Insignia is also revamping its core emulation engine, which currently simulates an Intel 286/287. SoftWindows can't run some programs that require 386 instructions (e.g., Borland's Paradox for Windows) or Windows 3.1 in enhanced mode. Without enhanced mode, you can't have a virtual memory swap file, so you must allocate more RAM to run major Windows applications. For Power Macs, Insignia recommends allocating a total of 12 MB to SoftWindows: 5 MB for the emulator itself, 4 MB of simulated extended or expanded PC memory, and 3 MB for a special cache. Insignia hopes to have a 486 emulation engine ready this summer.

Meanwhile, Apple is pursuing Mac emulation on Unix. Because the Toolbox is about three times larger than Win16, it's much more difficult to port. The longtime absence of Mac clones has as much to do with the scale of this project as with the aggressiveness of Apple's lawyers. The closest attempt to date is a hybrid operating system from NuTek U.S.A. (Cupertino, CA) that duplicates most of the function, but not the look and feel, of the Mac OS. NuTek remaps the Toolbox to a 680x0 version of Motif.

Apple wants to preserve the Mac's look and feel while running a Mac session in an X window—much as Andataco's Liken does, but with full support for System 7 and its latest extensions. Now that System 7 is up and running on the PowerPC chip, Apple is retooling it for Unix under the name Macintosh Application Services.

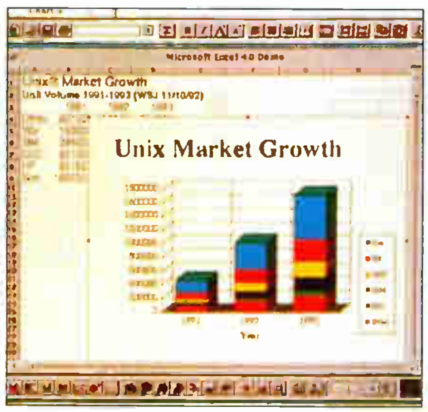
MAS is an optional layer that will ride atop future Unix operating systems certified by the PowerOpen Association (Burlington, MA). It supports a fully functional System 7 session in an X window and runs both 680x0-based and PowerPC-based Mac software.

In addition, on March 14, Apple introduced a new Mac-on-Unix emulator called the Macintosh Application Environment. MAE brings a full implementation of System 7 to Sun SparcStations running Solaris 2.3 and HP Series 700 workstations running HP/UX 9.0. As with MAS, MAE floats in an X window on the Motif or Open Look desktop. Some Toolbox calls are mapped to XLib and CLib for near-native performance, without sacrificing the Mac's look and feel. Unlike MAS, however, MAE 1.0 runs only 680x0-based Mac software, not the latest PowerPC-based applications.

Emulation Engines

API translation yields a quantum leap in performance but still isn't enough. Even the most API-intensive program spends time executing binary code that can't be mapped to high-level libraries. Handling that code requires an emulation engine to translate the program's native binary instructions into corresponding instructions on the host CPU. The emulation engine also has to simulate all the other functions of the original processor—registers, interrupts, status flags, privileged modes, and so on—plus other differences between the two platforms (e.g., absolute memory addresses referenced by programs).

This is where emulators have historically bogged down in performance. One problem is that different microprocessors have different instruction sets, so translation isn't straightforward. Sometimes it takes dozens of instructions to duplicate the function of a single original instruction. Microprocessors also have widely varying arrangements of registers, status flags, and interrupt mechanisms. All these



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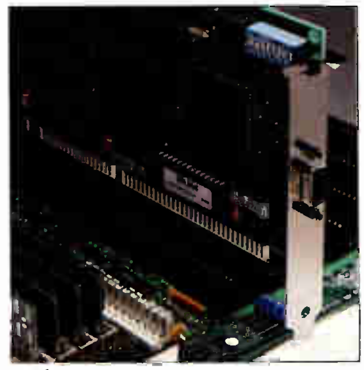

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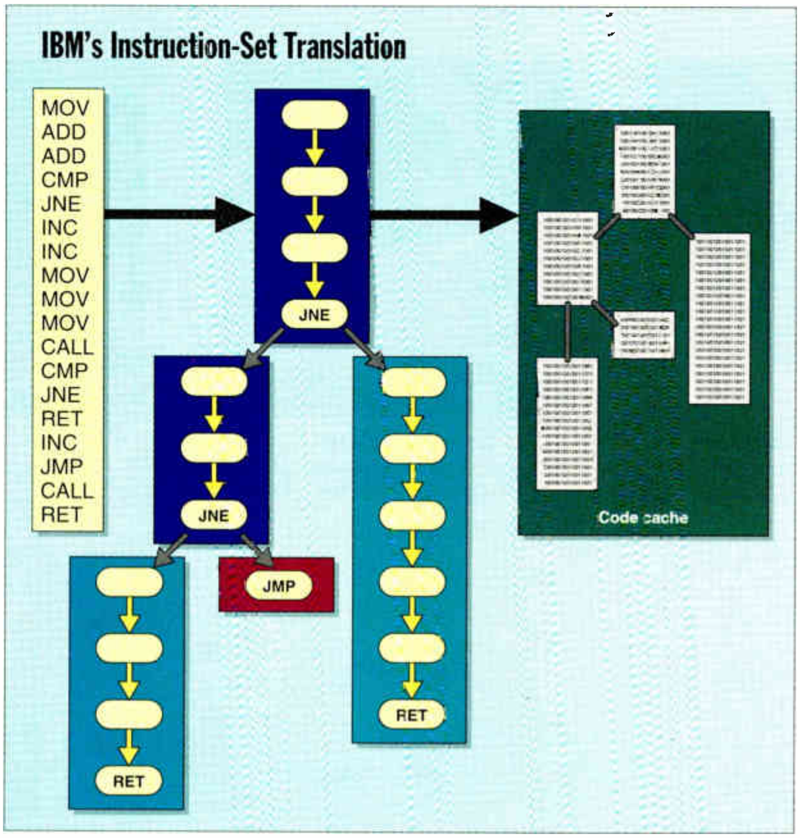
differences can be resolved by writing more emulation code, but the overhead soon becomes prohibitive.

Another problem is that straight emulation works much like an interpreted programming language. Incoming binary instructions are translated serially, and repeating sequences of code have to be translated again and again. For example, consider how the QuickBasic interpreter that comes with MS-DOS would handle the following simple loop:

```
For Loop = 1 To 100
Print "Hello"
Next Loop
```

This code fragment prints `Hello` on the screen 100 times, and for each pass through the loop, QuickBasic must interpret the `Print` instruction all over again. A traditional emulator has the same limitation when it's translating repeated sequences of binary code.



IBM's instruction-set translation *technology works like on-the-fly compilation. The stream of Intel 80x86 instructions from the application is first analyzed and divided into logical blocks of code. Those blocks are then translated into RISC code for the host platform, "wired" together in proper sequence, and stored in a special memory cache for subsequent execution. IBM says a fast RISC-based computer can carry out all these operations without perceptible degradation of performance.*

To attack these problems, emulation architects are increasingly turning to compiler technology. An emulation engine, after all, is essentially a code generator, like the back end of a high-level language compiler. The main differences are that a compiler has the advantage of working from source code instead of binary code, and it doesn't have to build its binary while simultaneously executing the code. Compilers are free to make multiple passes through the source code, carefully resolving branches and address offsets. An emulator has to translate and execute a stream of binary code on the fly.

Again, the unprecedented speed of today's advanced microprocessors is coming to the rescue. On-the-fly compilation techniques that were unthinkable a few years ago are now being adapted to emulation engines. Insignia Solutions and IBM are at the forefront of this technology.

Both companies are taking similar approaches. Insignia's SoftPC emulation engine and IBM's IST depart from the traditional model of serial emulation by storing blocks of translated code in a special cache for later execution. Both caches have mechanisms for discarding blocks of code that aren't needed anymore, making room for new blocks.

Consider the QuickBasic example above. Instead of laboriously translating `Print "Hello"` 100 times, Insignia's emulator would notice that the code fragment is within a loop. After translating the fragment the first time, it would store the recompiled binary in the cache. On subsequent passes through the loop, the emulator would hit the cache, thus eliminating the overhead of retranslating that piece of code. This technique yields big gains in performance.

Insignia refers to its cache as the delta cache. When running SoftWindows with the recommended 12 MB of RAM, the delta cache is 3 MB. Allocating more than 3 MB yields diminishing returns, although it's difficult to measure, because it partly depends on the instruction mix of the emulated program.

IBM appears to be pushing the caching technique even further. The IST caches blocks of code whether they are frequently repeated or not and then "wires" the blocks together for execution. It's remarkably like a multiple-pass, optimizing compiler.

In a process that's called *discovery*, the IST analyzes the original binary to construct a *directed graph* representing the program's flow of execution. In concept, the directed graph is like a flowchart, with each series of related instructions divided into *basic blocks*. Typically, the basic blocks are delineated by branches, jumps, calls, returns, and other instructions that redirect program flow. However, if a jump or call references a target address within 256 bytes, it falls within a basic block and discovery continues.

In any case, the build of the directed graph stops when the number of instructions hits an arbitrary limit that balances the benefit of deeper analysis against additional overhead. Larger blocks might be desirable for optimization, but they would take too long to create.

In the next step, *analysis*, the IST optimizes the code while translating it. In some cases, it might fold two or more 80x86 instructions into a single instruction on the target CPU. In other cases, the IST is intelligent enough to recognize frequently repeated pairs or triplets of 80x86 instructions, such as CMP (compare) followed by JNE (jump if not equal). These common sequences—or *idioms*—are quickly translated into their RISC equivalents.

Another optimization eliminates redundant CPU condition states. For example, if a series of ADD instructions that repeatedly set the 80x86 carry flag are followed by a CMP instruction that generates all new condition codes, there is no need to simulate and track the condition-code

The Apple Report On PowerPC

Number 3 – Applications Accelerated For PowerPC

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Major developers on board.

Right now, the world's leading developers are updating their most popular and memory-intensive programs to take full advantage of PowerPC technology.

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And since software development kits became widely available in January, hundreds of additional developers have begun the move to PowerPC.

PowerPC technology enables them to incorporate new levels of speed and functionality into their applications for the Macintosh system. Developers everywhere are eager to exploit these new capabilities.

What programs will be ready?

While a Macintosh with PowerPC technology will run virtually all of your existing Macintosh system–based programs, the real benefit of PowerPC will be with applications optimized to take advantage of the chip's advanced capabilities. More than 50 of these native applications will be available in the first half of 1994. Here are some of them:

ACI 4th Dimension	*Frame FrameMaker*
Adobe Dimensions	*Insignia Solutions SoftWindows*
Adobe Illustrator	*Microsoft Excel*
Adobe Photoshop	*Microsoft Word*
Adobe Premiere	*Specular Infini-D*
Aldus FreeHand	*Strata StudioPro*
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You can also expect to see new kinds of applications — software that is both more intelligent and easier to use.

Developers will be exploring new features in areas such as intelligent help, 3-D design, video, animation, speech recognition and text-to-speech conversion.

Many of these new functions simply wouldn't be practical without the superior processing capabilities of a RISC chip and innovative Macintosh technology.

Why RISC?

The new generation of Macintosh computers will be the first personal computers with RISC (Reduced Instruction Set Computing) chips — ultra high performance chips that were previously available only in workstations.

(In fact, many workstation developers are now writing applications for the Macintosh platform for the first time.)

RISC chips are smaller and less complex than comparably powered CISC chips, so they cost less to produce — which means that Macintosh computers with PowerPC technology can offer a significant price/performance advantage. But more important, they'll give you an unprecedented new kind of power.

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states for the ADDs. IBM says this optimization really pays off in reduced overhead, because almost every 80x86 instruction affects some kind of flag.

Finally, the IST stores the translated and optimized blocks of code in its special memory cache for execution. Soon the cache holds the referenced sections of the original program, reducing the need for further discovery and optimization. Amazingly, all this analysis, optimization, and code generation happens on the fly, while the program is running.

IBM says the IST currently delivers the SPECint performance of a 486DX/33 CPU when running on a PowerPC 601 processor, approximately one-ninth the performance of native code on the PowerPC. With further refinements, the goal is one-third the performance. Future versions of the IST might spawn a separate thread that continues to optimize the cached code, even while the discovery and translation steps are executing on another thread.

One-third to one-ninth of the original CPU performance may not sound impressive, but remember, it's worst-case emulation: pure 80x86 code that doesn't call high-level API routines. Ironically, Windows programs may run faster than DOS programs under this kind of emulation.

The IST is new technology that will probably show up later this year in IBM's version of Wabi. The IST may also appear in future RISC versions of IBM's Workplace operating system.

Although Insignia and IBM are making great strides with code caching, the idea may not work as well when it's applied to other platforms. Dave McMillen, who is manager of software technology for Andataco, says code caching isn't nearly as effective when emulating the Mac. As a legacy from the days when the Mac had only 128 KB of RAM, Mac programs use a great deal of indirection to shuffle blocks of code and other resources around in memory. If an emulator translates, caches, and attempts to use this code later, it may find that references to memory addresses are no longer valid. The cache would have to be flushed and the code retranslated. These cache misses happen so often, says McMillen, that little or nothing is gained.

Nevertheless, Liken does take advantage of other on-the-fly techniques to boost performance. The approach is becoming more and more commonplace, and programmers who are experienced in writing compiler back ends are becoming a frequent sight in the labs of emulation developers.

Optimized compiler technology holds even more promise for the future. As microprocessors keep getting faster, emulators will benefit not only from linear gains in brute force, but also from the additional on-the-fly optimizations that become possible. And as APIs mature and encompass more of the same high-level functions, translations from one library to another will become more straightforward.

Someday soon, you may be able to walk into a computer store blindfolded, pick a software package off the shelf, and be sure it will run on your computer—no matter what kind of computer you prefer to use. ■

Tom R. Halfhill is a BYTE senior news editor based in San Mateo, California. You can reach him on the Internet or BIX at thalfhill@bix.com.

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UNDER THE HOOD

The Power Mac's Run-Time Architecture

RANDY THELEN

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If you put a 680x0-based Mac Quadra 800 next to a new PowerPC-based Power Macintosh 8100/80, you might think they were identical except for the nameplates. Glancing at the screens wouldn't help, since the menus, icons, and windows are exactly the same. The applications also look the same; in fact, you could install the same ones on both machines. But if you used both computers for a few minutes, one difference would jump out at you: The Power Macintosh is distinctly faster.

This is just what Apple's software engineers planned. Power Macintoshes maintain 100 percent compatibility with existing Macintosh software. This was accomplished through PowerPC implementations of the Macintosh API, a 68LC040 emulator, a new Mixed Mode Manager, and modifications to the Process Manager. (A *Manager* is a set of related functions that work with a given series of data structures. The Process Manager has routines that manage processes. A *process* is a running application.)

However, backward compatibility wasn't the only goal of the Power Macintosh's operating-system design. While support for existing applications is crucial, the system software was also engineered to support future developments, where powerful new applications will take full advantage of the PowerPC's speed.

In this discussion, I'll take a look at how Apple achieved these two contradictory goals. I will concentrate on the new portions of the design where appropriate, since much of the compatibility issues are covered elsewhere in this issue (see "Emulation: RISC's Secret Weapon" on page 119).

Application Structures

I'll start by examining the structure of an existing 680x0 application. (From this point on, I'll use the term *68K* to denote any of the 680x0 processors.) Macintosh files are composed of two structures called *forks*. Each file has a data fork and a resource fork.

Physically, there's no difference between these two types of forks. They're just streams of bytes located somewhere on disk. However, the Mac OS treats them differently. A file's data fork contains data—typically the output from an application, such as text from a word processor or numbers from a spreadsheet. A file's resource fork contains information on the file's creator (this is how the Mac OS knows what application to launch when you double-click on a document), the icon that is displayed on the Desktop, and other information.

An integration of PowerPC code and 680x0 code yields compatibility and speed while providing new capabilities

For 68K applications, the resource fork also contains program code. When you double-click on a file icon, the Finder summons the Process Manager to start—or *launch*, in Macintosh parlance—the application. The Process Manager then uses a part of the Mac OS called the Segment Loader to read the code resources from this fork into memory.

The 68K Macintosh application code resources are divided up into *code segments* that the Segment Loader loads into and out of memory. Code segments are typically 32 KB in size, because Mac applications use PC-relative (program counter) instructions. Such instructions are used so that code is address independent and capable of being placed anywhere within scarce physical memory. These segments might be used briefly, purged from memory to make room for other code segments, and then reloaded as necessary into another portion of memory.

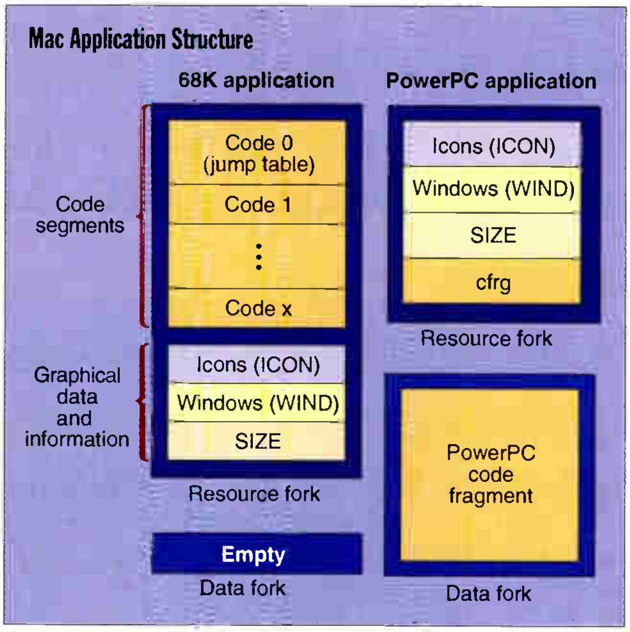
Because the 128-KB Macintosh used a 68000 processor, the offset values of these instructions were limited to 15 bits in size. The sixteenth bit was a sign bit to indicate the direction of the offset (either forward or backward in memory). This limits references to within ±32 KB of the instruction. Subsequent 68K processors had larger offset values, but PC-relative instructions and segments are still being used to implement address-independent code.

The Segment Loader loads code segments on demand as functions within them are called. Essentially, any function call outside of the current code segment is made through a nonpurgeable code block called the *jump table*. If the code block with the called function isn't in memory, its entry in the jump table is actually a call to the Segment Loader. The Segment Loader loads the missing code block into memory and then modifies the corresponding jump-table entry, along with all the jump-table entries associated with that code block.

Instead of acting as calls to the Segment Loader, these jump-table entries have jump instructions to the functions themselves. When the code block is purged from memory (an operation that only the program has control over), the jump-table entries are reset so that they are again calls to the Segment Loader.

The Power Macintoshes use a significantly different design (see the figure "Mac Application Structure"). Applications are a single code fragment (except for imported library functions, which reside in other code fragments). *Code fragments* are the atomic units for libraries and applications in a Power Mac application, and they can be any size.

An entire PowerPC application's code is stored as one continuous unit in a file's data fork. Code fragments can export internal entry points (e.g., a Mac OS function library) and can import entry points of other code fragments (e.g., an application that requires a Mac OS function). The system software is responsible for dynamically linking the entry points of code fragments at run time. As you might expect, the part of the operating system called the CFM (Code Fragment Manager) deals with loading and managing code fragments.



The structure of a 68K Mac *application and a PowerPC Mac application. The program code for the PowerPC Mac (i.e., the code fragments) is located in the data fork of the file, while resources for windows, icons, and controls still reside in the resource fork.*

The process of launching a PowerPC Mac application is similar to that for a 68K Mac application. The Finder hands the job to a slightly modified Process Manager, which calls the CFM to load in a code fragment. From there, the CFM handles the details of dynamic entry-point resolution, which I will cover later.

But on a Power Mac, the Process Manager faces a dilemma when you double-click on a file. How does it know whether to use the Segment Loader or the CFM? The answer is a special cfrg resource that has flags that inform the Process Manager whether the application is a PowerPC application or a "fat binary" (i.e., a combination of PowerPC and 68K code that can run on any Mac). The Process Manager uses this resource to determine whether to use the CFM or the Segment Loader to launch the application. If the Process Manager fails to find this resource, it assumes the application has only 68K code and uses the Segment Loader.

Code Fragments Revealed

While Power Mac applications are single code fragments, they often depend on functions in other code fragments, such as libraries or system software. In fact, portions of the Power Mac ROMs are packaged as code fragments. One of the CFM's jobs is to resolve all dependencies of a given code fragment after it loads the fragment into memory.

Code fragments exist in two executable formats, XCOFFs and PEFs. XCOFF is IBM's Extended Common Object File Format, while PEF is Apple's Preferred Executable Format. Here I will focus on the PEF file structure. A PEF is a container of code, data, and loader information. The PEF container is the code fragment itself, and the loader information spells out imported functions and data, exported functions and data, and version information.

To see how this all fits together, consider the example of when the CFM launches a Power Macintosh application. It first loads and locks the given code fragment into memory. The CFM then searches through the import portion of the PEF container to obtain a list of all the libraries that the application depends on. Iterating through the list of dependencies, the CFM builds a list of all entry points into each code fragment that the application needs. The CFM loads each fragment required by the application. This process is recursive.

Once a fragment that has no other dependencies is loaded, its globals and statics are built within the application heap. Then the recursive function of loading fragments is unraveled via a two-step process. First, each dependent fragment receives the addresses of the entry points into the fragments that they use. Then the dependent fragment's globals are created.

A concrete example of this is where application code fragment A depends on code fragment M, which in turn depends on fragment X. The Process Manager first allocates a heap space for application A. Next, code fragment A is loaded by the CFM. (Note that the code fragment might not be loaded into the application heap space, as is the case with 68K applications.) Then fragment M is loaded, followed by fragment X.

The CFM, knowing that X doesn't rely on other libraries, creates X's globals within A's heap space. Then the CFM preinitializes M's jump table with the addresses of all entry points within X that M is dependent on (i.e., addresses of functions, procedures, gobal data structures,

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and other global variables). Then, M's global variables are created. Finally, A is preinitialized with the entry points and addresses of M. Then A's own global variables are built by the CFM. Finally, A's `main()` function is called, which begins program execution.

Statics and Globals

A critical part of the Power Macintosh's application setup is the creation and initialization of a fragment's global variables and data. The CFM gives the code fragments access to global variables, static data, and a jump table through a data structure called the Table of Contents, or TOC. The TOC contains a list of pointers to the various data elements and entry points within the global data space and to other shared libraries to which the code fragment needs access.

After the CFM loads and resolves all of a fragment's dependencies, it prepares and initializes the fragment's globals and statics. First it allocates memory for the globals' data space—which also contains the TOC—within the application's heap space. Shared libraries that are required by an application fragment build their data structures within the application's heap space as well. Then the CFM initializes the pointers within the TOC.

The TOC has three kinds of pointers. They can reference the code fragment's own globals and statics, the globals and statics of another code fragment, or entry points within other code fragments (which is essentially a jump table). See the figure "The Structure of Dynamic Links for Code and Data."

References to globals require two assembly language references to memory. The first retrieves the address of the global, while the second actually gets and sets the global's value. The question that's often asked is, "Why two references?" There are two benefits that code fragments get from using double indirection. First, TOC entries are referenced using a fixed 16-bit offset from a base register. This means that code can have only 32 KB of global data (64 KB if negative offsets could be used). In the double indirection model, code can have 32 KB (or 64 KB) of pointers to data, yielding up to 8192 (or 16,384) individual items, each of which can be any size. A second benefit is that one fragment might wish to access a variable used in another fragment. Double indirection allows this type of memory sharing, since both fragments can have pointers to the same shared location.

Consider in detail how the mechanism for calling another code fragment works. The PowerPC physically has 32 general-purpose registers. One of those registers, which is a pointer to the globals, is known as GPR2 (General Purpose Register 2). It's commonly called the TOC register because it points to the TOC for the currently executing code fragment.

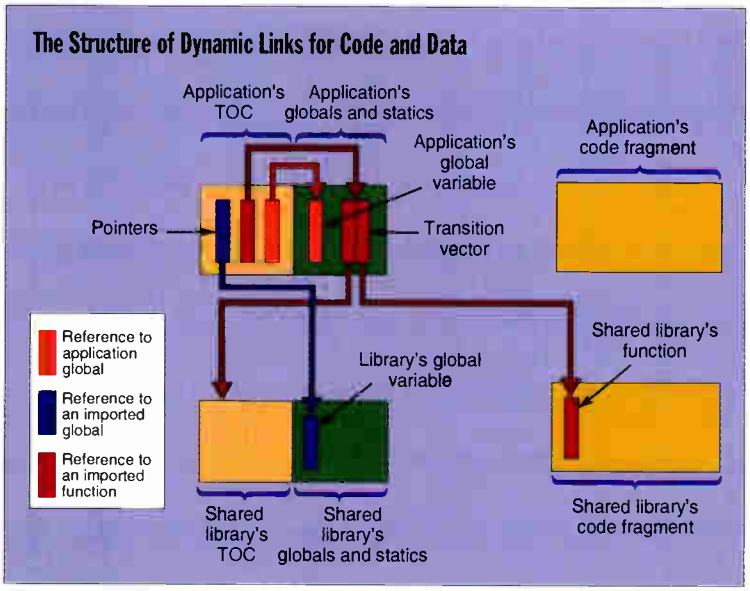
If code fragment A calls a function in code fragment M, what's going to set the TOC register to point to M's globals? The Power Macintosh run-time architecture assigns this responsibility to the caller. In other words, whenever a code fragment executes, it can rely on the TOC to be a valid pointer to its globals (except, perhaps, for some native interrupt handlers).

Therefore, the application needs to have not only the address of an entry point into a code fragment, but also the address of that code fragment's globals. This information is stored within the globals' space in a structure called a *transition vector*. This structure contains two elements: the pointer for the target code fragment's TOC, and the entry point of the function being called.

The process of calling another code fragment is called "making a cross-TOC call." The code to perform this must do four things. First, the caller saves the current TOC GPR within the linkage area of the stack. Second, it sets the TOC GPR to point to the called fragment's globals. Then the caller makes the function call. Finally, when execution returns to the original code fragment, the TOC gets reset to point back to the caller's globals, which completes the cross-TOC call.

This dynamic linking strategy works to minimize the copies of various libraries in RAM during concurrent execution of applications that rely on the same libraries. Each application that relies on a library invokes an "instance" of the library. Each instance has its own global variables, unless the library implements a shared global-memory strategy.

One major benefit of this design is that access to global information is significantly easier than was possible with the 68K run-time architecture. Previously, extensions, plug-in modules, and various periodic tasks had to resort to assembly language code to access globals within the operating system or in an application. Now global data access is a characteristic of the Power Macintosh run-time architecture itself; no special programming is required to use information inside another code fragment.



A PowerPC application *uses a TOC to point to various structures required by the application. The TOC points to the application's own global and static variables, other fragments' globals, and transition vectors that point to the TOC and function-entry points of shared libraries that the application uses.*

Compatibility Components

As mentioned earlier, the Power Macintoshes support existing 68K applications using the Macintosh API, a 68LC040 emulator, and a new Mixed Mode Manager. Macintosh applications rely on the services of system software through published entry points, which are collectively called the Macintosh API.

This API is made up of numerous Managers, including QuickDraw (which handles screen drawing), the Window Manager (which uses QuickDraw to draw windows), and the Font Manager (which handles the display of text in a variety of typefaces and

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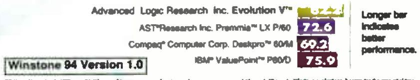

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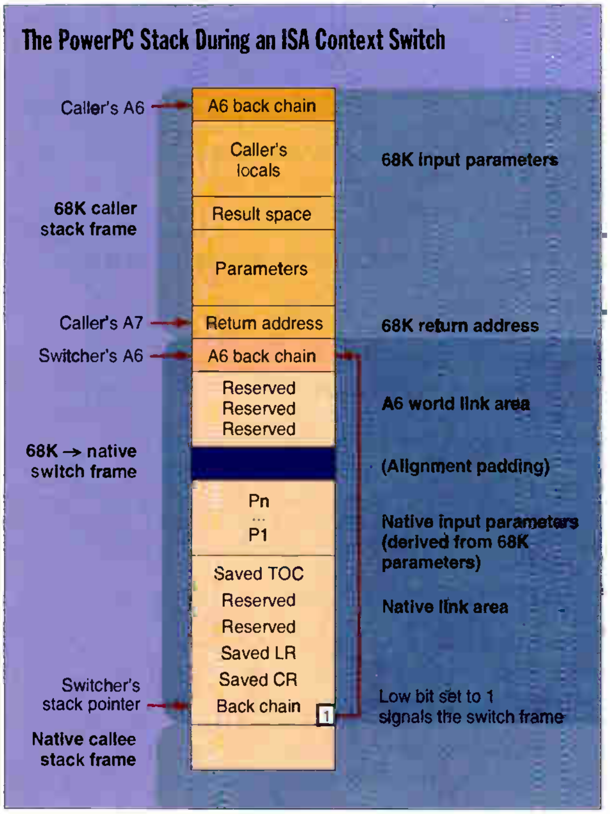

The PowerPC stack *during a mode switch. A 68K application calls a PowerPC function, which invokes the Mixed Mode Manager, which in turn uses information in a routine descriptor to build a switch frame. The switch frame contains information about the function to be called, the state of various registers, and the parameters passed to the function. Register A7 is the 68K stack, and A6 is the 68K link register. The 601's Link Register (LR) points to code that cleans up the stack and restarts the emulator.*

styles). The Macintosh API also provides high-level, hardware-independent access to low-level functions, such as sound generation (via the Sound Manager), expansion boards (via the Slot Manager), and serial I/O (via the Communications Toolbox).

Because applications use only these well-defined published entry points, Apple software engineers could replace the code behind the API without requiring huge changes to existing applications. Furthermore, replacing the API code with PowerPC code improves the performance of these applications dramatically because they rely so heavily on API calls.

The 68LC040 emulator deals with those portions of the application code that do not make calls to the Macintosh API. It maintains the stack frames, user and supervisor mode, interrupt handling, and other processor characteristics on which programmers depend. The emulator supports all 68LC040 user-mode instructions. However, it does not emulate either the FPU or the MMU (memory management unit).

The applications that query the system software for the processor type discover that a 68020 is operating. The 68020 is used because this processor marked the greatest expansion of the feature set of the 68K processor line. The 68020 introduced many new user instructions, several addressing modes, and support for a coprocessor. Subsequent processors have become faster, not more complicated.

The Mixed Mode Manager

At any given moment, a Mac application might be running emulated 68K code or executing native PowerPC code when it makes a call to the Macintosh API. This is further complicated by the fact that, in the interest of getting the Power Macintoshes on the market rapidly with a minimum of compatibility problems, the designers did not write all the Macintosh API calls in the PowerPC code.

The new Mixed Mode Manager is at the heart of making disparate PowerPC code and 68K code work together, while providing the benefit of both ISAs (instruction set architectures). It allows functions in the PowerPC ISA to call functions in the 68K ISA and vice versa.

Essentially, the Mixed Mode Manager is a stack-frame transformation engine. Switching between 68K emulation and PowerPC execution is fairly straightforward, while converting a 68K stack into a PowerPC stack can be quite involved. The calling conventions used by the Macintosh 68K model are dependent on the language (Pascal, C, and 68K assembly language each use a different calling convention), while the PowerPC has a unified strategy for all languages.

This problem is resolved by supplying a UPP (Universal Procedure Pointer) for all exported functions. The UPP points directly to 68K code (on a 68K Mac) or to a *routine descriptor* (on a Power Mac). A routine descriptor is a data structure that gives the Mixed Mode Manager the necessary pointers to the actual implementation(s) of the function, either in 68K or PowerPC code. The routine descriptor also provides information on the function's language-calling convention (Pascal, C, or assembly language), the number of arguments used, and their size. This way, the Mixed Mode Manager can determine what ISA to use when jumping to a called function, as well as how to massage the stack parameters if an ISA context switch is involved (see the figure "The PowerPC Stack During an ISA Context Switch").

For calls made to the parts of the Mac API that are written in PowerPC code, the thread of execution proceeds as follows. First, a routine descriptor is encountered, which invokes the Mixed Mode Manager. The Mixed Mode Manager uses the routine descriptor information to place any passed parameters into a switch frame for use by the PowerPC function. The routine descriptor also points to the transition vector, which in turn points to the code fragment's globals and code. The Mixed Mode Manager uses the transition vector to pass control to the target code fragment.

Apple has supplied headers that define UPPs for every Macintosh API function, so porting existing code to a Power Macintosh should be transparent to the programmer. You have to write a UPP only if you are writing a plug-in module, an extension, or a custom procedure. This UPP lets the Mixed Mode Manager know what to expect when functions in your code are called.

Memory Management

By and large, system-level memory management on the Power Macintoshes has not changed from that of 68K Macs. The design decision for this was strongly influenced by the desire to maintain compatibility. There is, however, one major enhancement: *file mapping*, which is essentially virtual memory where the backing-store data for the application is the code fragment itself. Put another way, an application's code fragment on disk is mapped into a logical address space above the backing-store file. (The backing-store file is where virtual memory is written out to disk.)

As other applications run, a background application's variables might be swapped

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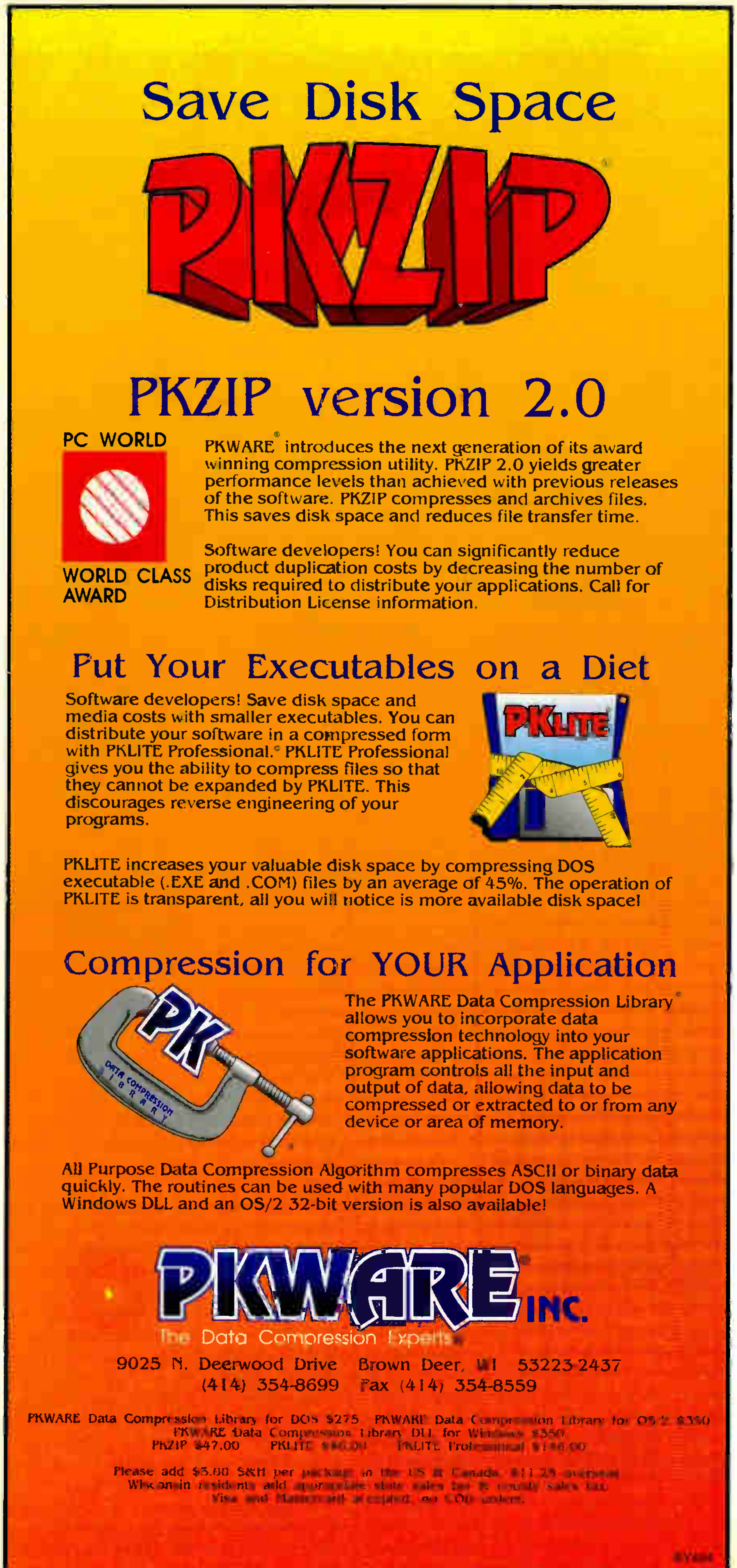

out to the backing-store file. The only time that code fragments are loaded into memory is when they execute. When the section of memory in which a code fragment resides must be reused, that fragment simply gets purged, because fragments are read-only code: No changes need to be swapped out to the backing store. When necessary, the fragment is read back into memory. This minimizes disk I/O, because the only data actually written to the backing-store file is an application's variables, not the invariant code in the fragment.

The major benefits of file mapping, besides virtual memory, are that PowerPC-based applications do not consume valuable virtual memory space in the swap file; and application heaps do not need to be so large, because the application code itself is not within the heap. Therefore, a user can run more applications within the same-size virtual memory footprint. The Macintosh 68K segmented application strategy, on the other hand, is not a flat memory model, it supports self-modifying code (e.g., the jump table), and in general it does not lend itself well to file mapping.

Back to the Future

The speed and power of the PowerPC processor has enabled Apple to accomplish what many thought couldn't be done: incorporate a RISC chip into a mainstream consumer product. The 68LC040 emulator allows the existing base of 68K applications to operate with good performance. The Macintosh API provides public entry points that enable existing 68K applications to access system resources. It also taps into the speed offered by the operating-system functions that are written in PowerPC code. The new Mixed Mode Manager seamlessly integrates the two incompatible processor ISAs into one smoothly operating whole.

Nevertheless, this major design improvement is not just for backward compatibility. The new Power Macintosh application run-time architecture is also ready for the time when applications can more easily communicate with one another and share resources. It lays a solid foundation on which a microkernel-based operating system with memory protection, preemptive multitasking, and multiple threads will evolve. ■

Randy Thelen is a system software engineer for Apple Computer (Cupertino, CA). You can reach him on AppleLink as "RANDOM," on the Internet at random@applelink.apple.com, or on BIX c/o "editors."

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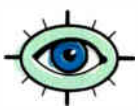

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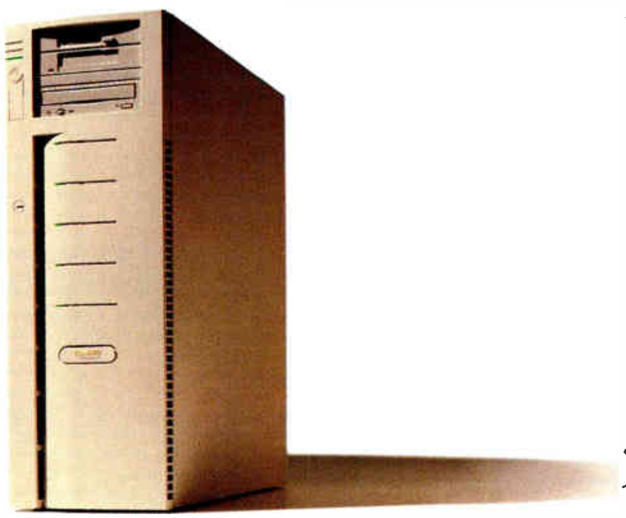

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Developing for RISC

ALEX LANE

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Tools for Intel-class processors are easier to use and more plentiful, but RISC tools are beginning to close the gap

RISC processor makers are looking to take on the dominance of Intel and its CISC architecture at the desktop level. To do that, RISC system vendors will have to capture the hearts and minds of the software developers who will create the applications. Several processors—primarily IBM/Apple/Motorola's PowerPC, Mips Technologies' R4x00, Sun Microsystems' SPARC, Hewlett-Packard's PA-RISC, and DEC's Alpha—are competing to become the RISC standard. Consequently, those software developers must choose not only between RISC and CISC, but also which RISC processor.

The key to the success of this effort is the ability to deliver software that solves user problems and takes full advantage of RISC architectures. To create this software, developers need tools. For some RISC platforms such as PA-RISC and SPARC, those tools are readily available. Newer processors such as the PowerPC and the Alpha are not so well endowed at this time.

The various RISC chips are being used in conjunction with several operating systems and environments. Conversely, operating systems have become "multidenominational" platforms that run on a variety of hardware systems. These operating systems include Microsoft's Windows NT, Apple's System 7, and variations of Unix. In addition to AIX, IBM is working to move OS/2 to the PowerPC, with the eventual goal of having every current operating system running on PowerPC-based systems.

The Key to RISC Performance

RISC chips are generally faster than popular CISC processors, such as the Pentium. For software developers, however, clock speed isn't the only quality by which they judge a computer system.

The performance of any given RISC processor is closely tied to compiler and, more precisely, to optimization technology. CISC-oriented compilers from companies such as Microsoft, Borland International, Symantec, and others compete largely on the basis of ease of use and slick development environments—the "front end" of the development task. In the code-generating "back end," processor-independent optimizations are the rule, owing to the complex nature of the instruction set and (prior to the Pentium) the absence of superscalar, pipelined architectures.

In contrast, RISC compilers typically have so-so front ends and rely heavily on processor-dependent optimizations in the back end to squeeze maximum performance from the hardware. Issues such as instruction scheduling, cache management, and register tracking are vital in light of the memory-intensive and pipelined nature of RISC chips and become even more important for superscalar architectures. Proper optimization can improve RISC benchmark results by as much as 50 percent over nonoptimized code, according to Gary Guardia, president of Kuck & Associates (Champaign, IL), a publisher specializing in C and FORTRAN optimizing tools for RISC platforms.

What Kinds of Tools?

Tools for RISC development mirror those used for CISC development. Compilers, interpreters, database development systems, 4GLs (fourth-generation languages), and so on are used to build applications. Applications can't be built without such tools, and applications are the key to the success of a platform such as RISC on the desktop. Of these, compilers are the "core" tool, because all other tools are built using a compiler. *continued*

The RISC Decision

Because RISC performance is dependent on compiler technology, compiler writers often work together with hardware architects on chip design. As a result, it's difficult for outsiders to achieve the depth of knowledge required to write a suitable compiler. That's why companies who sell chips also build RISC compilers specifically for those chips.

Preprocessors (e.g., those from Kuck & Associates), which analyze source code files and rewrite portions of the code before it is passed on to a compiler for compilation, are an important development-tool niche for RISC systems. Kuck & Associates markets C and FORTRAN preprocessors for IBM's POWER (Performance Optimized With Enhanced RISC) architecture, encompassing IBM RS/6000 and PowerPC systems. The preprocessors restructure code and rewrite it so that it takes advantage of the processor's architecture, performing such tasks as loop unrolling, strip mining, and function-code inlining (see "Optimizing for Today's CPUs," February BYTE). Other Kuck preprocessors for C or FORTRAN are available for the DEC Alpha AXP chip in systems running OpenVMS or OSF/1, as well as for the Mips, PA-RISC, and SPARC processors.

> **"We have not bothered to recompile our product for any RISC platform," said Phillip Jain, a manager at WinSoft (Menlo Park, CA), "because the market is too small and too fragmented."**

Other development tools lever off the core compilers. For example, Harlequin (Cambridge, MA) sells a Common Lisp development environment called LispWorks that is used for writing applications. Although the tool was built by iteratively more sophisticated versions of Lisp (analogous to building a C compiler in C), the original compilation of the bootstrap loader that produced the starting Lisp image was done using vendor-supplied C compilers. LispWorks is available on a variety of RISC platforms, including Alpha (OSF/1), SPARC (Solaris and SunOS), RS/6000 (AIX), Mips (Irix and Ultrix), and PA-RISC (HP-UX), with possible future appearances on NT and PowerPC systems, according to Randy Zeitvogel, a technical consultant at Harlequin.

Another example of a tool that leverages off the core compiler is Cognos's PowerHouse 4GL, an applications development environment with integrated CASE features. Built using DEC compilers, the product is available for Alpha systems running OpenVMS. Cognos is porting the application to OSF/1 owing to a perceived increased interest in DEC's Unix operating system. While low-level effort is needed to do the port, Cognos notes that the overall effort is simpler since the tool does not directly generate executable code. Cognos expects to ship the Unix product in the second half of this year.

Windows NT: A Common Thread

One of the factors that is setting the stage for a new generation of RISC-based PCs is the NT operating system. It is available for Mips R4x00–, Alpha AXP–, and 80x86-based systems. It is being ported to the PowerPC and SPARC platforms. Applications that use the Win32 API will be able to run on any of these systems after recompilation with the appropriate tools. This strategy allows developers to preserve their investments in tools and in the time spent learning the API.

Currently, developers can create NT applications for Intel platforms using Microsoft Visual C++ and then recompile them for the RISC platforms using command-line tools found in Microsoft's Win32 SDK (Software Development Kit), including RISC versions of the Microsoft Foundation Classes (MFC 2.0). See the text box "Porting to RISC: Not Just a Recompile" on page 142. Microsoft is committed to delivering its visual tools to the Alpha, Mips, and PowerPC platforms, with delivery of the Mips tool set slated for the first half of this year. Microsoft's MS Test product will also be ported to the RISC NT platforms, although no ship date has yet been announced.

Microsoft's approach appears to work. Doug Hamilton, president of Hamilton Laboratories (Wayland, MA), says that porting the Intel version of the Hamilton C shell product to the Mips version of NT took about a week; most of that time was spent working around compiler differences. Once that port was done, the effort to create an Alpha version of the product took one day—and it ran without debugging.

What's significant here is what Microsoft's competitors in the Intel arena—Borland, Symantec, Watcom, and others—are not doing. Even though they are offering NT compilers for Intel machines, they are not following Microsoft's lead in providing cross-platform tools for RISC-based NT.

The likely reason for this is that the market for RISC is minuscule when compared to Intel processors (see "Intel Pushes the 80x86 Envelope" on page 22). So, while NT offers a fine opportunity to make applications available on multiple platforms, some developers believe that providing tools for RISC systems is not worth the investment. "We have not bothered to recompile our product for any RISC platform," said Phillip Jain, a manager at WinSoft (Menlo Park, CA), "because the market is too small and too fragmented."

For other companies, it's a matter of setting priorities. "Symantec will be focusing first on the high-volume platforms," said Gene Wang, executive vice president for development tools and applications, talking about NT.

Indeed, some RISC architectures may not survive, as was the case with Intergraph's Clipper RISC processor. While working on a port of NT (including a set of tools) for a PC-bus version of a Clipper, Intergraph decided it no longer wanted to be in the microprocessor business. Its chip designers went to Sun to work on the next-generation SPARC processor, and Intergraph is now working on a port of NT for that chip, with a tentative ship date in mid-1995.

Unix: RISC's Traditional Partner

A strong traditional interrelation exists between Unix and RISC-based systems, due primarily to Unix's portability, which allows it to be implemented relatively easily on any hardware platform. However, this portability is offset by a lack of binary compatibility across systems, as well as by the variation in hardware available to different systems.

A problem developers face with Unix is standards—there are too many of them. Among these are the SVID (System V Interface Definition), Posix, and XPG (X/Open Portability Guide) source-level standards; the COFF and iABI binary standards; the OpenWindows and OSF/Motif graphics standards; and the BSD and Unix System V release 4.0 implementation standards. Further, a number of standards are

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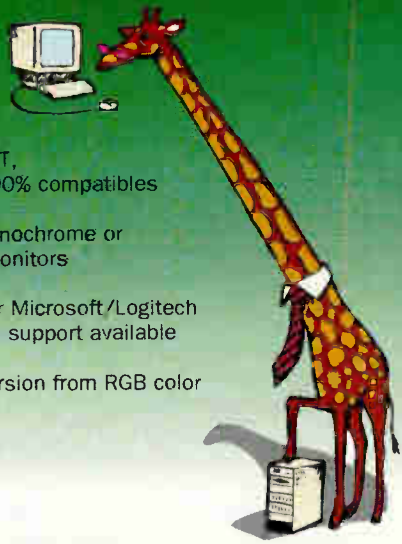

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- Mouse support available at both local and remote workstations
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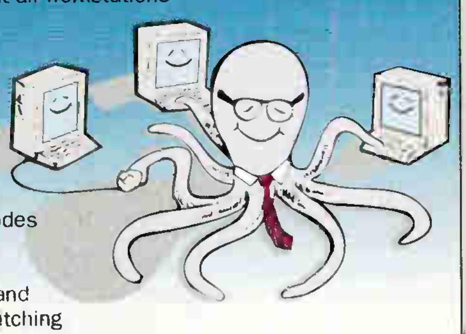

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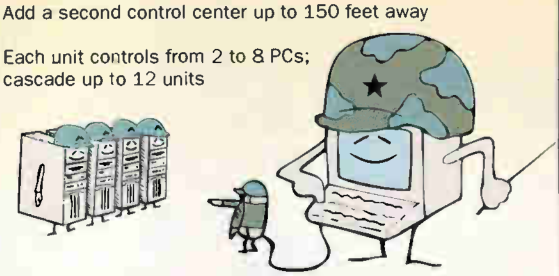

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enhanced with proprietary extensions by different vendors.

There is no dearth of tools for Unix developers, but no software giants such as Microsoft are selling (cross-platform) Unix tools, either. Consequently, many developers use the compilers that come bundled with the hardware. Other developers use the GNU suite of tools, simply because the source code is available and the tools are free and available via the Internet for virtually every processor. GNU is a project of the Free Software Foundation. Still others purchase tools from third parties such as MetaWare (Santa Cruz, CA). Overall, there are over 300 compiler and language products and programming tools and utilities available for the Unix platform.

Unix initiatives such as PowerOpen—an idea initially backed by Apple, IBM, and Motorola and now a consortium with more

Porting to RISC: Not Just a Recompile

ED PERRATORE

The list of developers porting desktop applications from Intel and Mac systems to RISC-based platforms is growing at a rapid clip. Microsoft's Windows NT is the main driving force, owing to the clear field left by its competitors. Desktop flavors of Unix have yet to earn widespread confidence. IBM's Workplace OS remains in development. And while a number of ISVs (independent software vendors) intend to formally announce ported Mac applications the day Apple announces its PowerPC Mac, a native development environment has been slow in coming.

NT also has in its favor the single Win32 API, which leaves the door open for vendors who develop first for Chicago. But despite Microsoft's success at promoting NT as the platform of choice across systems such as Mips Technologies' Mips R4400, DEC's Alpha AXP and, soon, the IBM/Apple/Motorola PowerPC, for some ISVs the road to RISC is not without its potholes.

When Mips helped Cadkey (Windsor, CT) port Cadkey to NT on Mips in only 10 days on the heels of Spring Comdex 1993, it was a revelation for the vendor, which previously sweated to release Unix versions of its 3-D CAD software 30 to 60 days after the DOS version shipped. After exhibiting at the Microsoft OEM booth, relates senior vice president George Krucik, "We said to ourselves, 'Why are we doing Unix ports? Why are we spending two to four months suffering the pains of not being able to release our product on multiple platforms over a reasonable period of time? This is nuts!'" The end result: "In the future, we're just not going to do it."

Krucik, however, called Microsoft to task on the absence of a front end matching that of Microsoft's Intel offering. "The Microsoft [Win32] Software Development Kit has a Mips compiler, but it's not the same as the Visual C++ version," he says. "Unless your compilers are in sync, you never quite know whether any bugs generated are compiler-based or whether they're yours." This uncertainty, he added, has precluded Cadkey from moving ahead more quickly with production-based software for the Mips platform. Microsoft plans to introduce Visual C++ for Mips in the first half of this year. Alpha and PowerPC versions are slated for the fourth quarter. Once those versions become available, developers will have a consistent user interface and code base across platforms.

For Bentley Systems (Exton, PA), the development brains behind Intergraph's MicroStation software, early success at porting the CAD package to NT on an Intel 80x86 did not deter the company from waiting out the first versions of DEC's Alpha AXP compiler. "They evidently went through quite a bit of shakeout in their tools, and we let somebody else be the leading edge on that," said executive vice president Barry Bentley. Aside from the task of facing two sets of compilers, Bentley complained of some "pretty significant bugs" they found when they did begin the Alpha port. The compiler would crash, and early on, a program that did compile wouldn't run.

Once DEC worked out the problems, MicroStation became an easy port—actually a recompile—from NT on Intel to NT on Alpha. The 1.5 million lines of C in the program (plus components written in assembly language and in MicroStation Development Language, a pseudo-interpreted C language) required two weeks to produce a version that not only ran but could be shown to customers.

A third developer, Fractal Design (Aptos, CA), ran into difficulty merely in porting Painter 2.0 to the PowerPC to run under the ported Apple System 7. The biggest problems with early versions of the Macintosh on the RISC SDK, says chairman of the board Tom Hedges, showed up in both the compiler and the linker. "The first release of the compiler was very slow; it barely worked," he said. "And the first release of the linker didn't work. It was not capable of linking any application." Hedges noted that Fractal Design's experience would have been far more difficult had the company not already ported its product to Windows using Altura Software's Mac2Win technology, which implements the Macintosh API on Windows.

While Apple has since gotten both the compiler and linker working to some degree, Fractal Design found another problem in the linker that, although Apple claims it should be corrected by the time you read this, would otherwise affect any product ported to run natively under System 7 on the PowerPC. Namely, that the generic PowerPC 601 optimizations in the compiler introduced as many as two dozen bugs that rendered the program unusable.

"What compounds this problem," says Hedges, "is that whenever you turn the optimizer on, it disables all symbols and all debugging information. So where you might say, 'Gee, there's a bug in the compiler. I'll just get into the debugger and figure out what it is.' But than 170 members—for the PowerPC offer a tantalizing vision of a system running Unix with the capability of running Windows and Macintosh applications in emulation: however, all this must wait for the delivery of PowerOpen-compliant Unix implementations, which will begin to appear in June.

The idea behind PowerOpen is for all applications to share a common ABI (Application Binary Interface) and API across different PowerPC platforms, allowing developers to write to a single set of functions. Porting, say, AIX applications to PowerOpen will require a set of appropriate libraries, as well as taking account of a handful of implementation details such as long double variables being 128 bits in length.

Several vendors have signed on to develop tools for PowerOpen. Tools that pass

no, you can't do that. You can only use very difficult, low-level assembly debuggers, and an assembly debugger with no symbols, which makes it almost impossible to use if you turn on any compiler optimization."

The fix was expected sometime in February, but until then, Fractal Design has resorted to turning off all compiler optimization whatsoever for the sake of a program that runs. "That means we're giving up a fair percentage—I'm not exactly sure how much—of the potential performance," he says of what they hope to make available when Apple releases a Mac PowerPC. "I'm not happy about that."

Of course, in every game there are a number of players who sit it out at least until the market requires their presence. "We don't see a real desktop opportunity," said Peter Cohen, a spokesman for Lotus Development's desktop applications group. In general, desktop productivity will naturally carry DOS and lower-end Windows applications first to Chicago and then, if the market demands it, to NT. Vendors in this group include Intuit and Central Point Software, although the latter intends to provide a native Mac PowerPC version of Central Point Anti-Virus.

"We will not build it and wait for users to come," said Traveling Software chairman and CEO Mark Eppley of his company's plans to eventually bring its flagship LapLink to NT on the PowerPC and hold off on Mips, Alpha, or Workplace OS on any processor. ■

Ed Perratore is a BYTE news editor. You can contact him on the Internet or BIX at eperratore@bix.com.

Developers Committed to RISC

Mips R4400 (Windows NT)

Adobe Systems: PostScript, Photoshop
Arbor Software: eSSbase, eSSbase Application Server
Attachmate: Extra
Autodesk: AutoCAD
Cadkey: Cadkey
Calera Recognition Systems: WordScan-OCR
Computer Associates: CA-Realizer
Corel Systems: CorelDraw
DEC: PrintServer for Windows NT
FutureSoft Engineering: DynaComm/Elite
Image-In: Image-In-Color Professional
Intergraph: MicroStation
Interleaf: Interleaf
Lenel Systems International: Media Viewer, MultiMedia Works
MathSoft: Mathcad
Micrografx: Windows Draw, Designer
Microsoft: FoxPro, Office (and core applications), SQL Server, SNA Server, Visual C++, C/C++ for Win32, Hermes, Project, Macro Assembler, Object Basic, Visual Basic, Works
Novell: NetWare Client
Oracle: Oracle7 Server
Quark: QuarkXPress
Software Publishing: Harvard Graphics
Wall Data: Rumba
Wolfram Research: Mathematica
WordPerfect: WordPerfect

Alpha AXP (Windows NT)

Arbor Software: eSSbase
AutoDesk: AutoCAD
DEC: Print Server for Windows NT, Pathworks for Windows NT (client/server versions), C/C++, DCE (client/server versions)
Design CAD: Design CAD 2D, 3D
FutureSoft Engineering: DynaComm/Elite
Intergraph: MicroStation
MathSoft: Mathcad
MetaWare: C/C++ multiplatform tool
Microsoft: Office (and core applications), SNA Server, SQL Server, Visual C/C++
Micrografx: Picture Publisher
Novell: NetWare Client
Quark: QuarkXPress
Wall Data: Rumba
Wolfram Research: Mathematica

PowerPC (Workplace OS)

Quantum Development: Quantum Leap for Workplace OS
Microformatic: Fax PM
ChipChat-Cawthon Software: ChipChat Communications Objects
Hilgraeve: HyperAccess
Media Cybernetics: Halo Imaging Library, Halo Advanced Imaging Library
The Software Lifeline: Software Lifeline (product line)
SAS Institute: SAS System
Ask Group: Ask Windows 4GL

PowerPC (System 7)

Aci US: 4th Dimension, 4D Server
Adobe Systems: Photoshop
Aladdin Systems: StuffIt Deluxe, StuffIt SpaceSaver, StuffIt Lite, StuffIt InstallerMaker 2.0
Aldus: PageMaker, Persuasion, FreeHand, Digital Darkroom, Fetch
Canto Software: Cumulus Image Database
Claris: ClarisWorks
Deneba: Canvas
Fractal Design: Fractal Design Painter, Fractal Design PainterX2
Frame Technology: FrameMaker for Macintosh
Graphisoft Software Development: ArchiCAD
Great Plains: Dynamics 2.0, Dynamics C/S+
HSC Software: Kai's Power Tools
Insignia Solutions: SoftWindows for the Mac with PowerPC
Itedo Software: IsoDraw 2.0
Metrowerks: CodeWarrior
Ray Dream: Ray Dream Designer
Specular International: Infini-D, BackBurner
Wolfram Research: Mathematica
WordPerfect: WordPerfect, WordPerfect Works

an application compliance test suite will offer developers the option of mixing and matching different tools (e.g., compilers, debuggers, and profilers) from different vendors. Third-party tools are expected to ship approximately one year after PowerOpen ships.

PowerPC: An Attractive Platform
Strong commitments from IBM and Apple to the PowerPC series of processors have given it instant credibility among both potential customers and software developers (see "Apple, IBM Bring PowerPC to the Desktop" on page 44). Apple sells its Macintosh on RISC SDK in a prerelease version and promises to have the final product ready by mid-May. This SDK has Apple's MPW Development System, a PowerPC assembler, a two-machine debugger, a C/C++ compiler, and a MacApp framework for PowerPC systems.

One promising third-party Mac PowerPC tool is CodeWarrior from Metrowerks (St. Laurent, Quebec, Canada), a cross-compiling development environment containing a single-pass C and C++ compiler, along with project management tools and an object library. A PowerPC version will ship in concert with the PowerPC Macs. Elsewhere, a joint effort is also under way at Apple and Symantec to provide native PowerPC tools for the Mac for delivery later this year.

IBM's Programming Systems Laboratory in Toronto, Ontario, Canada, has available C and C++, FORTRAN, Ada, and Pascal compilers for the RS/6000 and PowerPC, as well as class libraries, debuggers, class browsers, and an IDE (Integrated Development Environment).

Chip architectures—particularly RISC—are becoming increasingly superpipelined and superscalar as more features (e.g., on-chip cache and branch-prediction logic that already are featured in existing chips) are introduced. New optimization techniques will be developed to take advantage of new architectures. These new techniques will be more complex and require a finer understanding of how the chip operates, making the overall job of tool development more difficult.

Operating-Systems Support

PowerPC
System 7, AIX, B.O.S./X (Bull), Workplace OS, OS/2 (IBM), Solaris, Unix

PA-RISC
HP-UX, MPE/iX (HP)

SPARC
Solaris, SunOS

Mips R4x00
Windows NT, Unix

DEC Alpha
Windows NT, OpenVMS, OSF/1

Alpha AXP
The DEC Alpha AXP is the highest-performing RISC processor, with a superscalar, superpipelined, 64-bit architecture running at 150 MHz and better. The Alpha features 16 KB of cache memory, divided into instruction and data caches, that funnels into a seven-stage integer pipeline and a 10-stage floating-point pipeline. The faster and more extensively pipelined architecture of the Alpha requires a high-quality compiler to restructure the source to avoid stalling the pipelines with incorrectly ordered instructions.

NT, OpenVMS, and DEC's OSF/1 are the operating systems available for Alpha-based machines, and it is basically DEC tools that are available for creating applications on these platforms (the Alpha compiler in the Win32 SDK is licensed from DEC).

Other RISC
Two other popular RISC platforms are Sun Microsystems' SPARC processor and HP's PA-RISC. As mentioned earlier, next-generation versions of these processors are likely candidates for NT.

Several tools exist for the SPARC architecture, including an Ada Software Development Environment from Alsys (Burlington, MA), embedded C/C++ tools from Cygnus Support (Mountain View, CA), and various language compilers from Edinburgh Portable Compilers (Edinburgh, Scotland), as well as from SunPro (Mountain View, CA), a spin-off of Sun.

Although PA-RISC is little known in PC circles, sales of PA-RISC systems achieved a more than 34 percent share by revenues of the RISC-system market in 1993, according to Andrew Allison, editor of the newsletter *Inside the New Computer Industry*. HP has several software development models for its system, the primary one being the host-based model, where a customer buys a workstation and uses the tools that come with the workstation to compile applications. A second model involves systems partners who want to compile to a different operating environment, as in the case of Convex Computer, which uses PA-RISC for supercomputing applications. In this model, the partner licenses compiler technology from HP and creates development tools for their systems. A third model involves the possible porting of third-party compilers or licensing of HP technology for embedded applications. Both SPARC and PA-RISC systems generally run Unix-based operating systems.

Outlook for New Tools
There is no reason to expect the development of new kinds of tools to accommodate RISC architectures. Even compilers designed to generate code for multiprocessor systems will likely have a front end that's similar to today's tools. Nevertheless, some interesting variations on existing tools are possible.

For example, the fact that RISC compilers tend to perform aggressive optimizations makes source-level debugging ever more challenging. This is because as source code is increasingly optimized, the resulting code that executes bears less correspondence to the original code. Recently developed debug formats may help partially by identifying enregistered variables that reside in different registers in different instruction-code sequences. This is a very active area of research, with no easy solution in sight.

Optimizations will continue to become increasingly aggressive, according to Kuck & Associates' Guardia, particularly as chip architectures become more complex. One new technique may involve the use of a profiler to help determine the best way to arrange for branches in code, in effect augmenting the branch-prediction logic embedded in many RISC processors.

Ironically, one missing tool is a quick-and-dirty, high-speed compiler that could be used to create applications quickly. Such a tool would be useful in situations where performance of the application is not an issue or where you simply want to prove a point. It would also likely compile three to five times faster than existing tools and appeal primarily to end users.

The availability of tools used to create applications for any given platform is a requirement for a platform to prosper. Those tools for RISC-based systems exist today and will enhance the chances for the successful deployment of RISC-based systems on the desktop that Intel dominates. ■

Alex Lane is a Colorado-based writer, speaker, and consultant. He can be reached on the Internet or BIX at a.lane@bix.com.

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Justifying NT

NT Advanced Server and SQL Server for NT let you deploy file and database servers over a range of RISC and CISC platforms

JON UDELL

If Windows NT could run everywhere, from laptops and desktops to applications servers and file servers, Chicago would still be just a city in Illinois. No one at Microsoft pretends that cramming Win32 into a 4-MB procrustean bed—the Chicago design goal—yields optimal results. Sadly, most PCs today ship with just 4 MB of RAM—too little, really, for Windows 3.1. Even when new systems default to NT's required 16 MB (perhaps by 1995), most of the tens of millions of previously installed desktop systems will remain unable to run NT. That inescapable reality will shape NT's role in the enterprise for the next few years.

Some companies will ante up and deploy NT to the desktop anyway, just as some have done with OS/2 and desktop Unix. Why? Everyone's mission is critical; downtime is unacceptable; multitasking matters; and real operating systems pay back the investment required to run them in ways that are hard to quantify on the comptroller's spreadsheet. When Win32 versions of BYTE's line-of-business applications arrive, I'll be the first to argue that we should run them on NT, not Chicago. Then, when I lose that argument to the finance people, I'll make a more modest proposal that defines which systems should run NT and why.

Today, you have two important options. First, Windows NT Advanced Server 3.1, the latest in a long line of SMB-/NetBIOS-based LAN operating systems from Microsoft, offers a capable, attractively priced alternative to NetWare. Second, Windows NT 3.1, without the full LAN operating-system capability of Advanced Server, is a fine platform for server applications such as Oracle and SQL Server. In these scenarios, NT delivers robustness, connectivity, ease of installation and use, RISC and multiprocessing support, threaded multitasking, manageability, and a 32-bit Windows-compatible API. On paper, none of the competitors—OS/2, Unix, and NetWare—can match NT feature for feature. In reality, each is supported by the type of sophisticated infrastructure that comes from years of deployment in various niches.

In evaluating NT for production use, I wanted to answer two questions. First, is it the right database-server platform? Second, is it the right LAN operating system? The short answers are yes and no, respectively. The long answers are, naturally, more complex. Before diving in, I'll explain how the evaluation worked.

NSTL supplied two kinds of benchmarks—SQL database tests and file-server tests. The file-server tests, conducted at NSTL, pit NT Advanced Server against NetWare and LAN Server on a uniprocessor Intel machine. The SQL tests, performed jointly at NSTL and BYTE, compare the OS/2, NLM (NetWare loadable module), and NT versions of SQL Server on uniprocessor Intel hardware. They also assess SQL Server for NT on uniprocessor Mips and Alpha machines and on a multiprocessor Intel box (see the text boxes "How We Tested SQL Server on NetWare, OS/2, and NT" on page 150; "SQL Server for NT on CISC and RISC" on page 158; and "LAN Operating-System Testing" on page 164 for discussions of the benchmark results).

In addition to quantitative testing, I worked extensively with NT Advanced Server and SQL Server in a production environment—BYTE's own editorial LAN. Our mix of

One of NT's strengths is its ability to run on RISC-based hardware such as the Alpha-based DEC AXP 150 and the R4400-based SGI/Mips Magnum.

How We Tested SQL Server on NetWare, OS/2, and NT

CHARLES VOGT

NSTL's database-server tests measure the speed of transactions and queries against a database of books, authors, orders, payments, and shipments. In the tests, the three SQL Server/operating-system combinations were tested on the same hardware—an IBM PS/2 Model 95 configured with 32 MB of RAM and a pair of IBM 400-MB SCSI drives—one for the database, and one for the transaction log. The tests were both transaction- and query-oriented.

Each transaction test stresses the database server in a different way. For example, the multitable selects make the order-entry tests fairly processor-intensive. The payments tests, which feature simple record-selection criteria and in-place updates of existing records, are by contrast more disk-intensive. The transaction tests consist of the following:

ISBN Order. The test program generates a random ISBN number, selects the book, and identifies the author using a three-table join.

Author Order. The program generates a list of authors using the LIKE operation. After the user selects an author, the program generates a list of titles by that author.

Title Order. The test program selects book titles using a partial title key and the SQL LIKE operator. It selects a title from those returned and retrieves additional information from that book's record.

Payment. The test program generates a random order number and then selects an order record and its corresponding entries and updates the order record.

Shipment. The program finds the lowest order number for an unshipped order. It selects the order record for that number and all corresponding entries, and the order record and the entry records for book records with ISBN numbers that correspond to the selected entry record.

The query tests quantify a server's ability to handle the types of information requests you see in a corporate environment. The tests consist of the following:

Query 1. This is a single-table query with range search. The test program retrieves order number, customer name, payment status, and shipment status for a range of ZIP codes. The query returns approximately 2000 rows. During the six- and 12-user

SQL SERVER ON NETWARE, OS/2, AND NT: TRANSACTIONS

	16 MB OF RAM		13 MB OF RAM	
	SYBASE SQL SERVER NLM	MICROSOFT SQL SERVER 4.2 FOR NT	MICROSOFT SQL SERVER 4.2B FOR OS/2	MICROSOFT SQL SERVER 4.2 FOR NT
One station				
ISBN order	2.2	1.5	1.8	1.5
Author order	3.7	2.0	2.4	2.0
Title order	3.0	1.7	2.0	1.8
Payment	0.3	0.2	0.2	0.2
Shipment	0.5	0.4	0.5	0.4
Six stations				
ISBN order	2.8	2.4	2.3	2.7
Author order	4.5	3.8	3.6	4.0
Title order	3.9	3.6	3.9	3.9
Payment	0.4	0.3	0.2	0.3
Shipment	1.1	1.0	1.0	1.1
12 stations				
ISBN order	4.5	4.5	5.3	5.3
Author order	6.8	6.9	7.1	7.0
Title order	5.9	6.4	8.0	6.9
Payment	0.5	0.6	0.4	0.6
Shipment	2.0	1.6	1.9	2.1
24 stations				
ISBN order	8.9	8.8	11.6	10.9
Author order	13.7	13.2	15.3	15.9
Title order	11.4	12.6	15.8	15.5
Payment	0.8	1.1	0.7	1.1
Shipment	3.8	2.9	3.9	4.2

System: IBM PS/2 Model 95 (a 33-MHz 486DX with 32 MB of RAM, two IBM 400-MB SCSI hard drives, and an IBM SCSI drive controller).
Numbers represent average response time in seconds.
Red = best.

tests, one-third of the users execute this query while the others execute payment transactions.

Query 2. This single-table query is based on a list of values. The test program retrieves an order number, customer name, payment status, and shipment status for a list of 100 order numbers generated at random. During the six- and 12-user tests, one-third of the users execute this query while the others execute payment transactions. Note: NT would not process this query. The list of 100 order numbers creates a long SQL statement; NT truncated that statement, and the query failed. Thus, we didn't report results for this test.

Query 3. This test uses a three-table join. For a range of ISBN numbers, the query lists the book title, the quantity in stock, the number shipped, and customers who have ordered each book. The ISBN numbers, generated at random, span 500 values. During the six- and 12-user tests, one-third of the users execute this query while the others execute order transactions.

Query 4. This test uses a five-table join. For a range of order number values, the program lists the customer name, all books ordered, and each book's authors. The highest order number, generated at random, falls within 200 values of the lowest order number. Because no values are selected that are updated by transactions, background transactions are not run with this query.

Query 5. The final query is a grouped query with an outer join. For a range of ISBN numbers, the program lists the total number of orders placed for that book, the total number of books ordered, and the total cost of the books ordered for all books with two or fewer orders. To include those books with no orders placed, the program executes an outer join between the book table and entry tables. During the six- and 12-user tests, one-third of the users execute this query while the others run order transactions.

About the Results

For transactions, the NT version was a clear winner. For queries, the NLM (NetWare loadable module) version and the NT version both exhibited very good performance. The OS/2 version did relatively poorly, even when compared to a cache-constrained NT.

Why did we use OS/2 1.3? SQL Server for OS/2 remains a 16-bit application, and Microsoft recommends OS/2 1.3, rather than OS/2 2.1, as the best operating system on which to run it. Since OS/2 1.3 could use only half the RAM on the Model 95, that left at most 13 MB of RAM for SQL Server. So we ran the NT tests twice—once with the standard 16 MB of RAM and once with 13 MB.

SQL Server for NT obtains a high cache-hit ratio on our test (approximately 98 percent), even with 24 active-client sessions. When the amount of memory allocated to SQL Server is set the same on NT and OS/2 1.3, the two versions perform similarly on the transaction-processing tests. The NT version performs better on queries, however. One explanation may be its more sophisticated use of threads. Another reason may be that it incorporates some query optimization that appears in Sybase System 10 but is not present in the OS/2 (or NetWare) versions of SQL Server. ■

Charles Vogt is manager of performance testing at NSTL. You can reach him on the Internet or BIX at editors@bix.com.

SQL SERVER ON NETWARE, OS/2, AND NT: QUERIES

	16 MB OF RAM		13 MB OF RAM	
	SYBASE SQL SERVER NLM	MICROSOFT SQL SERVER 4.2 FOR NT	MICROSOFT SQL SERVER 4.2B FOR OS/2	MICROSOFT SQL SERVER 4.2 FOR NT
One user				
Query 1	6.80	10.43	11.48	10.20
Query 3	24.00	15.46	17.57	16.40
Query 4	51.10	28.22	46.49	31.10
Query 5	7.60	5.30	5.45	5.20
Six users				
Query 1	8.00	21.16	27.22	26.30
Payment with query	0.70	0.48	0.52	0.40
Query 3	36.10	39.86	129.46	76.50
ISBN order with query	3.20	2.91	7.38	3.40
Query 4	56.40	40.16	74.87	50.40
Query 5	9.40	10.39	10.12	9.90
ISBN order with query	5.50	12.93	38.23	15.20
12 users				
Query 1	13.20	44.22	54.63	55.70
Payment with query	1.30	0.86	0.88	0.70
Query 3	60.20	112.11	328.62	157.00
ISBN order with query	5.40	6.36	41.66	10.40
Query 4	76.00	74.47	179.24	86.80
Query 5	12.30	17.33	19.45	16.70
ISBN order with query	43.60	74.99	115.71	69.50

System: IBM PS/2 Model 95 (a 486DX/33 with 32 MB of RAM, two IBM 400-MB SCSI hard drives, and an IBM SCSI controller). Numbers represent average response time in seconds.
Red = best. Blue = worst.


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DOS, Windows, Mac, and NetWare systems typifies what you'll find in many corporations today. My work in converting a homegrown FoxPro contact manager into client/server form and fielding it on our LAN convinced me that NT is ready for prime time as an applications server and that SQL Server leverages NT's strengths. When I evaluated Advanced Server as an alternative to NetWare, considering its pros and cons for DOS, Windows, and Mac users and for network administrators, the picture that emerged was cloudier.

NT as Database Server

For the qualitative evaluation, I ran SQL Server 4.2 for NT on four machines. The version that ran on RISC hardware—an SGI/Mips Magnum and a DEC AXP 150—was beta code, scheduled to ship in final form in late January, just after completion of this review. For that reason, take the benchmark results for the Mips and Alpha systems with a grain of salt. The version that ran on the Intel platforms—a Compaq Proliant and an Everex Step 486/50—was the shipping version.

The reliable sameness of NT and SQL Server across this range of processors and system architectures represents a stunning accomplishment. That portability, along with SQL Server's 32-bit addressing and NT's 64-bit file pointers and disk-spanning capability, means you can bring nearly unlimited resources to bear on data management.

Matching Up

NT and SQL Server are a natural match in many ways. Under 16-bit OS/2, SQL Server can't make optimal use of threads, according to Microsoft. The limit of 53 threads per process made it impractical to assign one thread to each user connection. Instead, a single OS/2 thread services all connections, and SQL Server schedules simulated threads within the context of that worker thread. Under NT, however, SQL Server uses a pool of worker threads. This approach leverages native NT scheduling services and ensures even distribution of work across multiple processors in SMP (symmetric multiprocessing) systems. OS/2 2.x's per-process (and systemwide) limit of 4096 threads will support the same approach, but neither the 32-bit OS/2 version of SQL Server nor the SMP version of OS/2 2.x is yet available.

NT simplifies the management of SQL Server in many ways. With respect to SCSI peripherals, for example, NT users today enjoy many of the benefits that Chicago users with Plug and Play hardware will enjoy tomorrow (and that Mac users have taken for granted for years). NT's boot-time procedure for enumerating devices on a SCSI bus and recording information about them in the system registry was in fact the model for Chicago's similar mechanism. The payoff, for me, came when I ran the NSTL tests, which require that the test database and its transaction log reside on separate disks. Adding a second disk to the Alpha machine and then moving it to the Mips machine was a trivial exercise. Because NT's Disk Administrator can shuffle drive letters around—a terrific convenience—I was able to make the disk show up as drive F on both machines, and thereby avoid changing drive letters encoded in SQL scripts and batch files.

The ability of NT to stripe data across physical disks (and of Advanced Server to stripe with parity) means that you no longer have to juggle SQL Server disk devices and segments to spread out the I/O load. Managing SQL Server storage at the segment level is complex and scary. Creating stripe sets with Disk Administrator is child's play.

The instrumentation built in to NT—hundreds of counters that continuously measure the vital signs of processes, disks, memory, cache, network transports, and other system objects—reports a wealth of data that you can use to analyze the performance of an NT system using the NT Performance Monitor utility. The mechanism is open to applications, and SQL Server uses it to report its own statistics to Performance Monitor in the same way that system objects do. This integration of system and application performance data can yield crucial insights.

You can use Performance Monitor to know, not merely guess, what SQL Server's optimal memory allocation should be for a given NT configuration. You can even use Performance Monitor to set alerts (i.e., thresholds on system or application counters) and specify commands that run in response to the triggering of those alerts. NT's sophisticated and unified approach to monitoring, though not widely recognized, contributes mightily to its mission-critical capability.

SQL Server for NT

PROS
- **Employs multiple clients and protocols**
- **Supports ODBC**
- **Automates data administration with Object Manager**

CONS
- **Poor backup capabilities**
- **Ill-matched security with operating system**

Getting Connected

NT comes out of the box ready to run three network protocols: NetBEUI, IPX/SPX, and TCP/IP. (Advanced Server adds a fourth—AppleTalk.) SQL Server puts that flexibility to good use. The ability to communicate using multiple IPC (interprocess communications) mechanisms over multiple transports was formerly available in the form of SQL Server "integration kits" for NetWare and Vines. Those capabilities are now bundled with NT.

Of the most interest to me was the ability to support some DOS, Windows, NT, or OS/2 clients using named pipes over NetBEUI and other protocols—simultaneously—using SPX sockets. The target audience for my test application included Windows for Workgroups nodes running NetBEUI and plain Windows 3.1 nodes running IPX/SPX. SQL Server made deployment a snap. The client software's installer let me pick the Net-Library I needed in each case. It was not always this easy to field a SQL Server application in a predominantly NetWare environment like ours.

My only gripe is that Microsoft doesn't bundle the Mac client components. Mac (and Unix and VMS) clients can talk to SQL Server using TCP/IP sockets, but to make this happen you need versions of DB-Library (the SQL Server API) and Net-Library available only from Sybase.

SQL Server also now comes out of the box ready to support ODBC (Open Database Connectivity) clients. This is irrelevant to the SQL Server version of the NSTL benchmark, which is written to DB-Library and makes extensive use of stored procedures, but it isn't irrelevant to me. Unlike the benchmarks, the application I built is purely generic; the tool I used to construct it, Coromandel Industries' Integra Visual Database Builder, talks only to ODBC. In choosing that tool, I traded advanced back-end features for flexibility; thus, I can point the application not only at other servers (e.g., Oracle and Informix) but also at dBase or FoxPro files—an option that creates interesting possibilities. Any client application for NT SQL Server can

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run locally on LAN-attached nodes, or remotely on a node that dials in to NT's Remote Access Service. With ODBC, there's also the possibility of stand-alone use. If you export SQL Server data into, say, dBase or FoxPro files, an unconnected client can simply switch ODBC drivers and use the same application to access the snapshot data for read-only purposes.

Managing the Data

To make SQL Server's high-performance engine hum, administrators traditionally had to climb under the hood and monkey around using rather primitive tools. That began to change when version 4.2 provided SQL Administrator, a graphical tool for OS/2 and Windows that you use to create, mirror, and modify storage devices; assign databases and transaction logs to storage devices; manage users and groups; configure SQL Server options; and issue queries. The NT version of SQL Administrator adds a few enhancements. For example, the query tool can now graph query statistics (e.g., scans and logical and physical reads) and display a graphical summary of the query plan.

The big news, though, is the new SQL Object Manager, a real Swiss Army knife for managing data. (Incidentally, it is also available with the 4.2b upgrade of OS/2 SQL Server.) You use Object Manager to create and manage tables, indexes, keys, views, triggers, and stored procedures and to assign permissions to these objects.

One powerful feature that I put to use in my application is the ability to generate *triggers*: special stored procedures that fire on update, insert, and delete events. This let me enforce referential integrity between tables in a nearly automatic way. Object Manager makes setting up primary key/foreign key relationships a point-and-click affair, but it relies on triggers to cause changes to ripple from one table to another.

My simple contact manager, for example, uses company and contact tables related by a company-name key. When I asked Object Manager to create a new update trigger for the company table, it found the related contacts table and wrote the half-dozen lines of Transact-SQL necessary to synchronize the two tables. As a result, when I rename a company, all the related contact records snap instantly into place in the master-detail view that my application presents. If you've solved this kind of problem in a navigational database like FoxPro, you'll appreciate the economy with which SQL Server's triggers express the same logic. And if you've written triggers yourself, you'll love the fact that Object Manager automates the task.

Is the lack of true declarative referential integrity a serious flaw? In that religious debate, I side with the Microsoft/Sybase camp. Users tell me they want changes logged and business rules enforced when transactions occur. With triggers, you can write the code to do these things in a server-based, application-independent way.

Object Manager also tracks object dependencies, so you can select a table and list the triggers and stored procedures that refer to it or, conversely, select a stored procedure and list the tables it refers to. In addition, Object Manager can write out the SQL scripts that define all the objects in a database. It even wraps a graphical shell around the venerable BCP (bulk copy program)—which imports and exports BCP-formatted and comma- or tab-delimited ASCII data. An early beta version dangled the promise of support for other formats, such as dBase, FoxPro, and Access, but unfortunately, these didn't make the cut.

Hands On

With SQL Server installed on NT, it took just a couple of days to build my test application, dividing my time about equally between server-side and client-side chores. I've been using the application ever since, because it's faster and more convenient than its FoxPro predecessor. SQL Server's newfound ease of use, and Coromandel's first-class application builder, made the development task vastly more approachable than it was even just a year ago. The barriers to client/server development are crumbling; it's fast becoming a game the average corporate programmer can play and win. I'm excited by the new vistas NT SQL Server opens up, but there are still a few items on my wish list.

For starters, backup and recovery procedures remain rather primitive and do not integrate with the (also rather primitive) backup facility of NT. NT needs something like Novell's Storage Management Services architecture.

While I'm wishing, how about an agent that can digest SQL Server's diagnostic data and form useful recommendations? Interpreting Performance Monitor screens usefully requires a lot of expertise. The same holds true for the output of ShowPlan, a utility that lets you view the deliberations of SQL Server's cost-based query optimizer. Moving some of that expertise into software would be a tremendous boon.

SQL Server and Advanced Server work together on security matters, but not as well as I'd like. The rules governing user names differ between the two systems, and smoothing out those differences proved tricky. Synchronizing the database and network directories requires manual intervention; new users added to an NT group don't automatically show up in the corresponding SQL Server group, and there's no link to the NetWare bindery.

There's also a quirk in the Sybase/Microsoft client software that needs fixing: Only one database cursor can be active per client connection. The problem showed up when I implemented a two-table, master-detail view. When a query against the master table returned hundreds of records, the dependent query against the detail table was slow to respond. According to Coromandel, that's because the client software can't keep both cursors simultaneously active. By constraining the master result set—which was the right thing to do anyway for my application—I solved the performance problem. But the underlying limitation shouldn't exist.

Despite these details, NT SQL Server gets an emphatic thumbs-up from me. Client/server computing, RISC, and multiprocessor systems have been dry seminar topics for too long. With a platform like NT and an application like SQL Server, they come alive as practical technologies that you can apply today in the enterprise.

NT as File Server

With the advent of Windows NT 3.1 and Windows for Workgroups 3.11, Microsoft has standardized on a rich workgroup foundation. Peers in a Windows workgroup can share files, printers, and clipboards over NetBEUI, IPX/SPX, or TCP/IP and exchange mail using simple MAPI. (For more on the use of routable protocols with NT, see "Wide-Area Windows Networking," January BYTE.) NT and Windows nodes are equal partners in workgroups and communicate effortlessly across the 16-bit/32-bit divide. Other network services available to 16- and 32-bit applications include named pipes, NetDDE, Windows sockets, mail slots, and the WNet APIs used to browse for, connect to, and share resources. This common substrate contains much of the capability that LAN Manager formerly provided. *continued*

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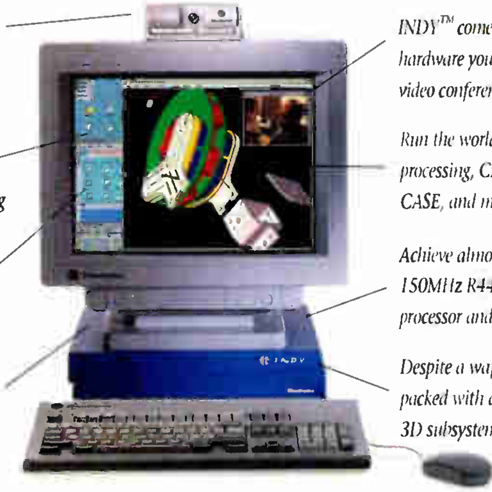

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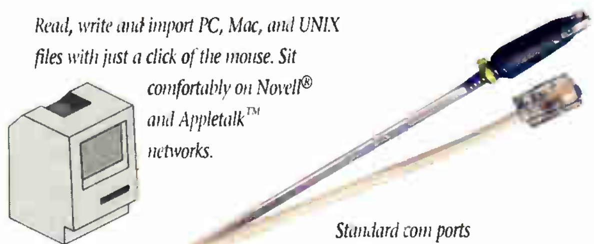

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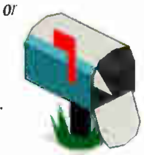

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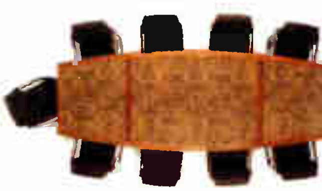

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SQL Server for NT on CISC and RISC

This test examines various hardware platforms for SQL Server for NT. The test machines were a SGI/ Mips Magnum (a 75- to 150-MHz R4400SC with 1 MB of cache memory and 32 MB of RAM), a DEC AXP 150 (a 150-MHz DECchip 21064 with 512 KB of cache memory and 32 MB of RAM), a Compaq Proliant (a dual 66-MHz Pentium with 256 KB of cache memory, and 32 MB of RAM), an Everex Step 486/50 (a 486DX2/50 with 256 KB of cache memory and 16 MB of RAM), and an IBM PS/2 Model 95 (a 486DX/33 with 256 KB of cache memory and 32 MB of RAM). The SGI/ Mips Magnum is a favorite of mine. It's the fastest, smoothest NT workstation I've used regularly—a real thoroughbred. It's quickly becoming a collector's item, however, because SGI has passed the baton to NEC for the manufacturing of Mips-based NT workstations.

Waiting in the wings was a Carrera Pantera II (a 200-MHz Alpha with 2 MB of cache memory) and an NEC Express RISCserver (a dual 75- to 150-MHz R4400), neither of which arrived in time for testing. On the horizon, DEC is working on Alpha-based multiprocessing systems.

The tests used are the query tests from NSTL. The transaction test results are not reported because of anomalies in the hard disk used for the transaction log.

About the Results

Best scores on individual queries were distributed rather evenly among the Compaq Deskpro 66/M, the Proliant, and the Magnum. The Proliant's multiprocessor technology, clearly capable of great results, can also falter. The Magnum's RISC engine similarly shows flashes of brilliance. But neither multiprocessing nor RISC clearly dominates these tests. RISC versus CISC? It's all just horsepower to NT, and if you can yoke the horses into teams, so much the better.

WINDOWS NT SQL SERVER QUERY PERFORMANCE ACROSS SYSTEMS

	IBM PS/2 MODEL 95	COMPAQ DESKPRO 66/M	COMPAQ PROLIANT (TWO CPUS)	SGI/MIPS MAGNUM	DEC ALPHA AXP 150
Processor	486DX/33	486DX2/66	Pentium 66	R4400SC	DECchip 21064
Processor clock rate (MHz)	33	66	66	150	150
Processor secondary cache	256 KB	256 KB	256 KB	1 MB	512 KB
RAM (MB)	32	32	32	32	32
One user					
Query 1	10.43	7.82	4.24	4.65	13.50
Query 3	15.46	12.87	35.37	6.31	14.07
Query 4	28.22	17.32	5.31	13.68	16.41
Query 5	5.30	2.89	13.22	1.87	4.38
Six users					
Query 1	21.16	16.38	8.89	13.12	37.66
Payment with query	0.48	0.30	0.17	0.22	0.34
Query 3	39.86	31.51	257.73	62.29	174.47
ISBN order with query	2.91	1.49	1.69	1.98	3.18
Query 4	40.16	31.79	6.72	18.61	25.37
Query 5	10.39	6.07	4.33	3.69	9.08
ISBN order with query	12.93	6.80	9.52	9.15	19.37
12 users					
Query 1	44.22	34.97	20.08	30.37	82.82
Payment with query	0.86	0.57	0.29	0.38	0.60
Query 3	112.11	76.15	319.96	87.20	273.75
ISBN order with query	6.36	3.12	5.37	5.84	9.99
Query 4	74.47	62.82	11.65	34.25	46.53
Query 5	17.33	12.19	26.44	6.16	16.58
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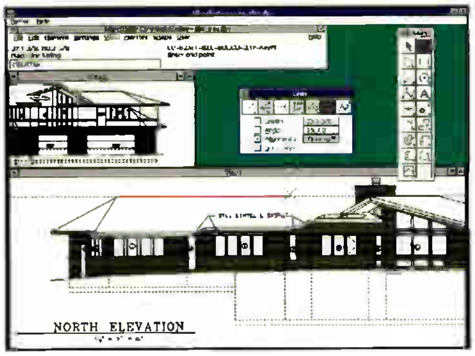

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As a result, LAN Manager's heir, Advanced Server, focuses exclusively on the issues that separate enterprise networking from workgroup networking: central administration, fault tolerance, heterogeneous client support, and remote access. To that end, Advanced Server inherits and extends LAN Manager's domain-based security model, offers disk mirroring/duplexing (RAID 1) and striping with parity (RAID 5), delivers Macintosh file and print services, and bumps NT's limit of one remote user to 64.

All this costs a lot less than NetWare. A 100-user NetWare setup lists for $6995 (for version 3.12) or $8795 (for version 4.01)—and that doesn't include Mac support. And while NetWare's licensing cost climbs as you add more users, Advanced Server's stays flat at $2995 ($1495 until June 1). Of course, there are a host of other considerations, not the least being that Advanced Server needs a bigger, faster machine to run acceptably. But when you toss in features not included (e.g., remote access and RAID 5) or not possible (e.g., RISC and multiprocessing support and local GUI application capability) with NetWare, Microsoft's latest LAN operating-system offering merits a close look.

Out of the Box

I ran Advanced Server on two machines: the SGI/Mips Magnum and an IBM PS/2 Model 90 486 XP. Each machine was a primary domain controller, accessible to Windows, OS/2, NT, and Mac clients on BYTE's Ethernet LAN. While it's faster and easier to install from CD-ROM, the Advanced Server package also includes a stack of 23 floppy disks if—as was the case with my PS/2 machine—your server lacks a CD-ROM drive.

With Advanced Server, as with NetWare, it's a breeze to set up disk partitions and configure network protocols. When you want to reconfigure these things, however, NT sometimes lacks NetWare's flexibility. For example, exploring the use of IPX/SPX and TCP/IP as alternate substrates for the basic Windows networking features (file-, printer-, and clipboard-sharing), NT forced me to reboot every time I added or even just tweaked a protocol. With NetWare, I can load or unload TCP/IP and AppleTalk stacks without downing the server or disrupting logged-in IPX/SPX clients, and I've been grateful to be able to do that. While NT's transport drivers are, in principle, unloadable, the mechanism that binds transports is rooted deep in NT's boot process. Continuous availability is a vital issue for me. With NetWare, I can change an IP address or an AppleTalk zone name on the fly; Advanced Server needs to be equally adaptable.

The Knowledge Gap

My protocol experiments also brought to light another glitch that underscores the immaturity of NT and Advanced Server. Installation and binding of drivers, protocols, and services are highly automated in NT. Graphical utilities kick off routines that create and destroy keys in the system registry, where all configuration information lives in binary form.

This is a great feature when the installation tools work properly, and in my experience, they almost always do. But in one case, I got stuck. NT has the notion of service dependencies—for example, NWNBLink, Microsoft's NetWare-compatible NetBIOS, depends on NWLink, Microsoft's IPX/SPX transport. When I installed NWLink, NWNBLink came along for the ride. I could have removed both by uninstalling NWLink, but instead, I mistakenly uninstalled NWNBLink and, per instructions, rebooted. That left things in a state of limbo. I couldn't remove NWLink, nor could I add NWNBLink.

To compound the trouble, I next removed the network card driver, planning to reinstall all the networking pieces from scratch. But the NWLink transport remained in limbo. In retrospect, I realized that I should have reverted to the "Last Known Good" configuration at the first sign of trouble; that's how you recover from catastrophic configuration errors. But my error wasn't catastrophic. And because the undo stack is just one level deep, when I took out the network card driver and rebooted, NT marked the prior—and problematic—configuration as "Last Known Good." I tried booting from the NT panic disk and restoring the configuration stored there, but for some reason, that didn't expunge the rogue NWLink. Finally, I took a stab at deleting its registry keys, but NWLink, Lazarus-like, kept returning to haunt me. In the end, I fired up the installation CD and took a coffee break.

Don't get me wrong. On the whole, I find NT a little easier to configure than NetWare and a lot easier than OS/2 or Unix. But it has its own unique approach. Experts who fully understand that approach, books that document it, and third-party tools that complement it are, today, in scarce supply. (The invaluable three-volume Windows NT Resource Kit is the outstanding exception to this rule.) Some would-be implementors will cite this knowledge gap as reason to adopt a wait-and-see stance with respect to Advanced Server. Others will view it as a career opportunity.

NT Advanced Server

PROS
- **Low per-user costs**
- **Easy to install and configure**
- **Works great with NT clients**

CONS
- **Must reboot after changing protocols**
- **Limited remote administration**
- **Limited flexibility in changing domain configurations**

Working with Advanced Server

Advanced Server does what every LAN operating system must do—share files and printers—with minimal fuss and maximal point-and-click ease of use. You share directories using File Manager; the procedure will be familiar to users of NT or Windows for Workgroups. You can share FAT (file allocation table), HPFS (High Performance File System), or CDFS (CD-ROM file system) volumes, but only with directory-level security. (Unlike NetWare, Advanced Server makes CD-ROM sharing a trivial exercise.) For full file-level security, you need to use NT's journalizing file system, NTFS.

Advanced Server's Mac file services use NTFS for two reasons: file-level security, and because the ability of an NTFS file to contain multiple-named data streams of unlimited size maps neatly to the data-fork and resource-fork components of a Mac file. Because NT's back up utility is NTFS-aware, you can backup and restore Mac files without damage to long filenames or creator/type resources (I checked; it works.) Unlike NetWare's Mac name space, which you install once to make an entire volume visible to Mac clients, Advanced Server's Mac volume maps to an individual NTFS directory. The advantage of this scheme is that you don't litter your whole volume with Mac directory entries when, as is true on our network, Mac and PC users tend to exchange files using a few directories designated as drop boxes. The disadvantage

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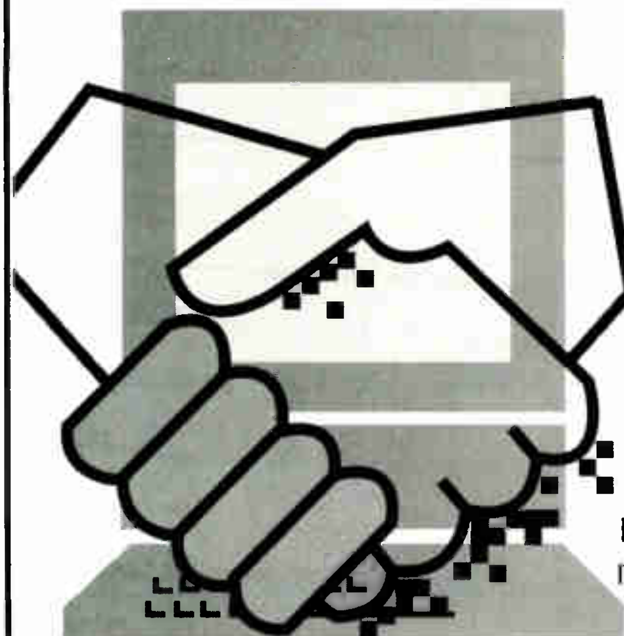

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LAN Operating-System Testing

CHARLES VOGT

The relative performance of network products can vary substantially because of differences in how applications access files, so the NSTL file-server tests use a mix of popular applications. Programs such as Lotus 1-2-3, cc:Mail, and XCopy read and write files in relatively large chunks. On the other hand, Microsoft's FoxPro makes many small read and write requests when accessing shared database files and can generate many lock and unlock requests.

About the Results

Lacking support for a high-end token-ring adapter, NT fared poorly. Ironically, Microsoft's own LAN Manager 2.2 was the best performer. The effect of using a slower 16-bit adapter with Microsoft NT Advanced Server is particularly noticeable on the XCopy tests, which move the greatest amount of data between the servers.

In addition, NT Advanced Server is particularly slow relative to both versions of NetWare and LAN Manager 2.2 on the FoxPro transaction-processing test. Microsoft says that the small size of the requests that FoxPro generates when reading and writing data, along with the processing of lock requests, substantially lowers the performance of NT Advanced Server. This test result shows that NT Advanced Server is not a good choice for a high-volume transaction-processing application written in a file-oriented database such as FoxPro.

NSTL FILE-SERVER PERFORMANCE TESTS

	BANYAN VINES 5.5	IBM LAN SERVER 3.0	MICROSOFT LAN MANAGER 2.2	MICROSOFT NT ADVANCED SERVER 3.1	NOVELL NETWARE 3.11	NOVELL NETWARE 4.0 (VLM)	NOVELL NETWARE 4.0 (NETX)
Four workstations							
cc:Mail	0.31	0.34	0.27	0.22	0.32	0.31	0.32
Lotus 1-2-3	0.33	0.41	0.40	0.41	0.33	0.28	0.30
WordPerfect	0.42	0.48	0.55	0.31	0.43	0.38	0.34
FoxPro	10.67	10.69	11.37	7.81	14.07	7.47	10.96
XCopy-1 (26 files, 40 KB)	0.04	0.21	0.24	0.08	0.12	0.24	0.21
XCopy-2 (104 files, 10 KB)	0.02	0.12	0.13	0.02	0.08	0.10	0.08
Eight workstations							
cc:Mail	0.51	0.62	0.70	0.42	0.56	0.50	0.45
Lotus 1-2-3	0.60	0.79	0.79	0.77	0.61	0.51	0.46
WordPerfect	0.55	0.75	0.83	0.40	0.66	0.52	0.40
FoxPro	15.38	18.39	19.81	10.86	23.75	12.08	13.98
XCopy-1 (26 files, 40 KB)	0.03	0.19	0.24	0.08	0.08	0.24	0.24
XCopy-2 (104 files, 10 KB)	0.02	0.10	0.11	0.02	0.05	0.11	0.07
16 workstations							
cc:Mail	0.66	0.94	1.11	0.58	0.81	0.78	0.65
Lotus 1-2-3	0.97	1.51	1.55	1.40	1.01	0.74	0.66
WordPerfect	0.50	0.99	0.99	0.40	0.85	0.63	0.57
FoxPro	15.58	20.50	22.05	10.74	25.93	13.72	14.65
XCopy-1 (26 files, 40 KB)	0.03	0.17	0.25	0.08	0.06	0.25	0.21
XCopy-2 (104 files, 10 KB)	0.02	0.08	0.11	0.02	0.04	0.10	0.06
24 workstations							
cc:Mail	0.57	1.05	1.25	0.56	0.84	0.85	0.75
Lotus 1-2-3	0.93	2.14	2.24	1.72	1.23	0.78	0.78
WordPerfect	0.41	1.05	0.96	0.37	0.90	0.61	0.66
FoxPro	12.49	19.20	21.07	11.49	25.88	12.81	13.25
XCopy-1 (26 files, 40 KB)	0.00	0.14	0.15	0.08	0.05	0.15	0.14
XCopy-2 (104 files, 10 KB)	0.00	0.11	0.08	0.02	0.04	0.07	0.05

All results are in transactions per second. Red = best. Blue = worst.

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"The 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.... Its image-quality score was well above average."

- BYTE Magazine, January 1994 -

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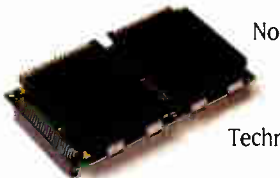

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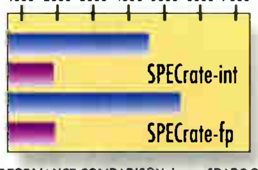

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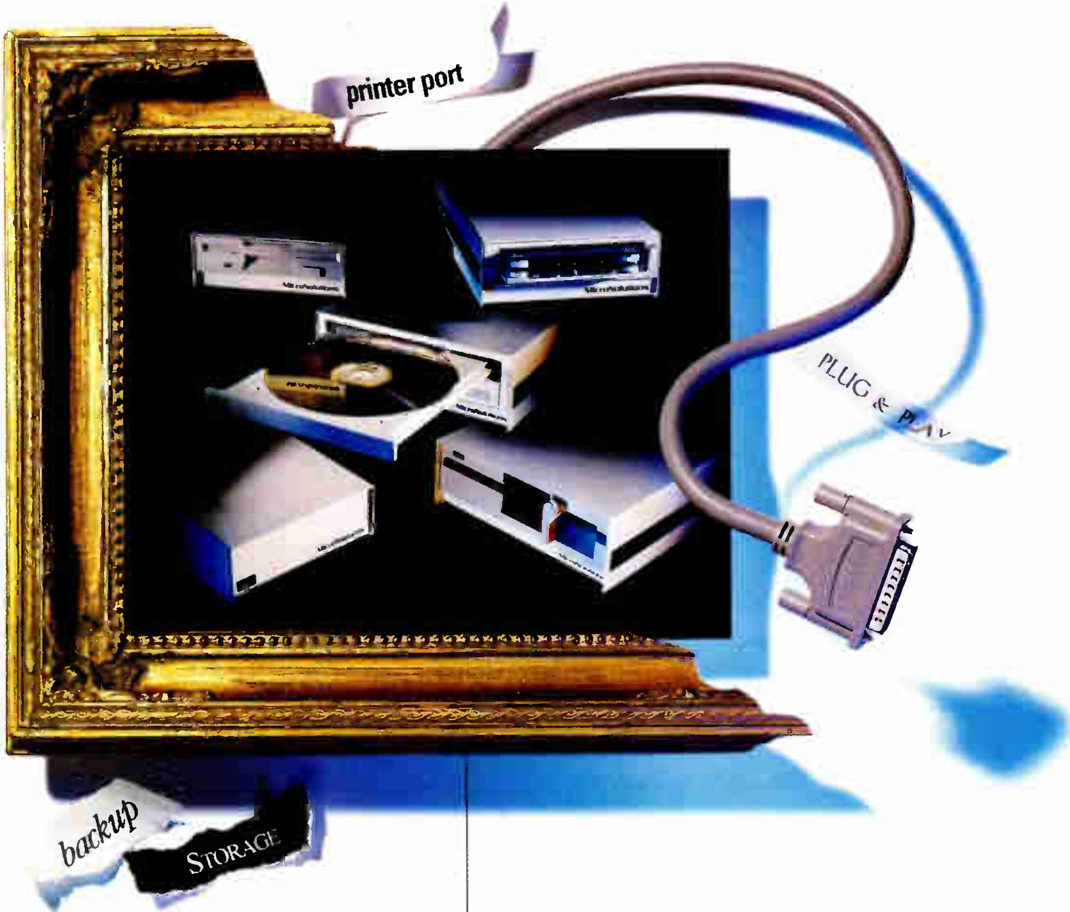

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is that you have to maintain PC shares and Mac shares separately. On our NetWare server, a single directory called Temp is available to everyone. With Advanced Server, I had to create Temp twice and deal with two sets of permissions.

Advanced Server lets you set up the systemwide auditing policy so that it records the success (or failure) of file access requests in its security event log. It also lets you fine-tune your auditing policies using File Manager. For selected files or directories, you can adjust the list of users and groups whose actions Advanced Server will audit and the list of actions that it will audit. Advanced Server dumps the audit trail into the security event log, which you can read using the same Event Viewer that you use to explore the system and application event logs.

The Win32 APIs that write and read event logs invite third-party drivers and applications to cooperate with current and future system management tools. Like the standard monitoring techniques exposed through Performance Monitor, the standard logging techniques exposed through Event Viewer bode well for Advanced Server's long-term manageability.

Management: The Dark Side

It's important to keep the manageability of an Advanced Server network in perspective. Widespread adoption of performance monitoring and event logging can vastly improve software maintenance and support. Because both Performance Monitor and Event Viewer are enabled by RPCs (remote procedure calls), I can point them at any NT system on my network, not just my local NT machine. Put on an administrator's hat and imagine how effective you'd be if your users' applications routinely reported trouble—low memory, file not found, unable to print—into standard logs that you could visit remotely.

Unfortunately, this rosy scenario requires NT on both sides of the RPC pipe. Event logging is a part of the Win32 API. Sadly, both Win32s and Win32c, the variant that Microsoft hopes to bring to the masses with Chicago, don't provide it. Thus, event logging isn't going to show up en masse on the client side anytime soon—a real pity because the heaviest support costs pile up on the client side. So while NT and Advanced Server offer tantalizing glimpses of holistic network management, only NT clients can enjoy the full benefits.

Another administrative benefit enjoyed only by NT clients on Advanced Server networks is the RPC-enabled Print Manager. It obviates the need to install printer drivers on clients. A driver installed once on an Advanced Server machine is available, in client/server fashion, to all NT workstations. Advanced Server's user profiles, which enable desktop settings, file and printer connections, and log-in scripts to follow users from workstation to workstation, are also NT-specific. In these cases, Windows 3.x clients are again left out in the cold, although Chicago clients, which can use the Win32 RPC and registry APIs, should fare better.

Even in the NT realm, even just considering server management, there are some key restrictions. A NetWare administrator can dial up a server from anywhere using a DOS laptop and manage that server with RConsole. But while an Advanced Server administrator can dial in from either Windows 3.x or NT clients, that person won't often be able to tuck an NT machine into a briefcase.

If you're one of the lucky few who can tote NT, you're still not home free. While many administrative tasks can be performed in client/server mode, others—including the control of services and the installation and configuration of drivers—require local access to the server. Lacking an X Windows System–like solution, Microsoft will not have an answer to this problem until the debut of Hermes, the suite of NT-based network management technologies due later this year. One Hermes feature is a remote screen/keyboard/mouse capability.

A Matter of Trust

A domain unites a group of servers into a single administrative unit. The idea is that you can log in and supply a password just once and then access any secure shared resource on any server. The reality falls a bit short because the MS-Mail address book doesn't yet integrate with Advanced Server's account database. Of course, Novell users have the same problem. Even in NetWare 4.0, the MHS address book isn't an integral part of the NDS (NetWare Directory Service).

In other respects, though, Advanced Server's domain-based security works as advertised and benefits greatly from the new ability to set up trust relationships between domains. If the administrator of Domain A agrees to trust Domain B (and B's administrator permits A to trust B), then B's users and groups can be granted explicit rights and permissions in A. This is actually easier to do than to explain. Basic trust relationships are a lot less confusing than global groups (which can contain users from just the current domain but can be referenced in foreign domains) and local groups (which can contain users from foreign domains but can be referenced just in the current domain).

Trusted domains can enable a bottom-up approach to the construction of large networks that's very different from the top-down approach required by NetWare 4.0. Advanced Server domains can evolve independently and then join in trust relationships if necessary, so you can delay enterprise-wide decisions about network structure. Novell's all-encompassing NDS forces you to design the enterprise-wide structure up front.

There's a key inhibitor to the organic growth of Advanced Server networks, however. I originally set up my two Advanced Servers as controllers of separate domains so I could explore trust relationships between the domains. My plan then was to convert one server to be a backup domain controller in the other's domain. No such luck. You can easily move an NT workstation from one domain to another, but to move an Advanced Server, you have to reinstall. With that discovery, multidomain networking suddenly looked a lot less flexible.

The bottom line? NetWare 3.11's in place, and it does the job. When it's time to upgrade our two 8-MB 386-/486-class servers, I'll likely recommend NetWare 4.0. For a population of NT workstations, Advanced Server makes a lot of sense. But for DOS, Windows, and Mac users, there's no compelling advantage. ■

Jon Udell is a BYTE senior technical editor at large. You can reach him on the Internet at judell@bix.com.

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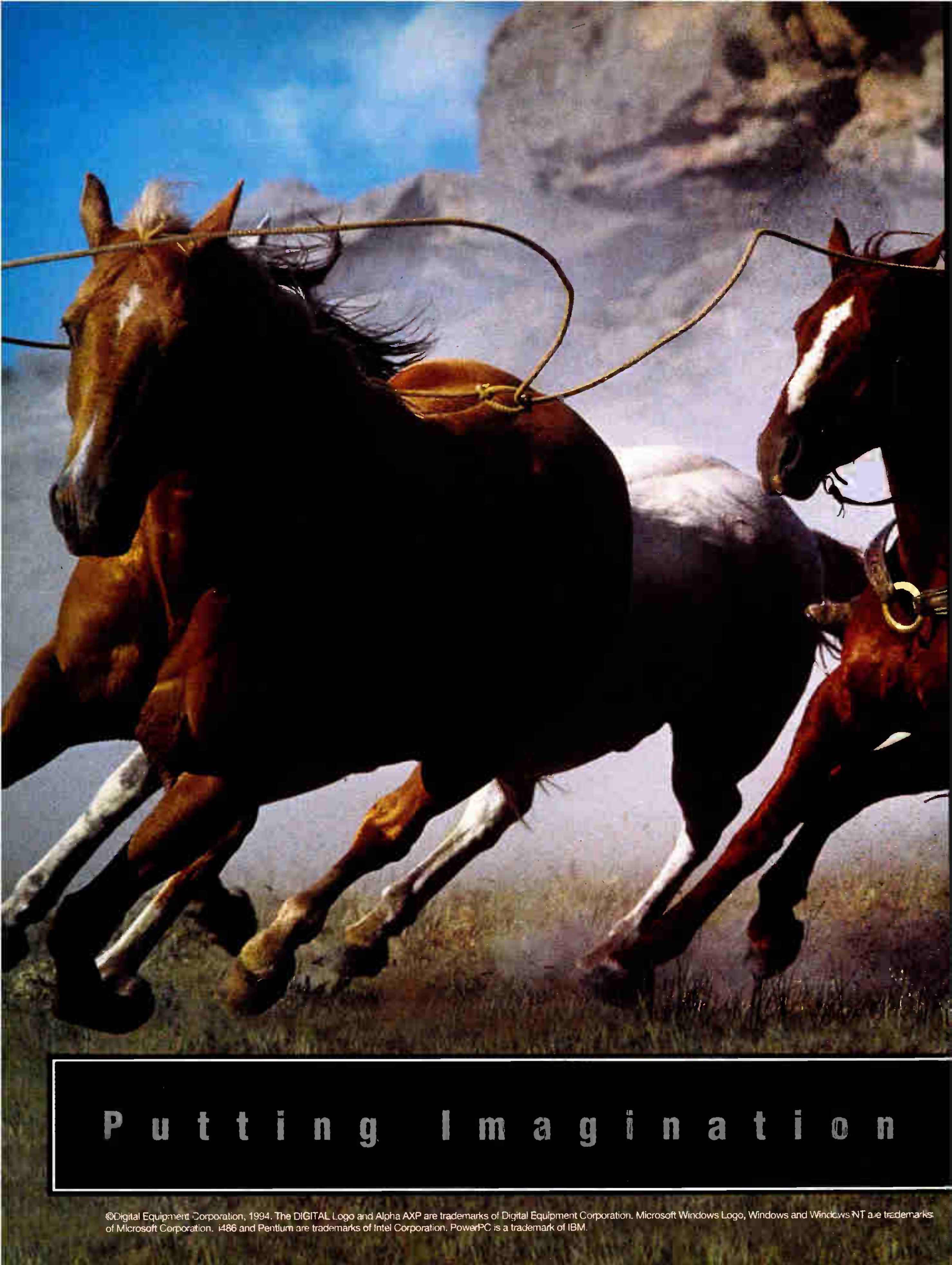
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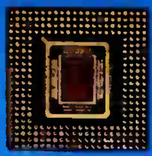

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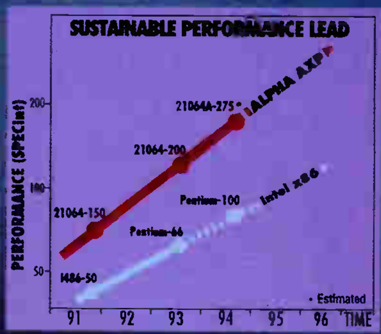

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Almost as Good as Being There

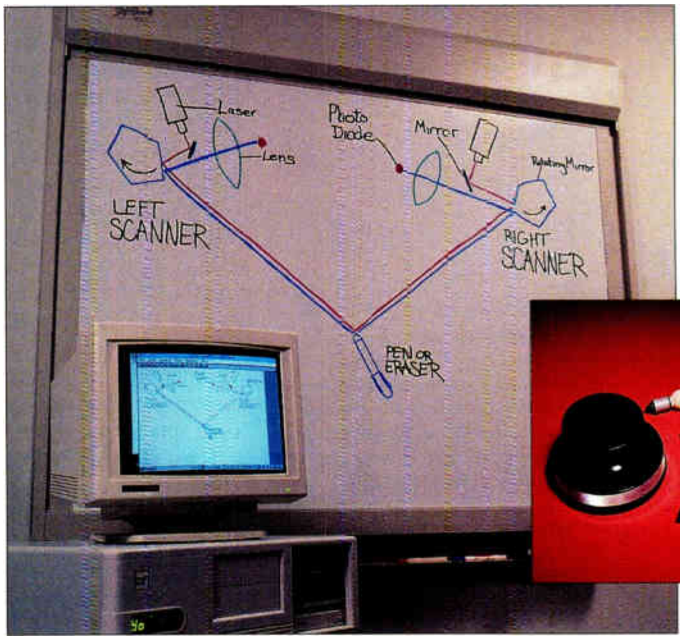
New technologies improve long-distance conferencing

HOWARD EGLOWSTEIN

Teleconferencing isn't exactly a new idea. If you've got the camera equipment, satellites make it possible to bounce live video across the country or around the world. New PC-based videoconferencing hardware promises to provide similar benefits at less cost, letting you get your point across long distance over high-speed phone lines. The real low-cost solution, however, is so-called document conferencing or whiteboarding software (see the text box "Whiteboarding with Software"). Although they don't yet support video images, packages like Fujitsu's DeskTop Conferencing or Modus Software's Synconference let you collaborate on computer-generated images and documents over standard telephone lines using modems, through a LAN connection, or both.

This review looks at two unique hardware products designed to augment conferencing software. Microfield Graphics' SoftBoard ($2995) gives you both a real whiteboard and the remote benefits of whiteboarding software. The SoftBoard is a high-quality porcelain whiteboard with an infrared laser scanning system that tracks every stroke, and even the color, of your pen. With the included software, you can record your drawing sessions stroke by stroke. There's also optional software available that lets you send the session live over a modem connection.

AT&T Paradyne's $535 DataPort 2001 modem simplifies your teleconferencing setup by merging voice and computer data over a single phone line—transparently to most software. By eliminating one phone connection, it also lets you share and discuss data with people who don't have the luxury of separate voice and data lines.



Each of the SoftBoard's pens *has a specially encoded reflective collar so the laser can identify the pen and determine its color. The larger eraser uses a similar reflective surface.*

Microfield Graphics' SoftBoard, *a porcelain/steel whiteboard, uses lasers to scan the surface and report any pen activity to an attached computer. Included Windows or Macintosh software converts your drawings into viewable images.*

Microfield's SoftBoard

It's hard to find a conference room anywhere that doesn't have a whiteboard, and people often have one in their private offices to stimulate their creative juices. There's something magical about having a huge surface that you can walk up to and draw on with a nice fat pen.

The biggest problem with whiteboards (besides figuring out how to clean the erasers) is that there's no easy way to record what you've drawn. Some people videotape their whiteboard presentations and play them back through video boards on their computers. Some whiteboards have scanners that can read in a finished drawing and print out a copy on thermal paper.

Microfield's solution, called SoftBoard, uses a pair of lasers and sensors to scan the surface of an otherwise ordinary whiteboard. When you connect the SoftBoard to a computer running Microfield software, you can record a presentation, print the resulting drawings, or send a blow-by-blow representation of your whiteboard session to a remote site.

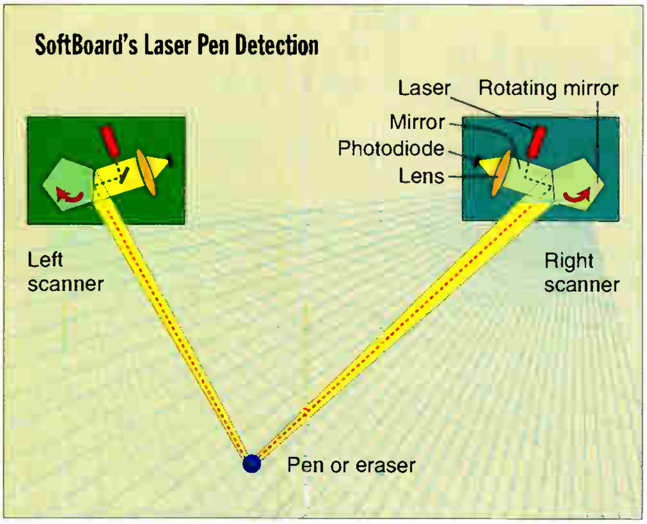
The pens have special reflective collars near their tips, and the eraser has one, too. When the sensors see the laser reflect from a pen's collar, software running on a 40-MHz Texas Instruments DSP (digital signal processor) uses triangulation to determine the position of the pen on the surface. The DSP can figure out not only the position but also the color of the pen you're using, because each pen has a different collar pattern.

The lasers scan the board 416 times each second and can discern 80 data points per second. Pen position is reported more accurately in the center of the board, although I found the results to be more than acceptable right up to the edges. The system can track only one pen or eraser at a time, and you must not block the coded collar with your finger while you're writing. The board measures 60 inches wide by 54 inches tall and has an active writing area of 54 inches by 40.5 inches.

Pen-stroke and color information is encoded into a 4800- or 9600-bps data stream and fed through a standard RS-232 connection. The data stream encapsulates your strokes as vectors, including all pen-up and pen-down motions. The scanning lasers are active up to about a quarter of an inch above the surface, so you must lift your pen deliberately between strokes.

Windows software (SBRECORD) interprets the data stream and re-creates the whiteboard drawing in real time on-screen. SBRECORD can save your drawing, along with the real-time information used to create it, in a file for later playback. The vector representations used to save the information are quite efficient—a drawing that

Almost as Good as Being There



Infrared lasers in the two upper corners of the SoftBoard *each emit a beam onto a five-faceted mirror spinning at 5000 rpm. The reflected beams effectively scan the entire surface of the board 416 times each second. Any beam hitting a special reflective surface on one of the erasable marking pens or on the felt eraser bounces back and is picked up by a photodiode. A 40-MHz DSP notes the rotation angle of the mirror and uses that information to determine the beam deflection angle. Comparing the angles from both laser/mirror/diode systems, the DSP triangulates the object's position. Bar-coded patterns on the pen tips let the DSP figure out the pen color.*

took 5 or 10 minutes to draw and used about a hundred pen strokes took only 30 KB on disk.

A set of controls, similar to VCR controls, at the top of the playback window allows you to play the image forward or backward, at real time or high speed. If you give a sales presentation to a group and capture it via SBRECORD, you can send it along with a companion play-only package (SBVIEW) to anyone who wasn't able to attend your meeting. SBVIEW plays back the captured file exactly the way you presented it. SBVIEW is also freely distributable, so you can use your SoftBoard to create a presentation and distribute it along with a copy of SBVIEW. (SBVIEW and a sample SoftBoard file can be downloaded from BIX or BYTE's BBS. See page 5 for details.)

SBRECORD can also export a drawing as a Windows metafile (WMF format) or as a bit map. A number of Windows applications support these formats. Using CorelDraw and Illustrator, I moved a drawing off the whiteboard into EPS format without difficulty.

If all you need is a hard copy of your artistry, attach any Windows-compatible (or, for the Mac version, Macintosh-compatible) printer. I found a Hewlett-Packard 1200C/PS color ink-jet printer to be a perfect match for the SoftBoard. I set the printer to run in PCL 5c (color PCL) mode using HP's drivers. Attached to a 33-MHz 486 PC, it typically took less than 15 seconds after selecting SBRECORD's print function before the printer started churning out copies.

Teleconferencing capability comes through the optional SBREMOTE software, which was in a beta version when I tested it. This is a remote-access version of SBRECORD. Using SBREMOTE, you connect a modem to the PC controlling the SoftBoard and dial up another PC at a remote site. Anything you draw on your SoftBoard appears simultaneously on the remote PC. If that remote machine happens to have a SoftBoard, too, the folks at that end can draw on their board, and their drawing appears in a window on your PC.

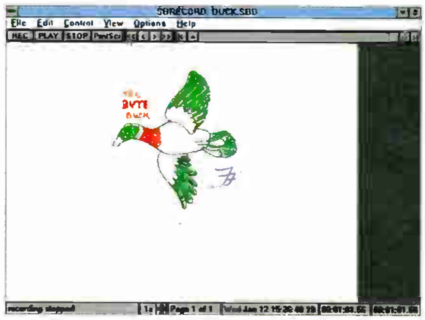
The remote software requires a high-speed modem. The beta version was set up for a limited selection of modems, but it worked amazingly well with a Practical Peripherals PM14400FXMT 14.4-Kbps modem. To connect the modem and serial SoftBoard at the same time, however, you'll need a PS/2 or bus mouse; three serial devices is one too many. Since a large number of clones ship with serial mice, check your machine configuration if you plan on running the remote software.

I also looked at a pre-beta copy of SBRECORD for the Mac. It works the same way as SBRECORD does under Windows. The interface has many of the same control elements as the Windows version and should be able to interchange files with its Windows cousin. The beta version I used didn't have the file interchange working yet. Microfield wasn't ready to announce any plans for other platforms or other Macintosh support.

Although the product is shipping, Microfield is still tuning a few details. Mounting the board requires a delicate touch. The drawing surface has to be held nearly flat and against a good, steady surface. A standard gypsum-board wall will do fine, and that's what the company expects you to have. My review unit came with four carefully machined mounting studs, one for each corner. Two simply attach to the wall with supplied wall mounts (molly bolts for hollow wallboard), and the other two have adjustable screws that let the mount move in and out. You use a template supplied with the board, drill holes for the molly bolts, attach the mounts, and slip the board's four keyhole slots over the mounts. Once you get the board mounted, a simple alignment procedure helps you adjust the two lower mounts in and out until the board is as flat as possible.

I had two significant problems trying to get the board mounted. First, the wall I needed to use was solid concrete, and there was no way to get Microfield's molly bolts into it. I ended up using masonry slugs and lag bolts to attach the board. The lag bolts were fatter than the recommended bolts, and the precision board mounts wouldn't fit over them. It took some trial and error, but two of us managed to maneuver the 60-pound (27 kg) board onto the four bolts. Without the fancy mounts, however, it took some doing to adjust the corners so that the surface was flat. I made those adjustments by turning the lag bolts to move the heads farther from or closer to the wall.

Microfield's alignment software bounces the laser beams off special reflectors at the corners of the board, measures the error, and suggests how to turn the adjustable



Microfield supplies software *(Windows version shown) that captures the data from the SoftBoard, displays it on-screen, and saves it for future playback. The software controls simulate a VCR and allow the drawing to be played back at any speed, forward or backward, and let you print the image to any Windows-compatible printer. With SBREMOTE, an optional program, you can transmit an image as it's drawn to a remote site over any high-speed asynchronous modem.*

mounts. The numbers change radically with even small adjustments, and the software makes the tiniest error look like you've just killed your best friend. (Microfield is planning to change the software to be more forgiving.) The board had to go on

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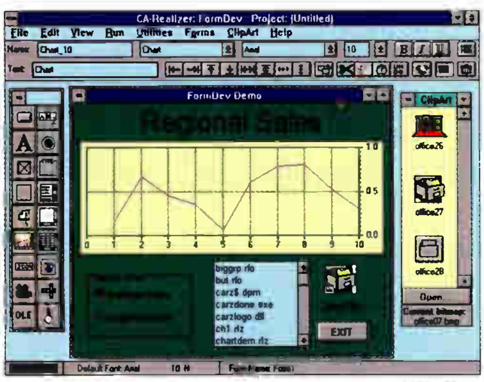

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and off the wall several times before I got the bolt heads at exactly the right height. Microfield is working on a new mounting design that should make the entire process easier and more flexible.

If your conference-room wall is made of anything other than standard wall board, plan on using a bit of creativity to get the SoftBoard mounted, or check with Microfield for suggestions. But even with the mounting difficulty, I had the board out of the box, mounted, and connected to a computer in less than an hour.

The SoftBoard sells for $2995 with a mounting kit, eight coded pens (two each of red, green, blue, and black), an eraser, a cable, and SBRECORD/SBVIEW software either for the PC under Windows or for the Mac. That price is high only when compared to a standard mute whiteboard or a software whiteboarding package—it compares favorably to whiteboards with built-in copiers and is far more versatile.

The Windows SBREMOTE software will sell for an additional $290. If you want the standard software for both PC and Mac platforms, the second platform will cost you $190. Supply costs are reasonable. A box of four pens goes for $7.95, and 12 boxes for $90. Erasers are either $9.95 or $4.95, depending on whether you replace the whole eraser or just the felt pad.

AT&T Paradyne's DataPort 2001 *is a 14.4-Kbps fax/data modem that can combine voice and data into one simultaneous connection. It allows you to send someone a file or a remote presentation and talk with him or her at the same time.*

AT&T Paradyne's DataPort 2001

The DataPort 2001 Multimedia Communicator isn't the first 14.4-Kbps data/fax modem in AT&T's family of DataPort modems. But it is the first to use AT&T's VoiceSpan technology, which lets you simultaneously talk and transfer data over the same phone line. VoiceSpan employs a single DSP to encode both voice and data signals.

Putting both signals on one line has benefits for almost any type of person-to-person communications session. Say, for example, that you're talking with a sales manager across the country and she requests a current copy of your product price list. If you both have a computer and modem attached to second phone lines, you can continue your conversation while the computers move the data. If a second line is not available, you have to hang up the phone and then set up the data connection, and if one of you isn't familiar with your communications package, the other can't help.

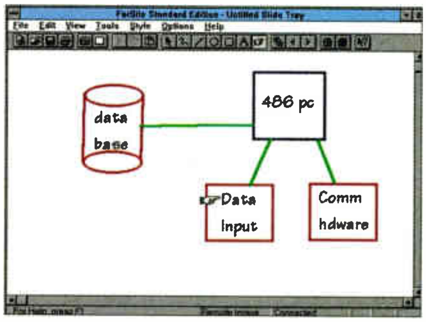
With phones connected through two DataPort 2001 modems, it's another story. Anytime during a voice call, you can set up communications software to dial out on one computer and answer calls on the other. At the calling end, the DataPort modem pretends to dial out, returning the signals necessary to keep the communications program satisfied. At the answering end, the other DataPort modem pretends to answer the call, also providing any necessary signals to the software. Even though you have been talking on the line the whole time, the two software packages think they have established a connection on an idle line.

In cases where you have established the data call first, you simply pick up a phone at one end to talk. This causes the DataPort 2001 modem on the other end to make ringing sounds, prompting the other person to pick up the phone. The modems maintain the data connection while you talk. The DataPort 2001's ability to make both voice and data connections will work transparently with most software and on any computing platform. I tried it with PCs, Macs, and a dedicated Canon word processor, with no problems.

The only catch is that you can't send data at 14.4 Kbps and talk at the same time. Data transfers at 14.4 Kbps require most of the available bandwidth on a standard telephone line. Adding a simultaneous voice channel eats into that bandwidth, so when a full-duplex voice channel is active, the maximum data rate drops to 4800 bps.

In some situations, you don't need a full-duplex phone connection. If, for example, you're using the DataPort to transmit a sales presentation to a remote site, the presenter will need to talk, but the person on the other end of the line will only be listening. If you want full 14.4-Kbps speed for a data transfer, you can disable voice transmission from your end with a hook flash (i.e., a quick press of your phone's hook switch). The other person can continue both to talk and to transmit data at full speed. You can reestablish your ability to talk with another hook flash.

The only problems you may encounter with combined voice and data communications are a little bit of echo in the voice



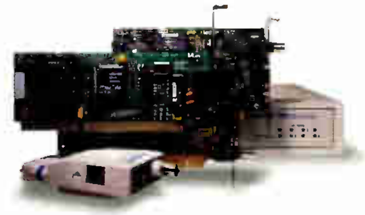
A version of DataBeam's FarSite, *a whiteboard application, comes bundled with AT&T's DataPort 2001 and complements the DataPort's voice/data capability. FarSite allows two computers to share a simulated whiteboard, transferring drawn graphics and pre-made slides over a modem connection.*

channel and configuring your application to talk to the modem. Like other high-speed modems, the DataPort 2001 can generate some unusual status messages that communications software may not understand without configuration.

AT&T bundles the DataPort 2001 with a version of DataBeam's FarSite for Windows, a typical electronic whiteboard program. In a nutshell, an electronic whiteboard connects two machines by modem, or two or more machines over a LAN. (The bundled FarSite doesn't provide LAN support.) Using the simple drawing tools provided, you can pen a flowchart, sketch a design on-screen, or annotate a preexisting image. The other participant in the "meeting" can see the drawing happen in real time and make additions, too.

FarSite tools consist of predrawn bit maps (called *slides*) and line, circle, rectangle, and text tools that work in many colors and sizes. Slides can come from just about anywhere, and the program supports a dozen different import formats, including PCX, TIFF, Windows or OS/2 BMP, EPS, and GIF. Either end of the connection can load a slide, grab an annotation tool, and point out salient features.

You can, for example, create a graph in Excel, grab the screen, paste it into a slide, and then save it as part of a FarSite slide tray. Later, when you establish the connection to another FarSite machine, a click or two on the mouse transmits the slide across the connection. You can then draw a circle around an important data point, or



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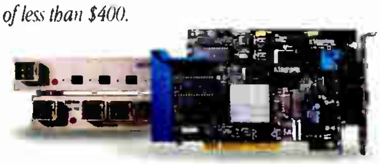

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Whiteboarding with Software

One point that confuses many people is the difference between whiteboard software (e.g., DataBeam's FarSite) and remote-control software. The difference is that, while remote-control software literally lets one machine act like a local mouse, keyboard, and screen for a remote computer, most whiteboard software simply transmits images to the remote site. (Fujitsu's DeskTop Conferencing is an exception; it can do both.)

With remote-control software, you can not only see the Excel chart at the remote site, for example, but also enter new data into cells or generate a new chart on the remote PC. If that same chart is displayed in a whiteboard package, someone had to capture the Excel screen and paste it into a predefined slide. You can see what the Excel chart looks like, but it's simply a static image that you can annotate with text or simple graphics symbols. The advantages whiteboarding software has over remote control are that you can prepare a presentation of slides or screen shots beforehand, and showing images is faster than actually going through a program to illustrate a point.

Whiteboard software usually incorporates special tools for annotating images that remote-control software doesn't. You may find tools like lines, circles, rectangles, paintbrushes, and text that you can use freely on the image. Crosswise's Face to Face, which works in both Mac and Windows environments, provides document layers that act as transparent overlays so that annotations from different people can be kept separate.

Most whiteboard software connects one site to one other through a pair of modems; many also support more than two participants through a LAN configuration. I didn't look at it here, but WorldLinx's VIS-A-VIS whiteboard package can support more than two participants if you have a multiport serial card, giving you the benefits of a LAN connection without the LAN.

indicate it with the pointer tool. Coupled with the simultaneous voice capability of the DataPort 2001, FarSite is a very effective application.

Drawing to a Close

Microfield's SoftBoard is a sophisticated input device that lets you make presentations to large groups or brainstorm ideas and then print them out, play them back, or send them electronically to colleagues who can't physically attend a meeting. I find a whiteboard pen to be an incredibly empowering drawing device, letting me think much better than I can when trying to sketch with a mouse.

Using whiteboard software is an effective way to teleconference without wasting the bandwidth (and expense) of a video connection. Two sites can effectively develop ideas cooperatively on an inexpensive voice-grade phone line. AT&T's DataPort 2001 allows you to establish this connection between any two asynchronous computers, regardless of platform, without sacrificing voice communication or using two phone connections.

With the combination of the SoftBoard and a voice/data modem like AT&T's DataPort 2001, you can connect your remote offices to in-house meetings with no more trouble than simply calling from a speakerphone. ■

About the Products

DataPort 2001 .... $535
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SoftBoard $2995
(includes SBRECORD and SBVIEW software;
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Howard Eglowstein is a BYTE testing editor. You can reach him through the Internet or on BIX at heglowstein@bix.com.

Multiprotocol Print Server

Axis Communications' NPS 550 Ethernet print server adds multiprotocol smarts to any printer

BEN SMITH

Today's multicultural networks make sharing peripherals complicated. With various PCs, Macs, and Unix boxes linked through the same cable, a shared printer must understand several LAN protocols in addition to juggling print jobs. Many modern printers understand multiple protocols, though at some extra cost, through their built-in standard or optional network connections.

A more effective and flexible way to make printers available to all systems on a network can be an external multiprotocol print server. These small boxes attach several printers directly to a network, interpreting various LAN protocols and managing job flow. A good one like the Axis NPS 550 Ethernet print server ($695) can also simplify administration.

While a print server can turn older printers into network printers, it can also be a better buy than a new network printer. That's because printers become technologically obsolete long before print servers do. If you pay more for a multiprotocol network printer, you throw away that extra investment when you replace the printer.

You can move plug-in print-server cards from one printer to another, but only as long as you stick to one printer family. A card designed for a Hewlett-Packard LaserJet II, for example, will not work in a QMS printer. An external print server works with almost any printer and can attach more than one printer to a network.

There are more than just financial advantages to going with an external print server. You get a dedicated processor that can manage print jobs coming from multiple sources and provide higher throughput. With the NPS 550, you also get Axis Communications' *virtual printer* technology, which vastly simplifies the problems of providing different printer configurations for different users.

The NPS 550 provides eight virtual printers, each of which is a custom printer configuration that you can select by name. You can, for example, set one virtual printer to use the letterhead tray and another to use the plain-paper tray. To the network user, the virtual printers appear as separate printers, whereas they may actually be the same physical device but with different print-control values.

Axis's automatic ASCII-to-PostScript conversion lets you print ASCII files on PostScript printers. The NPS 550 will detect ASCII files sent to any virtual printer set for this feature and wrap them with PostScript code.

You can connect the NPS 550 Ethernet print server to either thin Ethernet (10Base-2) or twisted-pair Ethernet (10Base-T). The NPS 550 automatically and simultaneously handles TCP/IP, Novell NetWare, Apple EtherTalk, and NetBEUI, and it interfaces with Unix (BSD, System V, and AIX), IBM MCS, MS-DOS, Microsoft Windows, Novell Portable NetWare, and Apple Mac OS. (The unit I tested did not support NetBEUI; the current product does.) Axis also sells the NPS 530, a pocket print server that supports Novell NetWare and NetBEUI for $399, and these plus TCP/IP and Apple EtherTalk for $599. The NPS 650 is a multiprotocol Token Ring print server that supports Novell NetWare and NetBEUI for $795, and also TCP/IP for $995.

With the NPS 550's two Centronics parallel ports and one nine-pin RS-232 serial port, you can simultaneously drive three printers. I tested the NPS 550 with a Dataproducts LZR 965 PostScript printer attached to one parallel port; the capability to wrap PostScript around plain text was invaluable. I hooked an HP LaserJet 4L, a PCL-controlled printer, to the second port.

The parallel ports are rated at above 100 KBps (with burst rates as high as 250 KBps)—more than fast enough to handle two HP LaserJet 4Si MX 600-dpi printers. You can set serial-port transmission as high as 38.4 Kbps and select either XON/XOFF (software) or RTS/CTS (hardware) handshaking. As serial printers are almost an extinct species, you'd typically use the serial port to connect to a plotter or specialized display that uses only serial communications. The serial port is on the front of the 8- by 5- by 2-inch NPS 550.

The front panel has four status LEDs to indicate power, network activity, printer activity, and print-server status. Also on the front is a test button. In addition to printing out a simple test page with some basic statistics and operating instructions, you can use the button to print out the entire set of more than 150 parameter settings, plus the 17-page set of installation and integration instructions that reside in ROM—a truly nice feature. Those little network peripherals manuals always seem to be somewhere else when you need them.

With one serial port *on the front and two parallel ports on the back, the Axis NPS 550 can connect three printers to a 10Base-2 or 10Base-T Ethernet LAN.*

Evaluating the NPS 550

I found the NPS 550 easy to install and use in the NetWare, Apple EtherTalk, and most Unix TCP/IP environments. With NetWare 3.11, I only had to run PCONSOLE to add a print server (the name must include the Axis serial number) and then assign the print server to a NetWare print queue. I had some difficulty making the second port available through NetWare. (The relationships between NetWare print servers, print queues, print jobs, and the utilities to configure them weren't very clear to this Unix-minded reviewer.)

The Mac installation was easy. When I powered up the NPS 550, it advertised its existence to Apple EtherTalk clients. Mac users on the network just needed to select one of the Axis virtual printers from their Chooser menus.

continued

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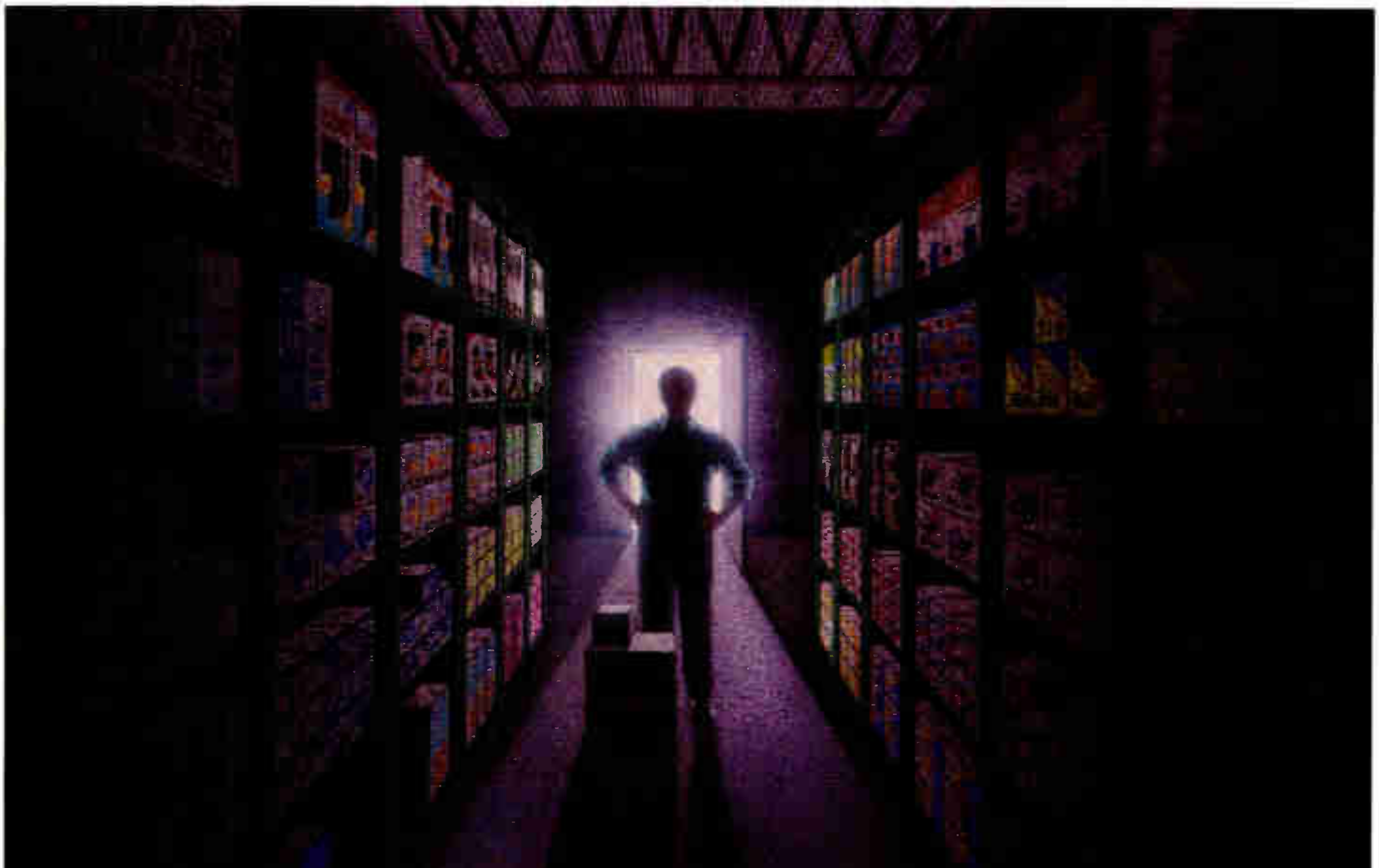

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Reviews Multiprotocol Print Server

The only complex installation was for the Unix systems. Some of the complexity arose from the fact that Axis provides several different Unix print-spooler interfaces for both System V spoolers and BSD spoolers. Once you use ARP (address resolution protocol) to assign an IP address and name to the print server, you must then decide which program the Unix print spooler will use to communicate with the printer: FTP (a simple copy without any error logging), a named-pipe daemon, or an Axis-written interface to the printer that sends error messages to the user as E-mail. Systems with BSD's `printcap`-based print spooler also have the last option.

The source code and installation instructions for all these methods exist in the print server's ROM. You copy the instructions to each of your print-spooler hosts using `ftp`. The named-pipe daemon, however, requires a compiler for installation on your system. (Even without a Unix print spooler, you can still print by copying your file to the printer with `ftp`. This is also a way of testing the basic setup.)

You can manage the Axis server from any system that has an `ftp` utility—even a Macintosh, if you have FTP for your Mac. You can also use menu-based DOS and Windows interfaces provided by Axis, or you can go with an SNMP interface program. The FTP method consists of downloading a configuration file, editing it, and then uploading it to the print server—a method very much in the Unix tradition. Axis has cleverly written the print server's FTP daemon to give you informative error messages when you send improper configuration settings to the print server.

I found the on-line instructions and the 50-page user's manual clear and comprehensive. For an extra $30, you can get an optional technical-reference manual, an excellent work of documentation that not only tells you what to do but provides some of the theory of why you do it and how the system works. This manual is necessary to fully appreciate the value of the print server, and I think Axis should package it free with the hardware.

About the Product

NPS 550 Ethernet print server..........$695
Axis Communications, Inc.
99 Rosewood Dr., Suite 170
Danvers, MA 01923
(800) 444-2947
(508) 777-7957
fax: (508) 777-9905
Circle 1085 on Inquiry Card.

Operating Parameters

Sitting on a shelf with a few cables plugged in and its LEDs flashing, the NPS 550 seems an unpretentious little box. When, as a network user, you access a printer attached to the NPS 550, you won't even know the print server exists; its operation is so transparent as to be invisible. When you access the NPS 550's configuration information as a network administrator, however, you will be duly impressed.

From top to bottom of each protocol stack, the NPS 550 is an example of fine engineering and attention to detail. The more than 150 operating parameters that you can modify are a clear symbol of its design quality. For example, you can set the Centronics parallel-port interface timing to three settings: slow (25 KBps), for older printers that don't support standard Centronics timing; standard (the default), up to 90 KBps; and fast (up to 125 KBps), for printers like the HP LaserJet 4Si MX.

You can also specify an action when a job arrives for a printer that's already busy; for example, have a secondary printer handle the job. There are parameters that hold the logical printer names that will be advertised on Macintosh printer Chooser lists. Also, there are parameters that you can use to optionally map NetWare print queues to logical printers within the NPS 550 rather than on the NetWare server.

The largest collection of parameters is dedicated to defining each virtual printer. They define the physical printer that a virtual printer represents, the control strings sent to the printer before and after a print job, string and byte substitutions for the incoming data string, whether to enable text-to-PostScript conversion, actions taken when a virtual printer gets a Printer Busy signal from the physical device, and even a flag for a hex dump mode.

Other parameters describe the PostScript that is wrapped around text when that feature is enabled: character font and size, page size and orientation, margins, and line spacing. A virtual printer can even map one of seven 7-bit ASCII character sets (ISO 8859-2, UK English, German, French, Norwegian/Danish, Swedish, and DEC) to the 8-bit IBM PC Set 2.

Not only is the NPS 550 an efficient way to connect printers to Ethernet, it is also a versatile "black box" that you can put between your applications and your printer. As such, the NPS 550 print server is a valuable addition to any Ethernet LAN that needs shared printers. ■

Ben Smith is a testing editor for the BYTE Lab. You can reach him on the Internet at ben@bytepb .byte.com or on BIX as "bensmith."

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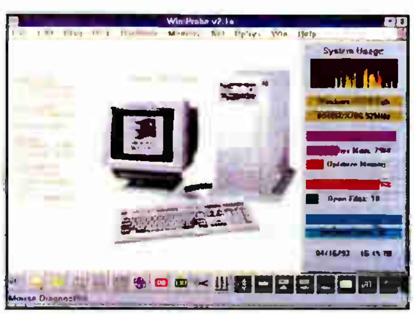

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Easier Ethernet

Tut Systems' Silver Streak adapter delivers 10 Mbps on plain telephone wire and makes it easier to build small Ethernet LANs

BARRY NANCE

When you are designing a small LAN, ease of installation can be as important as reliability and affordability. Tut Systems' new Silver Streak Ethernet connector promises all three traits by making plain telephone wire (also called *silver satin*) an Ethernet cabling possibility. Where you might once have installed thin Ethernet (or *thinnet*) cable, you can now string silver satin instead and get full 10-Mbps packet transmission.

Typically, you choose a LAN type based on the topology that fits the size and layout of your business and then balance reliability characteristics and cost to further choose cable type (see the text box "Ethernet Cabling Methods"). For small LANs (20 nodes or fewer), a daisy-chain or bus topology is often the best solution, and that has meant using thinnet cable—a high-quality, moderately expensive cable that is difficult to install in tight spaces.

Tut Systems' Silver Streak is a $99 Ethernet connector that borrows technology from the analog world of telephone lines to make digital LAN communications possible over plain, inexpensive, easy-to-install telephone wire. Plain telephone wire lacks the minimum number of noise-reducing twists per foot that is a characteristic of data-grade UTP (unshielded twisted pair) cable. No LAN installer would ever recommend using silver satin to create a LAN—until now.

A network that uses Silver Streak units has size and distance limitations that are similar to those of a thinnet-based LAN. The Silver Streak LAN can have up to 30 Ethernet connections per segment, a minimum distance between nodes of 7 feet, and a maximum cable length of 600 feet per segment (see the table on page 186). A Silver Streak network also uses the same topology as a thinnet LAN: a simple bus or daisy chain.

Silver Streak's Secret

Silver Streak is a small (approximately 2 by 3 by ½ inches) box containing a printed circuit board. The box has a 15-pin connector at one end to connect to the AUI (attachment unit interface) connector found on many Ethernet cards, and two RJ-11 jacks at the other end that attach the silver satin. The box's electronics filter noise from the data signals and match the impedance of the phone cabling to the AUI connector. (An AAUI, or Apple AUI, version for Macs also costs $99.)

Plug Tut Systems' $99 Silver Streak adapter onto your Ethernet card, and you can string inexpensive, easy-to-install silver-satin phone cord instead of thin Ethernet. Silver Streak allows full 10-Mbps Ethernet speed over the UTP phone cord.

With each Silver Streak unit you get good documentation, 20 feet of silver-satin cable with RJ-11 connectors at either end, a terminator, and an in-line phone-cord coupler for extending the network. You use telephone-wire terminators on Silver Streak LANs in the same way that you would use coaxial-cable terminators at the opposite ends of a thinnet LAN. Silver Streak has LEDs that flash to indicate when the unit is working and when collisions take place on the network.

Silver Streak incorporates a specially designed, patented balun. A *balun* is an impedance-matching transformer, most often used to connect coaxial cable to twisted-pair wiring. It converts the impedance of one type of wire to that of another type of wire to prevent unwanted signal reflections. (The characteristic impedance of a cable is the total opposition to AC current flow that a wire would have if it were infinitely long.) Baluns are commonly used with IBM 3270 terminals, for example, to connect to a host computer through twisted-pair cable instead of the usual coaxial cable.

Tut Systems' balun also provides extremely effective signal filtering, which is what allows Silver Streak to get 10-Mbps throughput over silver satin. The manufacturer claims that Silver Streak reduces interference by over 80 dB (decibels), for a ratio of 10,000 to 1, without attenuating the differential mode signal of the data transmission itself.

Performance and Price

I took a multiplatform approach to testing Tut Systems' new cabling technology. I installed four Silver Streak units on four workstations and ran a variety of network software products. In each case, I attached a Silver Streak to the AUI port of the workstation's Ethernet network adapter. I used adapters from Intel (the EtherExpress), Standard Microsystems (the EtherCard Plus Elite 16), and Asante Technologies (the EN/SC Ethernet connector for Macintosh PowerBooks).

In separate tests, I used Novell NetWare, Microsoft Windows for Workgroups, Artisoft LANtastic, and IBM LAN Server to provide the network file- and printer-sharing services. I bought the telephone wire used in the tests from a local hardware store.

In all cases, the Silver Streak units allowed LAN packets to flow normally over ordinary silver-satin phone cord. The Silver Streak technology created network connectivity through a type of wire that for an ordinary Ethernet setup might as well be rope or string.

In researching cable pricing, however, I was surprised to discover that there really isn't a big price advantage in buying silver-satin telephone cord over thinnet cable. A few phone calls to local suppliers of

Ethernet Cabling Methods

Most Ethernet cabling systems use unshielded twisted pair (UTP) or coaxial cable (thin or thick) to carry LAN packets. Twisted pair is just what its name implies—four wires twisted in two pairs. Twisted pair is used in a star topology for 10Base-T Ethernet networks. UTP runs from each node on a network segment to a hub, which may then connect with other parts of the network through a backbone or stacking hub arrangement.

Twisting the wires reduces electrical interference. *Shielding* refers to the amount of insulation around the wire and, thus, its noise immunity. Underwriters Laboratories certifies UTP cable as category 1 (voice grade; also called silver satin), category 3 (data grade), or category 5 (high-speed data grade). A 10Base-T network requires category 3, while category 5 is being used with new 100-Mbps Ethernet systems.

The STP (shielded twisted pair) used in some Token Ring networks looks somewhat like the wire used to carry house current (110 V) throughout your home. STP actually carries a relatively low voltage signal, however, and the heavy insulation is for noise reduction, not safety.

Though more expensive than twisted pair, coaxial cable has more advantages. Thick coaxial cable lets you run greater distances and attach more nodes, because it's less prone to signal interference and attenuation. (For these reasons, coaxial cable is also used for cable TV hookups.) Thin coaxial cable lets you daisy chain. Sections of Ethernet networks using coaxial cable employ a linear bus topology.

Standard Ethernet coaxial, or *thicknet*, cable has a greater degree of noise immunity and is more difficult to damage, but it requires a combination of vampire tap (a piercing connector) and a drop cable to connect to a LAN. The newer thinnet cable is somewhat thinner than thicknet. Although thinnet doesn't carry signals over as long a distance as thick cable, thin Ethernet cable uses a simple BNC connector (a bayonet-locking connector for thin coaxial cables), costs less, and has become a standard for small- to medium-size Ethernet LANs.

In an Ethernet network, the number of connections (or *taps*) and their intervening distances can be limiting factors for a particular cable type. For thicknet, you can use repeaters to regenerate the signal every 500 meters or so. Without repeaters in a long network, standing waves (i.e., additive signal reflections) distort the signal and cause errors. Detection of collisions (i.e., two network adapters trying to transmit at the same time) depends partly on timing; only five 500-meter segments and four repeaters can be placed in series before the signal propagation delay becomes longer than the maximum time period allowed for detection of a collision. Without this limit, the workstations farthest from the sender would be unable to determine whether a collision had occurred.

cable and wire revealed that silver satin costs approximately $35 to $45 per thousand feet, while thinnet goes for $110 to $120 per thousand feet. Once you add in the cost of a $99 Silver Streak at each node, what you save on less expensive cable disappears. LAN cables just aren't that expensive.

If saving on cable price isn't one of Silver Streak's attractions, what is? According to Jeff Ellerbruch of Tut Systems, the company feels that people who are creating or upgrading a small network will like the convenience of being able to buy LAN cable from a hardware store rather than from a supplier of specialized cable and wire. Ellerbruch also said that Silver Streak allows people to take advantage of some existing telephone wiring systems and avoids the need to install a completely new cabling system. Note, however, that you cannot use Silver Streak units to piggyback Ethernet signals on top of an active telephone system. You also can't use data-grade UTP wire with Silver Streak. Only silver satin (category 1 UTP) will do.

One disadvantage of using Silver Streak units and phone cable for your LAN is that you won't be able to upgrade to one of the fast new 100-Mbps Ethernet standards, which require category 5 UTP. And you can't use cable testers from companies such as WaveTek, Fluke, and Microtest to troubleshoot your LAN (see the text box "Verifying Your LAN Cables"). These testing units expect to find themselves attached to data-grade wire and will flunk silver-satin wire.

NETWORK DISTANCE LIMITATIONS

Strung between Silver Streak adapters, silver-satin phone cord behaves most like thin Ethernet. Note the 7-foot minimum distance, however. (N/A = not applicable.)

NETWORK ADAPTER TYPE	CABLE TYPE	MAXIMUM (FEET)	MINIMUM (FEET)
Silver Streak	UTP (silver satin)	600	7
Ethernet	Thin	607	1.67
	Thick (drop cable)	164	8
	Thick (backbone)	1640	8
	UTP (10Base-T)	328	8
Token Ring	STP	328	8
	UTP	148	8
ARCnet (passive hub)	N/A	393	Depends on cable
ARCnet (active hub)	N/A	1988	Depends on cable

In addition to the limitations shown here, keep in mind that you can't connect more than 30 computers on a thin Ethernet segment, more than 100 computers on a thick Ethernet segment, more than 72 computers on UTP Token Ring, or more than 260 computers with STP Token Ring cable. (N/A = not applicable.)

continued

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Verifying Your LAN Cables

For reliability and speed, the LAN cables in your network must form an unbroken, noise-free link between workstations and file servers. Electrical noise or other line transmission problems can cause your LAN to fail or, more often, mysteriously and insidiously slow down. When you're wiring a new LAN, modifying an existing system, or troubleshooting poor performance, a cable tester is an indispensable tool.

A cable tester contains a TDR (Time Domain Reflectometer) and perhaps additional test circuits. A TDR works by sending radar-like pulses through the LAN cable. It detects pulse reflections, analyzes them, and displays its findings. A cable tester typically can tell you the length of a cable, whether the cable is correctly wired internally (i.e., pin-to-pin wire mapping), whether it contains a short circuit (i.e., wires touching each other through damaged or missing insulation), whether it contains a broken wire (or an *open*), and whether it suffers from electrical cross talk (i.e., interference between wires).

When noise blocks the data signal flowing through LAN cables, the network responds by retransmitting the data signal. If the noise happens infrequently, the network's retry mechanism will hide the problem and you won't even know it exists. If the noise happens with slight to moderate frequency, you'll scratch your head wondering why the network has slowed down; the retries keep the network from running at normal speed.

Two important criteria by which cable-testing hardware can judge the cable quality are *signal attenuation* and *impedance*. Attenuation is the decrease in a signal's strength over the length of a cable. A cable tester measures attenuation in decibels, with 0 dB signifying no signal loss. As an example of a typical value, the maximum attenuation allowed for 10Base-T UTP cabling is 11.5 dB.

Measurement of characteristic impedance, measured in ohms, is more important for coaxial cables than for twisted pair. The thickness (i.e., gauge) of the copper conductors, the distance between the conductors, and the properties of the insulation (i.e., the dialectric material) in the cable all influence impedance. The characteristic impedance of both thick and thin Ethernet cable is 50 ohms; ARCnet cable has a characteristic impedance of 93 ohms.

The method that a cable tester uses to detect discontinuities within a cable relies indirectly on cable impedance. A change in the characteristic impedance of a wire somewhere along its length causes reflections inside the cable. Broken wires, short circuits, and mixed wire types cause such unwanted signal reflections because they create impedance boundaries. By measuring signal reflections, a TDR locates discontinuities.

Cross talk is electrical interference between wire pairs in twisted-pair cable. *Near-end* cross talk (abbreviated NEXT) is the interference that occurs in the cable adjacent to a connector at either end. The tester measures NEXT by transmitting a signal through one wire pair and detecting the resulting spillover of current into the other wire pair.

Short circuits and open connections can occur months or years after installation, especially if cheap insulation dries out, becomes brittle, and cracks. Similarly, a water-soaked cable won't carry LAN traffic very well. Sometimes during installation a person will pull a wire around a corner and part of the insulation will scrape off (this is a *shiner*). The cable problem may not manifest itself until months later when it causes a network outage.

Some wiring problems happen during cable manufacture or during connection. Once in a great while, the factory or the installer will put connectors on the cable with the wrong wire leading to the wrong pin, and the new cable won't work at all. Or the person may mix up the wire pairs by attaching connectors in a way that causes one of the wires to carry a signal that the other wire pair should carry (a condition known as *reversed pairs*).

Even with perfectly manufactured, carefully connected wire, you can still cause cable-related problems if you overlook the published limitations of the wiring specification in your planning of a network installation or enhancement. The result can be a LAN segment with cables that are too long or that have too many nodes in a segment. It's easy to overlook distance and number-of-nodes limitations when you're concentrating on giving people access to the network.

You should use a cable tester to check the installation of new LAN cables. When you build a new LAN or add a new cable segment to an existing LAN, you'll want to know that the new wires can carry noise-free LAN signals before you try to log on to a file server. If you have a contractor install and maintain your LAN wiring, insist that the contractor perform cable tests during the installation. If you install your own wiring, use a cable tester to check your work.

For Convenience's Sake

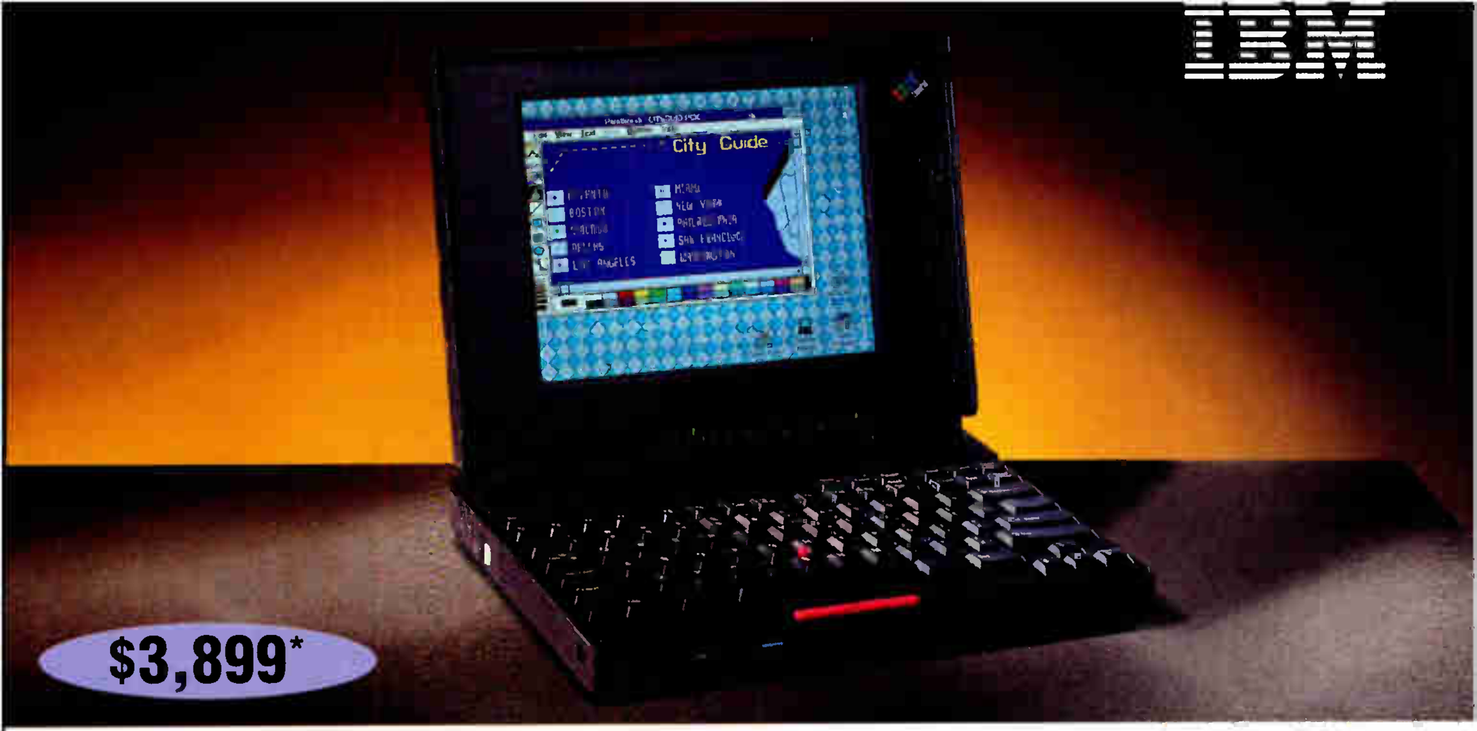
Silver Streak units provide convenience, allowing you to use existing telephone wire that you're currently not using. Or, if you are building a small Ethernet LAN, you get the simplicity of buying plain telephone wire from a local hardware store, phone store, or retail electronics outlet. Thin and flexible, silver satin is also easy to string.

Because of its daisy-chain topology, Silver Streak is suitable for small LANs only; as with thinnet, cable breaks can bring down the network. More important, you can't troubleshoot a Silver Streak setup with standard cable testers, nor can you upgrade to faster Ethernet. ■

About the Product

Silver Streak Ethernet connector $99
Tut Systems
2446 Estand Way
Pleasant Hill, CA 94523
(510) 682-6510
fax: (510) 682-4125
Circle 1077 on Inquiry Card.

Barry Nance is a BYTE contributing editor and has been a programmer for the last 20 years. He is the author of Using OS/2 2.1 *(Que, 1993),* Introduction to Networking *(Que, 1992), and* Network Programming in C *(Que, 1990). Barry is also the Exchange Editor for the IBM Exchange on BIX. You can reach him on the Internet or on BIX at barryn@bix.com.*



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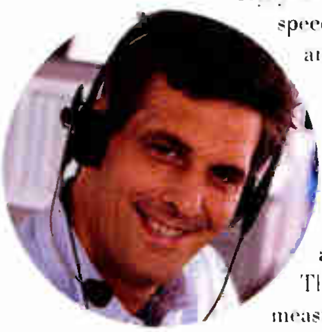

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Multimedia Presentations

Time-line-based presentation software spices up a traditional electronic slide show

SHELLEY CRYAN

Multimedia. It's the buzzword of the nineties. With cheaper, faster computers widely available, people who give presentations are often looking to incorporate the latest flashy elements into their shows: movies, sounds, and animations.

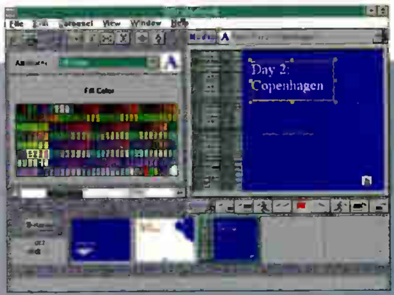
These elements can, of course, be used in top traditional slide-presentation programs. Programs such as Aldus Persuasion and Microsoft PowerPoint let you show slide presentations on your computer screen, complete with fancy slide transitions and some or all of these multimedia elements. There is a glitzier alternative, however.

I look here at programs that offer the added element of time. That is, they allow you not only to select a wide range of media formats to incorporate into your presentation, but also to define exactly when all this activity will occur. Picture this: The introductory scene of a presentation shows a title sliding into place; then colorful ellipses bounce around and reshape until they land behind the title. A sound track plays in the background throughout the scene, muted when an electronic narrator reads the title just as it appears on-screen. The final action shows a corporate logo rolling into place in the bottom left corner, and then the presentation date fades into the lower right corner. The scene ends by dissolving, bit by bit, into the next scene.

That's multimedia presentation, as executed by the programs in this roundup: Super Show and Tell from Ask Me Multimedia Center (Windows), Q/Media for Windows from Q/Media Software, Vividus's Cinemation (Mac), Macromedia's Action (Windows and Mac), and Gold Disk's Astound (Windows and Mac). I've limited the selection to programs aimed at the general business presenter rather than the multimedia jockey, so I've left out analyses of the more complex and pricier programs, such as Macromedia Director and Passport Producer Pro.

Breaking with Tradition

With the added factor of time, multimedia presentation programs give you more to

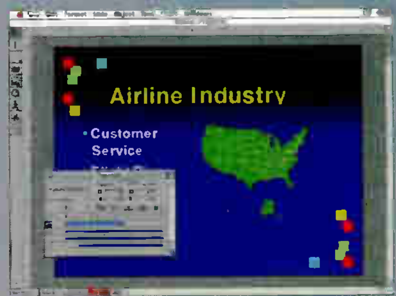


Super Show and Tell is anchored by a unique, streamlined interface. SST packs everything into a single window: scene preview (which shows the scene you're working on), navigation controls, media editors, and thumbnail sketches of other scenes in the presentation. If you're looking for a capable, basic multimedia presentation tool with a short learning curve, you'll be happy with SST.

Like most of the programs in this category, Q/Media for Windows is based on the familiar slide metaphor. Each slide is a scene that can be filled with sound, movies, graphics, and text. At $99, Q/Media is the least expensive program of the bunch. It lacks animation tools and interactivity, but it's rich in transition effects, import formats, time management, and fine control over presentation elements.

Vividus's Cinemation takes an entirely different approach to multimedia presentations. Instead of working with slides or scenes, you work with frames in a filmstrip. The biggest drawback: It's harder to set action durations, since you're dealing with frame quantities rather than the more familiar time quantities. The benefit: easier, better animation. In all, Cinemation is a powerful tool with an unconventional yet effective approach.

Macromedia's Action offers a slew of conveniences to streamline production. Templates, a content list, and a scene sorter all help you create your presentation painlessly. With a bar-style time line, standard interactivity controls, and a collection of animation options, Action packs all the major features of a multimedia presentation program into a solid performer.



Gold Disk's Astound not only offers the requisite multimedia presentation features but also includes features found only in top traditional presentation packages. This makes learning the program a snap for anyone who's familiar with traditional presentation programs. Astound pulls all this together into a slick, well-designed program.

juggle than you would have in a traditional slide-making program. But the payoff for some extra complexity can be substantial: With multimedia presentation programs, you've got more control over your show, so you can create stunning, memorable presentations.

Most multimedia programs also let you create simple animations, so you can show graphical elements flying around your screen along a path you define. All but one in this group (Q/Media) let you incorporate a bit of interactivity into your presentations, too. This is handy when you want to branch off into different topics at will during a presentation, where you press a button and the presentation jumps to a predefined slide. Other types of interactive controls let you play back movies and pause the presentation.

All this time-based activity, animation, and interactivity requires a computer's processing power during playback. This sharply diverges from the traditional slidemaking programs, which, besides running on a computer, can output to 35mm slides and overheads. You'll also give up the superior text-handling capabilities of the traditional slidemakers if you opt for a multimedia presentation program. Traditional slidemakers offer an outliner, which makes it easy to create lots of text-based slides and perform such functions as spelling checking and find-and-replace.

Of course, every rule has an exception, and Astound fills that role among multimedia presenters. It hedges its bets by providing features of both traditional and multimedia presenters.

With its all-in-one-window approach, *SST is a snap to learn. The scene preview is your main work area. You modify elements with SST's media editor. By selecting objects and clicking on the action button, you can add effects such as motion or dynamic changes to size, color, or font.*

But to get this combination, you're not limited to Astound. Many of the multimedia presenters let you import static slide presentations, so you can use the features of both types of program. It's often not as convenient as Astound's all-in-one approach, but it can be a valuable option. If you've already created several traditional slide presentations that you now want to jazz up, or if you depend on particular features of a favorite program, you won't have to give those up.

The Feature Mix

Which features are most important? Ease of use is a key issue. To maximize the creative and persuasive impact of your work, you must be able to focus on content rather than production. Conveniences like templates and master pages, which streamline formatting by acting as overall design guides, are vital.

Also critical are support for a variety of import formats, interactive controls, animation capabilities, and a decent scheme for managing time-based events. For polished presentations, look for a good selection of transition effects. You'll also want at least basic tools for creating and editing various types of media, such as drawing tools, rudimentary sound editors, and graph generators. Don't expect full-blown features in this area; for a full set of such tools, you can turn to a dedicated third-party program like Adobe Illustrator or DeltaPoint's DeltaGraph Pro. But it saves time and memory to have a few basics in your presentation program.

All the programs discussed here include a free run-time player that lets others view your presentation if they don't have the source application. But because you can't be sure that everyone has the proper hardware and software drivers to run a multimedia program accurately, wide distribution is still tricky. It's critical to have the option, however, and each of these programs passed this test.

The write-ups that follow focus on the criteria I've discussed, with special emphasis on each program's approach. For a quick comparison of capabilities, check out the features table on page 194.

Super Show and Tell

Super Show and Tell, by Ask Me Multimedia Center, targets the true computer neophyte and defines one end of the ease-of-use spectrum. To achieve this distinction, SST has cut out a lot of the features and flexibility that you can find in other programs. You may outgrow it or be disappointed if you plan to create presentations frequently. Yet fewer features means less to learn, so if you're looking for a capable, basic multimedia presentation tool and a short learning curve, you'll be happy with SST.

SST is anchored by a unique, streamlined interface. Unlike the other programs, SST packs everything into a single window: scene preview (which shows the scene you're working on), navigation controls, media editors, and thumbnail sketches of other scenes in the presentation. This all-in-one approach makes it easy to find what you're looking for, and it's instantly obvious if a feature isn't available.

For real out-of-the-box productivity, templates would quickly give scenes a consistent look. Unfortunately, however, SST doesn't support templates or master slides. You'll need to create each scene from scratch.

To create a scene, you select the background in the preview scene area and turn to the media editor to apply a few overall attributes. Gradient or patterned backgrounds aren't an option; you're limited to a single-color background, or you can place an image in the center. You can "tile" the background image to create a wallpaper effect.

To add a background sound track, you use the media editor again. SST supports WAV and MIDI files, but the package doesn't include much clip media (e.g., sound, graphics, and movies). The alternative is to use third-party sources.

Adding objects that come and go over

SST Features

By the time you read this, version 1.1 of Super Show and Tell will be available. According to Ask Me Multimedia Center, new functionality will include the following:

- **Enhanced branching: Jump to a specific slide position within another slide set.**
- **Bring Forward/Push Behind: Reposition media elements to appear behind or on top of other media elements.**
- **Show multiple AVI files on the same screen and control playing time.**
- **Additional file formats: WMF, CGM, Kodak Photo CD.**
- **25 new transitional effects.**
- **Print handouts.**

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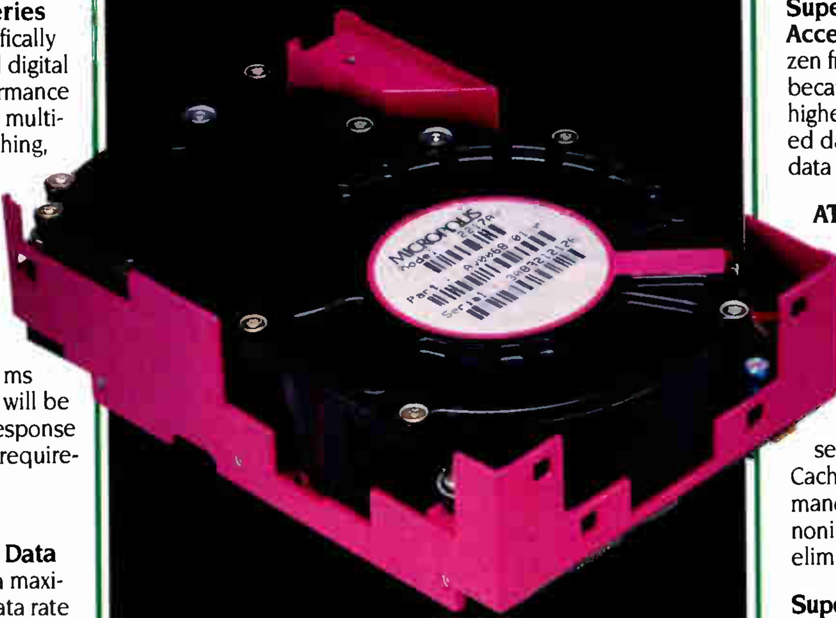

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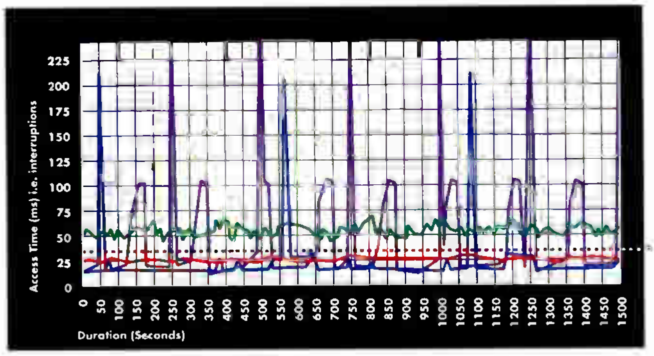

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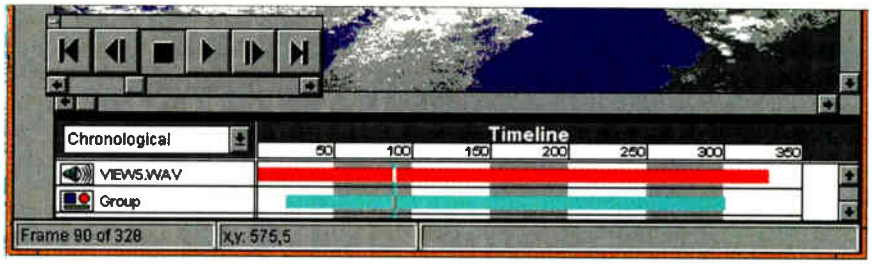
time is straightforward. You click on the media button to add text, imported images, sound, and movies. You select the draw option under the media button to create your own objects with SST's rudimentary drawing capabilities (you are limited to lines, rectangles, and ellipses). Again, you use the media editor to apply attributes like text formatting and colors. Any object can become an interactive button, jumping the presentation to a specified slide or calling up and running another SST presentation.

With your objects set, it's time to add action, such as motion, or dynamic changes to size, color, or font. This, too, is simple. Select the object, click on the action button, and make the appropriate modifications. To show text moving in from off-screen, for example, you first drag the text block beyond the bottom left corner of the preview screen. With the block still selected, you click on the action button and select move. Finally, you drag the text block to where you want it to end up, and SST fills in the in-between motion.

You can specify how long it takes to complete the move or any other action, and you can specify when such activities will occur. Yet the way SST manages and synchronizes time-based events is probably the one area where the attempt at simplification doesn't make things easier. There's no bar-style time line. Instead, there's a playlist, which lists actions in a scene in the order in which they occur, along with the amount of time the activity will take. Under this structure, it takes more than a glance to see exactly what is supposed to happen, and it's difficult to figure out how to change the timing of events.



Despite its low price, *Q/Media offers excellent control for managing time-based events. Although Q/Media's bar-style time line is not as flexible as Action's time line, it still provides a convenient way to stage the coming and going of disparate media elements. VCR-like controls help you navigate through a presentation.*

Q/Media for Windows

At $99, Q/Media is the least expensive program of the bunch. But instead of offering limited capabilities like SST, Q/Media focuses on a few areas and fully implements these targeted functions.

Q/Media lacks animation tools and interactivity. Without interactive capabilities, you can't branch to different topics in a presentation. However, Q/Media is rich in transition effects, import formats, time management, and fine control over presentation elements. It rivals its higher-priced competition in many of these areas.

Like most of the programs in this category, Q/Media is based on the familiar slide metaphor. Each slide is a scene that can be filled with sound, movies, graphics, and text. You start by defining the slide/scene size, background, and so forth. To do this, you click on the scene info button on the handy toolbar. Unfortunately, it can take a long time for the dialog box to appear; with my 33-MHz 386 PC, sluggishness cropped up fairly often.

Q/Media offers an impressive array of scene-format options. You can set a custom stage size for each scene, as well as fix its position on the computer screen. Scene background options include patterns, wallpaper, full-screen graphic, and gradient. Q/Media even allows you to customize how the rest of the screen will look if a presentation doesn't fill it entirely. There are 19 different slide transition effects to choose among.

This plethora of choices extends to adding transitional elements—sound, images, text, or movies—to the scene as well. You can set any color in bit maps to be transparent, and you can set up third-party editors to launch automatically from within Q/Media when you double-click on an object.

With no animation tools, you need to rely on Q/Media's object transition effects to add the feeling of movement. These object transition effects are the same as the slide transition effects. So, for example, text could appear on-screen from behind thin venetian blinds.

Time-based events are managed with Q/Media's bar-style time line. Although it is not as flexible as Action's time line, it still provides a convenient way to stage the coming and going of disparate media elements.

Q/Media has announced a CD-ROM version. For $149, you get Q/Media 1.2 for Windows along with a 500-MB clip-media library.

Cinemation

Cinemation, by Vividus, takes an entirely different approach to multimedia presentations. Instead of working with slides or scenes, you work with frames in a filmstrip. This distinction is striking. With a filmstrip, you see every step of every movement. If a graphic bounces across the screen, pauses, and bounces back the other way, it may span 100 frames, each one successively showing the graphic a little further along its path.

This filmstrip approach is certainly different, but it's fairly easy to work with. The biggest drawback is that it's harder to set action durations, since you're dealing with frame quantities rather than the more familiar time quantities. The benefit is that you get easier, better animation.

Imagine a presentation scene that shows a movie, followed by four text boxes slid-

Cinemation treats presentations *as a series of frames in a filmstrip, so you see every step of every movement. You can navigate through your presentation by clicking on frames in the filmstrip window.*

ing into view accompanied by sound effects. When a viewer clicks on any one of the text boxes, the presentation branches to the corresponding topic. Cinemation lets you create a relatively complex slide like this.

First, you open a design template, complete with background gradient and text and graphics placeholders. Then you add text and graphics where the placeholders are and adjust their placement. Next, you import the movie and place it next to the bullet points. Cinemation automatically adds frames to the presentation filmstrip to accommodate the movie's animation. Testing playback is simple using the VCR-like controls.

Cinemation really shines when defining motion. It offers four alternatives: You can apply an AutoMotion template, which attaches predefined movements to objects in your frame; you can define a beginning and an end position and ask Cinemation to fill in the motion between them; you can draw animations frame by frame; or you can drag objects around and record the activity.

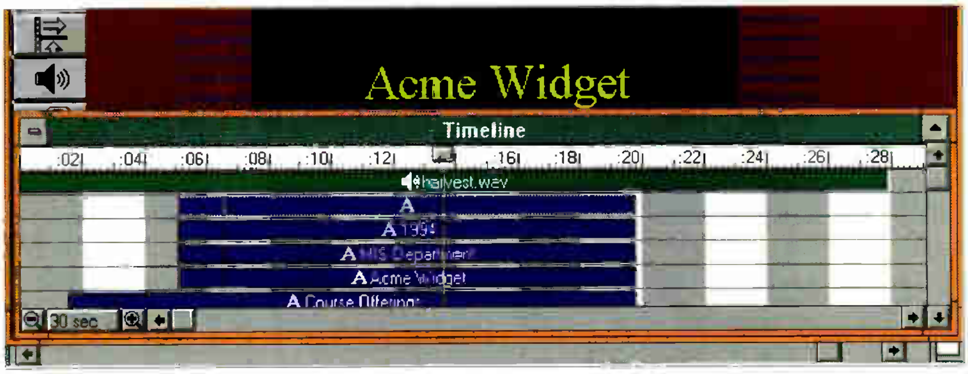
If you choose to drag-and-record, Cinemation automatically adds frames to accommodate each object's movements and automatically loops the QuickTime movie so it will continue to play while the bullets, markers, and text are moving into place. It also automatically copies all the graphical objects to any new frames that it creates.

Adding sound is easy, too. You select the frame during which a sound should play, click on the sound tool, and then select a sound file from the dialog box that pops up. Cinemation supplies an ample collection of sample sounds.

Cinemation's interactive controls include the basics: You can define buttons that, when pressed, jump the presentation to a specified frame in the filmstrip or jump to a different movie altogether. You can define a transition effect to occur when the scene changes. And you can set up pauses.

One of Cinemation's greatest capabilities is that it can import entire Aldus Persuasion and Microsoft PowerPoint files with a single command. Each slide in the presentation becomes a separate frame, to which you can add motion or interactive buttons.

In all, Cinemation is a powerful tool with an unconventional yet effective approach.



scene is represented by a bar. The longer the bar, the longer an object remains in the scene. As in other programs, you can move or resize the bars to alter an object's entry/exit time and duration.

Action

With a bar-style time line, standard interactivity controls, and a collection of animation options, Macromedia's Action packs all the major features of a multimedia presentation program into a solid performer. Action offers a slew of conveniences to streamline production. Templates, a content list, and a scene sorter all help you create your presentation rather painlessly. Action features excellent intuitive tools for manipulating and animating objects. One of the first multimedia presentation packages is still a sound choice.

Action's presentations are collections of scenes that structurally resemble slides. A collection of templates is provided, or you can create and save your own. And you can choose among gradients, patterns, and images for a custom background.

Action's media creators aren't as extensive as Astound's; in particular, Action lacks sound and movie editors. But its charting capabilities will save you from constant reliance on a third-party grapher. The charting features are available only in the Windows version, which is ahead of the Mac verson on several features.

The drawing tools are standard, as are the controls over interactivity. You set buttons to jump to a specified scene, replay the current scene, and pause.

As you'd expect given the program's name, Action's strong suit is its options for adding actions to objects such as text, graphics, and movies. You can apply transitions and motions to an object for when it enters or exits a scene and set custom durations for those actions. The large selection of transition effects includes ones that will reveal an object in a checkerboard pattern or from the outside in.

Action offers several options for object entry and exit motion. You can make the object swoop in from any side or corner of the scene, or you can define start and end placement and Action will fill in the movement. Action's Path Editor also lets you customize movement. You combine dragging and mouse-clicking to define straight path segments along which the object will move.

You can apply a third type of action—a light effect—to occur when an object isn't moving or in transition. A light effect such as a sparkle or shimmer can add interest to an object and, for example, help to highlight particular bulleted text.

Action's time management controls are centered around its bar-style time line, where each object in a scene is represented by a bar. The longer the bar, the longer an object remains in the scene. As in other programs, you can move or resize these bars to alter an object's entry/exit time and duration. VCR-like controls help you navigate through a presentation while editing. A particularly handy feature is the compressed-view option, which shows all the elements that will appear over time in

ACTION FEATURES

As this review went to press, Macromedia announced Action 3.0 for Windows. According to the company, some of the new features will include the following:

- **a new outliner**
- **text-formatting controls (e.g., ruler, tabs, and text alignment)**
- **a spelling checker**
- **OLE 2 support**
- **a larger selection of templates with motion and effects built in**
- **expanded format support, including QuickTime for Windows, Photo CD, and direct import of GIF, TIF, and PCX**

KEY FEATURES OF TIME-LINE-BASED PRESENTATION SOFTWARE

Multimedia presentation software should support a wide variety of media formats, including Video for Windows (AVI) and QuickTime on the Macintosh. Embedded media editors allow you to work on media elements without relying on other software. Templates and bundled clip media make it easier to assemble a multimedia presentation. N/A = Not available. (● = yes; ○ = no)

	ACTION 1.01.4/ MAC	ACTION 2.5.1/ WINDOWS	ASTOUND 1.01/ MAC	ASTOUND 1.5/ WINDOWS	CINEMATION 1.1	Q/MEDIA 1.2	SUPER SHOW AND TELL 1.0
Company	Macromedia	Macromedia	Gold Disk	Gold Disk	Vividus	Q/Media Software	Ask Me Multimedia Center
Retail price	$299	$299	$399	$399	$495	$99	$149.95
Platform(s)	Mac	Windows	Mac	Windows	Mac	Windows	Windows
Short take	Solid multimedia presentation program	More functionality than Mac product	Combines features of traditional and multimedia programs	Same functionality as Mac version, with enhancements (e.g., improved charting and interactivity)	Frame-based presentations; super animation tools	Good for linear presentations	Easy to use; limited
Requirements	Mac Classic II, System 6.x, 2 MB RAM (more with 7.x)	Windows 3.0, 386, 2 MB RAM	Mac Plus or better, System 6.0.8+, 2 MB RAM (more with 7.x)	Windows 3.1, 386, 4 MB RAM	Any Mac, System 6.07+, 2 MB RAM (more with 7.x)	Windows 3.1, 386, 4 MB RAM	Windows 3.1, 386SX, 2 MB RAM
Import formats							
Sound	AIFF, SoundEdit	WAV, MID, CD Audio	snd, SoundEdit, AIFF, SoundEdit Pro, AIFFc, Amiga IFF, WAV	WAV, MID, CD Audio	snd, SoundEdit	WAV, MID, CD Audio	WAV, MID
Images	PICT	BMP, DIB, WMF, convert utility for EPS, GIF, PCX, TIF	PICT, GIF, EPSF, TIFF, Photo CD	BMP, DIB, PCX, GIF, TIF, CGM, Photo CD, TGA, WMF, RLE, PCT	PICT	BMP, PCX, WPG, DIB, TIF, GIF, WMF, TGA, JPEG, PICT, EPS, CGM	BMP, PCX, DIB, TIF, GIF, TGA
Video	QuickTime	AVI, MOV	QuickTime	MOV, AVI	QuickTime	AVI, AVS	AVI
Animation	PICS	MMM, FLI, FLC	PICS, Animation Works	AWM, AWA, SCM, AIM (Gold Disk)	PICS, Scrapbook, Cinemation	FLC, FLI, MMM, AWI	FLC, FLI
Data	N/A	WKS, TXT, CSV, XLS, DBF, CHT	Excel, Lotus	Excel, Lotus, tab/return delimited	N/A	N/A	N/A
Import entire slide shows with one command	●	●	●	●	●	○	○
Interactive controls	●	●	●	●	●	○	●
Run-time player	●	●	●	●	●	●	●
Media editors/creators							
Sound	○	○	●	●	●	○	○
Draw	●	●	●	●	●	●	●
Graphs, charts	○	●	●	●	○	○	○
Number of scene transitions	30	46	22+	22	21	19	7
Animation	●	●	●	●	●	○	●
Design templates	●	●	●	●	●	○	○
Bundled clip media	Ample	Ample	Largest selection of category	Largest selection of category	Ample sounds and animation	Modest; 500 MB in CD-ROM version ($149)	Sparse

the scene. This view is useful for aligning objects relative to one another.

Although Action is available in both Mac and Windows versions, the two aren't compatible, so presentations created in one version can't be opened in the other.

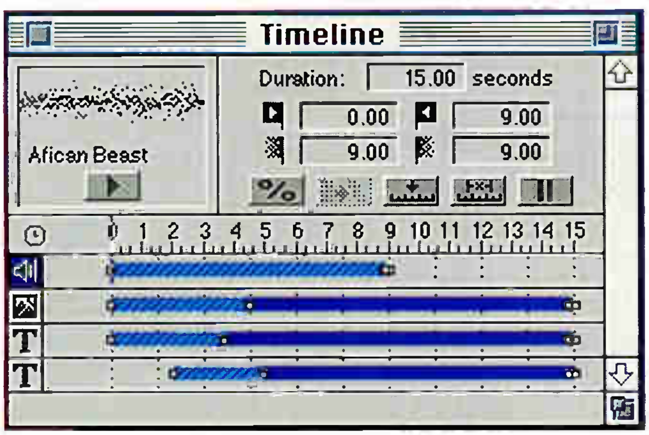
Astound

Not only does Gold Disk's Astound offer the requisite multimedia presentation features—time-based events, animation, and interactivity—but, unique to this category, it also includes features found only in top traditional presentation packages: an outliner, complete with some text-handling features, as well as the ability to output to 35mm slides. Astound's interface incorporates the traditional slide, outline, and slide sorter views, in addition to a timeline view. This makes learning the program a snap for anyone familiar with traditional presentation programs. Astound pulls all this together into a slick, well-designed program.

But don't trash your traditional slidemaker yet. Astound's outliner isn't as full-featured as PowerPoint's or Persuasion's. You can't import text or see text formats in outline view. It also lacks the seamless navigational aids of top slidemakers.

Yet Astound's outliner is still a welcome feature. It helps you organize your thoughts as you prepare a presentation, and it gives you a good overview of all your slides as you edit your work. And never turn down a spelling checker.

Like other packages, Astound lets you apply templates to quickly standardize a design. A healthy supply of templates is included for 35mm slides, 13- and 9-inch screens, overheads, and PowerBooks.



Astound does double duty *as a slide-making program as well as a multimedia presentation program. Its time line helps you synchronize the media elements that make up your presentation.*

Astound offers a wide assortment of media creators and editors. Its drawing tools are better than average for the group, and its graphing capabilities are fairly sophisticated. Astound's sound and movie editors are particularly full-featured and, for many users, will virtually eliminate the need for third-party editors.

Another strong area is the selection of transition effects. Astound offers 22 scene transitions, with nine customizing effects for most, leaving no shortage of creative permutations. But what's truly notable are the choices for object transitions. You can set entrance and exit text transitions that make text drop letter by letter, for example, or you can customize how an object rotates into or out of a scene.

Astound offers the standard interactive controls, and its bar-style time line is quite capable. You animate objects by defining paths along which they travel.

The package comes bundled with a CD-ROM filled with over 1300 pieces of clip media. The library includes graphics, backgrounds, sound effects, music, digital video clips, and animated actors. It's the largest set of bundled clip media in the category.

Be forewarned that, with all these features, Astound is not for the faint of hardware. Despite the manufacturer's listed minimum recommendations, you'll really need 4 MB of application RAM and at least a Mac IIcx to take advantage of Astound's feature set and to better your chances for smooth playback. And make some room on your hard drive for the generous assortment of clip media supplied with this package.

I looked at the Macintosh version in depth for this roundup; the final Windows version came too late to be included. However, the beta of the Windows version seems to perform much like the Macintosh version, and Gold Disk claims cross-platform compatibility—something unique to this category. Either way, Astound is a winner.

The Wrap

With the varying approaches of multimedia presentation software, the question is not "which is the best program?" but "which is the best program for me?" Consider your needs carefully before plunging ahead, and then match your needs with the appropriate offering.

Each program takes a different slant on how best to create stunning presentations, and each of the packages reviewed here does an admirable job of meeting its goals. For quick, basic presentations, Super Show and Tell is a good choice. Q/Media is the budget choice, limited to linear presentations without animation. For the best in animation, Cinemation is your program. Astound and Action are the top all-around, full-featured alternatives, with Astound offering a broader base of features than its chief rival. ■

Shelley Cryan runs a consulting business in Tarrytown, New York, that helps companies incorporate computer-based technologies. She holds an M.B.A. in finance and marketing from the University of Chicago. You can contact her on CompuServe at 71232,3673, on the Internet at 71232.3673 @compuserve.com, or on BIX c/o "editors."

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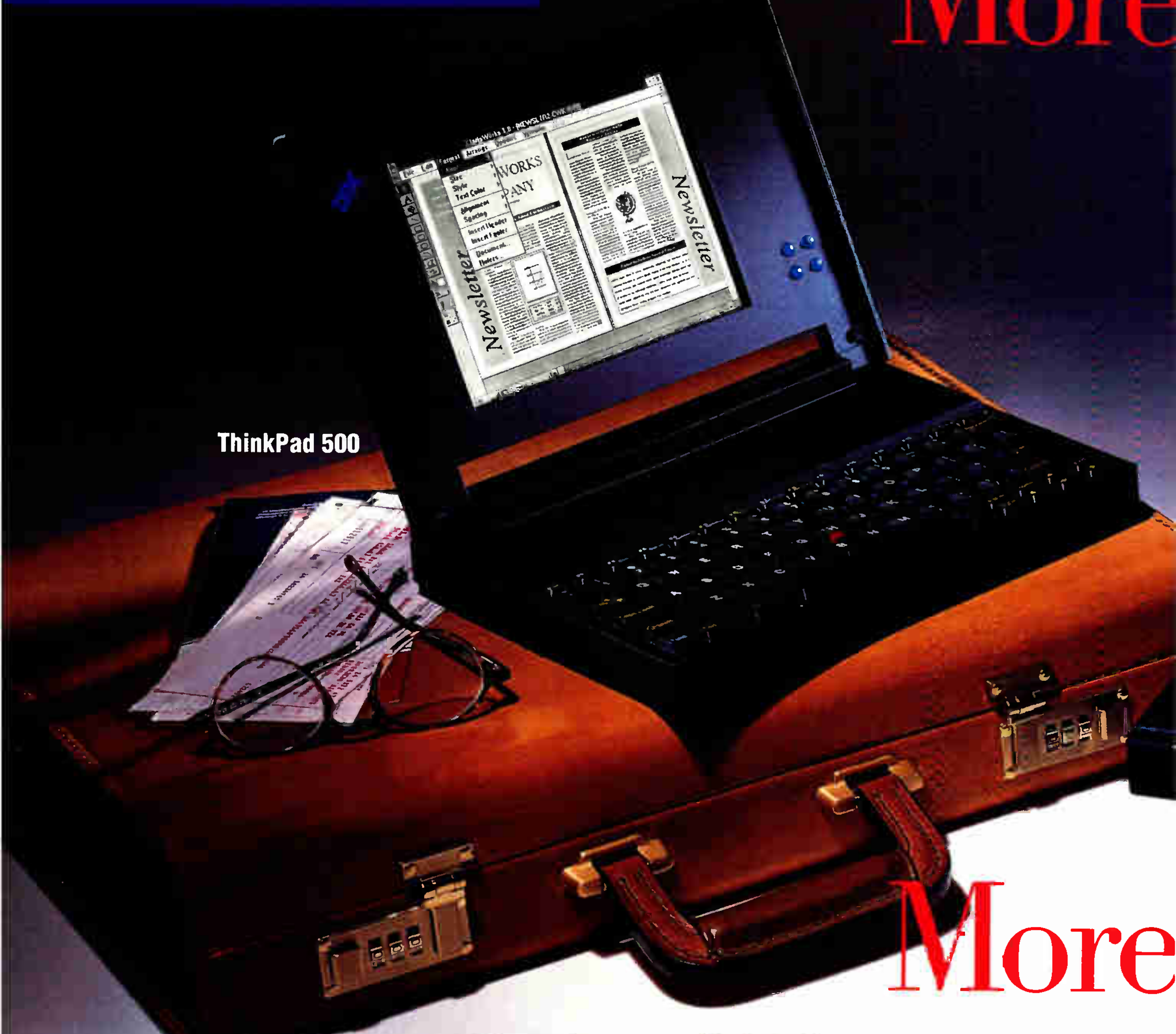

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Mac Programming Power Tools

Mainstay's VIP-C and VIP-BASIC can speed applications development for novice and experienced programmers alike

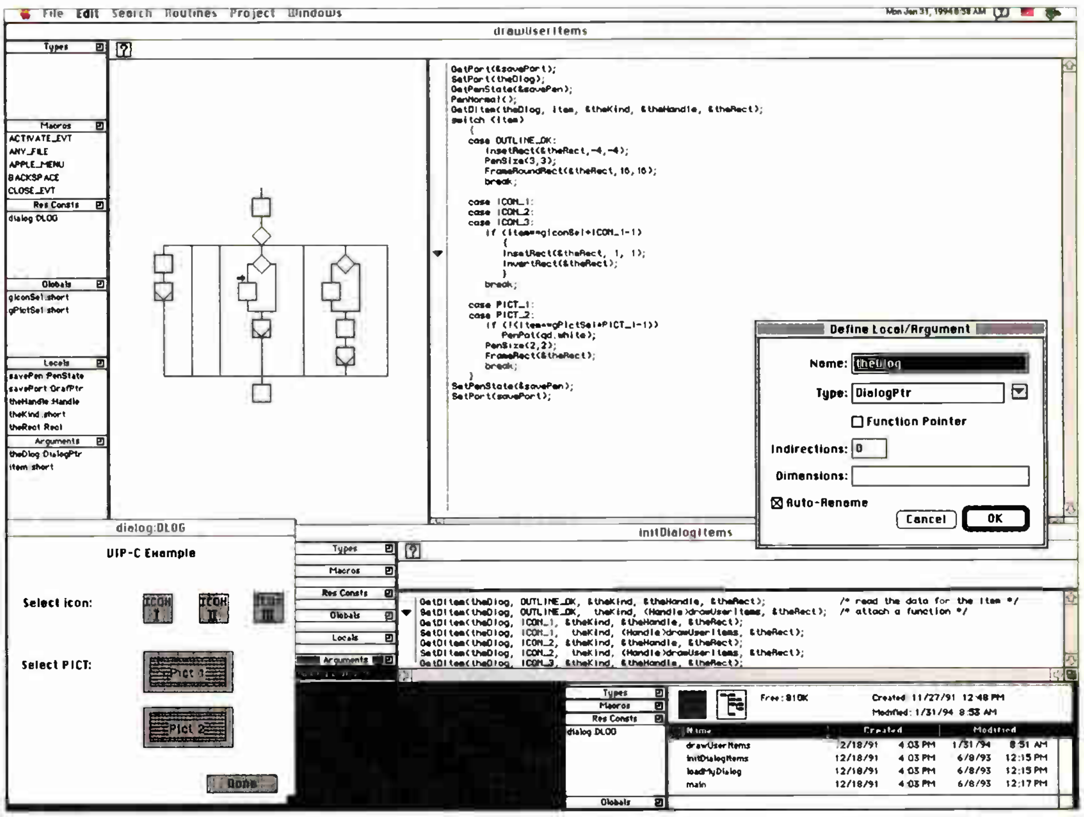
RAYMOND GA CÔTÉ

VIP-C and VIP-BASIC are a pair of Macintosh development tools that fit no single product category. Priced at $495 and $295, respectively, the two products provide complete structured-development environments for the C and BASIC languages. Because the VIP packages supply so many features not found in competing products, I found myself constantly redefining the programs as each new feature or capability popped up.

On first use, the VIP packages struck me chiefly as being structured editors. You create an application as a project, with each function a separate entry in the project window and all variables, type definitions, and macros in separate subwindows for easy tracking and definition. However, VIP-C and VIP-BASIC also include resource editors, an optimizing language interpreter, and a debugger. What's more, both packages can interface to external compilers (e.g., Symantec C and Microsoft QuickBasic) and also import ASCII text files into a project for reverse engineering.

VIP stands for *visual interactive programming*. This name, and a casual reading of Mainstay's marketing literature, might lead you to believe this is some form of CASE tool. Although both VIP products produce excellent flowcharts that help you decipher how your code behaves, they are really not CASE tools, because you can't edit the diagrams themselves.

I spent most of my review time with VIP-C. When I did switch over to VIP-BASIC, I found it to be an almost exact duplicate of the VIP-C application except for the actual language supported: BASIC rather than C. Everything else, including the ability to design interfaces, debug applications, and build stand-alone applications, is identical. I will use just plain VIP when I mean both applications, and though most of my examples will refer to VIP-C, you can assume they also apply to the VIP-BASIC environment.



A typical VIP screen layout with an application in development. Shown are the VIP-C project window (lower right); a dialog window being designed (lower left); two routines, one in the form of a flowchart; and a local-variable definition.

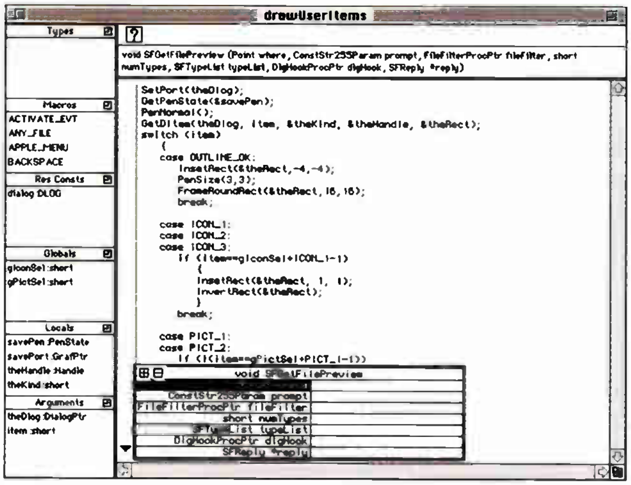
Structured Editing

More than anything else, VIP is a structured editor, which can be both good and bad. On the positive side, a structured editor can guide you through program development by automatically inserting program constructs (e.g., `if`, `while`, `switch`, and `do`) and checking your syntax on the fly. While these features are useful for the novice, or at least for a programmer new to a particular environment, they can annoy an experienced programmer who is also a good typist. Development tools should make programming easier, not get in the way.

VIP walks that thin line between guidance and annoyance. Every time you enter a new line of code, it checks your syntax and updates the accompanying flowchart. If you find syntax error messages derailing your train of thought while you're entering large amounts of code, you can temporarily disable these features. However, you may not need to. On a Mac IIci, I found that syntax checking and flowchart updating were sufficiently quick as to be unnoticeable.

VIP conveniently lets you access all your routines from a single project window. You can switch the display from an alphabetical list of routines to a diagrammatic function-call display that shows how the routines relate to each other. For easy

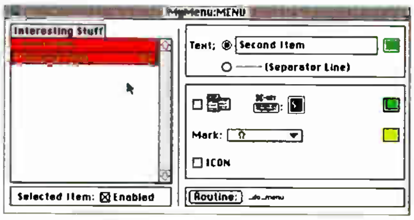
Reviews Mac Programming Power Tools



VIP-C templates *provide easy reference to the parameters for infrequently used functions. The window at the top holds a routine prototype, and the bottom window holds a template for that routine, ready to be filled in.*

reference. VIP also maintains a complete set of global types, macro definitions, global variables, and resource constants for each project.

VIP-C lets you enter standard ANSI C code as you would with a normal editor, but you must enter definitions of all variables, macros, and types through a special dialog box. While this approach ensures that you create definitions properly and provides the interpreter with information it needs, it is also tedious to enter the dozens of variables when you're initially creating the code. However, what I like least about Mainstay's approach is that you can't add explanatory documentation to the defined value. In the example shown in the screen shot on page 199, it would be useful to describe the dialog box for which I am defining the pointer.



A menu-item definition *dialog box allows you to set arbitrary marks, icons, and menu colors as well as link the menu item directly to an existing function. At the bottom right of the definition dialog box, you can see the routine that is executed whenever this menu item is selected.*

With VIP, you can add dated notes to a routine or a project. These notes to be seem designed mostly for maintaining the change history of a routine, since they are displayed in chronological order. A similar feature for definitions would greatly increase the product's usability.

The VIP structured-editor approach shines because it provides prototypes for all 500 of its built-in functions, for the complete interface to the Macintosh Toolbox contained in *Inside Macintosh* volumes I through VI, and for all the functions you define in your own application. VIP displays a routine prototype in one window and a template for editing the prototype in a second window.

Templates are convenient if you don't use a particular call often or if you need to verify how you have defined a routine. If you can't remember a routine's exact name, you can type in a fragment of the name in the Find dialog box and it will list all routines that contain that fragment. For example, to find `SFGetFilePrev`, I entered "sf" as the search parameter. VIP returned two dozen functions, ranging from the complete set of standard file routines to bit-map transformations.

VIP also features a palette that contains sets of frequently used functions. You access this palette by clicking on the small triangle that marks the current line in the edit window. The palette window comes up with 24 small icons, behind each of which is a list of related function calls. You can add and delete items in each palette list and even modify the icons shown on the palette.

The one item that is lacking from the function templates is the same thing that is lacking from the variable definitions—documentation. Even a one- or two-line function description would help. As it is, you must resort to the written documentation, and that makes the template feature less valuable than it could be.

Besides providing complete access to all standard Macintosh Toolbox calls, VIP includes a set of higher-level library functions (see the table on page 204) that simplify Toolbox access and the creation of some relatively complex applications. For example, initiating and using an AppleTalk network socket becomes a matter of

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just two or three calls. As another example, the Grid library provides a simple interface to the Mac's 2-D list manager—something that interface builders such as AppMaker don't support.

Dispatcher and Resources

I found VIP's interactive interface designer to be its most useful feature. The combination of a simple interface builder, an even simpler application framework (which Mainstay calls Dispatcher), and the ability to immediately test the live environment is unbeatable.

Dispatcher is one of the simplest application frameworks you could ever hope to use. It is basically a central switching point for events moving from menus, to dialog boxes, to windows, to code. Since it has less than two dozen interface calls, you'll feel comfortable with it after just a few hours of experience.

Although you don't need to use Dispatcher in developing an application, doing so allows you to immediately attach your code to dialog boxes, controls, and menus. With this capability, you can quickly generate applications and test them in a live situation.

The resource editor itself is flexible and provides functionality not available in other interface builders. In defining a menu, for example, you can set menu-item colors, define an arbitrary marking character, and provide an icon on the item line. At the bottom right of the definition dialog box, you can see the routine that is executed whenever the menu item is selected. You change it by simply pressing the routine button and selecting another function. Similar capabilities exist for window and dialog-box designs.

Interpreting and Debugging

VIP's interpreter checks all code for syntactical correctness and parses it into an intermediate language as soon as you enter it. It interprets this intermediate language when you run the application. You can also build stand-alone applications that use the interpreter, thereby ensuring that your final applications run precisely the same code as they do in your development environment.

An interpretive environment has certain advantages over a compiler—even an incremental compiler. One advantage is that the interpreter usually maintains a lot of information for decoding and displaying complex data structures. Another advantage is the ability to use `#if` macro commands to selectively activate particular

VIP FUNCTION LIBRARIES

A list of the specialized function libraries available within VIP-C, with a sampling of functions from each. Most are identical to functions found in VIP-BASIC. In addition to these, VIP-C also provides a complete set of ANSI-standard C libraries.

3-D GRAPHICS LIBRARY	**GRAPHICS LIBRARY**	**RESOURCE LIBRARY**
_clip_3D_line	_back_pattern	_count_res_types
_pitch_3D	_diff_region	_get_res_attrib
_skew_3D	_draw_icon	_get_resource
_transform_3D	_scroll_rect	_set_res_scope
APPLETALK LIBRARY	**GRID LIBRARY**	**SOUND LIBRARY**
_get_request	_add_grid_columns	_new_channel
_lookup_entities	_draw_grid	_note_command
_open_socket	_grid_event	_play_tune
_send_response	_set_row_height	_set_voice
COLORQUICKDRAW LIBRARY	**MATH LIBRARY**	**STRINGS LIBRARY**
_animate_palette	_angle_from_slope	_append_character
_is_real_color	_annuity	_box_text
_load_color_cursor	_binary_log	_match_pattern
_pick_color	_fixed_divide	_string_to_scrap
DIALOGS LIBRARY	**MENUS LIBRARY**	**TEXTEDIT LIBRARY**
_append_dialog_item	_count_menu_items	_copy_text
_do_alert	_load_menu	_get_text_length
_set_dialog_event_proc	_new_tear_off	_search_text
_set_item_update_proc	_set_hierarchic_menu	_set_text_style
EVENTS LIBRARY	**PRINTING LIBRARY**	**UTILITY**
_dispatch	_control_printer	_bit_and
_get_key	_print_bits	_get_date_string
_set_timeout	_print_text	_get_system_globals
_still_down	_set_print_options	_test_bit
FILES LIBRARY	**RECORDS LIBRARY**	**WINDOWS LIBRARY**
_count_appl_files	_allocate_record	_clear_window
_create_dir	_get_field	_get_screen
_get_vol_space	_memory_free	_load_window
_write_MacPaint_pict	_set_record_size	_set_port_picture

routines without having to recompile the entire project. In effect, the macro construct #if or #ifdef becomes just another interpreter command. The VIP interpretive environment also ensures that programs don't exceed defined array bounds.

The built-in source-level debugger is simple to use and lets you step through your application, set breakpoints, and observe variables and structure values. It also contains several advanced features, such as the abilities to continue execution until a Boolean expression is true, alter variable contents, and continue execution until the program returns from the current function.

Although you can always expect an interpreted application to run more slowly than a fully compiled application, I found no significant speed differences with the VIP applications I built. Of course, you will get different results if you are performing serious numerical computations or spending a lot of time in code created within VIP-C, as opposed to calling the Toolbox.

Exports and Imports

VIP produces stand-alone applications without additional tools, but there are times when you simply want the speed of a compiled application. By working with third-party compilers, VIP lets you take advantage of compiler speeds in your final executable file while still maintaining the flexibility of an integrated environment.

Most simply, you can export an entire VIP-C or VIP-BASIC project to a standard ASCII file and run it through a compiler. VIP-C exports are compatible with Symantec's Think C, Apple's MPW C, and Metrowerks' CodeWarrior C compiler. VIP-BASIC exports will work with Microsoft QuickBasic. Exports generally appear as a single monolithic ASCII text file, which makes it a little difficult to navigate through for follow-up editing. However, the export files' clean layout makes them very readable.

VIP-C provides the optional ability to link to Symantec Think C 6.0 and Apple's MPW C through the use of AppleScripts, using ToolServer to completely automate the process of creating, compiling, and linking an externally compiled application. I did not test the MPW C link, but I did successfully send several sample applications to Think C 6.0.

Aside from your having to ensure that several original and well-documented files are available for the build process, this last process is completely automated. All you need to do is select one menu entry to create the project, one menu entry to set all the project parameters (e.g., application creator ID and sizes), and then one last menu entry to actually build the application. You can even run the Think C debugger from the VIP-C environment to examine the newly compiled application.

The VIP documentation also states that you can import preexisting text files into an existing VIP project. Although this appears feasible in principle, it is not practical for any large amount of preexisting code. That's because VIP-C has difficulty finding and decoding all the myriad include files in a complex application.

In particular, VIP can't find header files in one directory that are used with source files in another directory. Mainstay acknowledges this problem and recommends that you use precompiled headers that you can then redefine in your VIP project. I opted not to do this because I did not want to change the source code for a currently active project.

Another problem with importing existing projects is size. Many of my ongoing projects have become quite large over the years. The thought of moving them into a single monolithic file is troublesome. According to Mainstay, this is not an issue with its current customers, who are mostly creating new applications, not importing old code.

For the Future

Operating environments are always changing, and the Mac is no exception. Mainstay plans to maintain the timeliness of its VIP-C and VIP-BASIC products with its VIP Extender utility. This program converts into VIP interfaces new Toolbox manager include files distributed by Apple. Since it converts only include files, you can use this utility to provide interfaces to new Toolbox functions but not to functions in third-party libraries.

VIP-C and VIP-BASIC provide a fully integrated development environment that can help novice and experienced programmers alike rapidly develop new applications. The three-pronged solution of framework, resource editor, and interpretive-language environment provides a powerful development tool. The VIP solution will not work for everyone, partly because of individual preferences. But VIP-C in particular is well worth considering as a front-end designer for your Think C and MPW C applications.

For my own applications, I plan to use VIP-C to create the initial user interface and basic functionality. Then I'll switch over to Metrowerks' C for the final development cycle, creating programs for both the original 680x0 platform and the latest PowerMac systems. ■

About the Products

VIP-C 1.0.2 ....$495
VIP-BASIC 1.0.1 ....$295
Mainstay
591-A Constitution Ave.
Camarillo, CA 93012
(805) 484-9400
fax: (805) 484-9428
Circle 1091 on Inquiry Card.

Raymond GA Côté is a BYTE consulting editor and vice president of product development for Appropriate Solutions, Inc. (Peterborough, NH). He can be contacted on the Internet at rgacote@world.std.com or on BIX as "rgacote."

57 PCS THAT SET THE PACE

We test 20 Pentiums and 37 66-MHz 486DX2 systems to find the best performers for Windows, Unix, and DOS

HELEN E. HOLZBAUR AND STEPHEN M. PLATT

If speed is your only concern, choosing between a Pentium and a fast 486 is easy. After testing 20 Pentiums and 37 486DX2 systems, we found Pentiums averaged 30 percent faster in Windows performance than their venerable cousins. In fact, the slowest Pentium under Windows (DEC's DECpc 560ST) outran the fastest 66-MHz 486DX2 (Cornell Computers' Power Pak) by almost 10 percent.

However, Pentiums still command a significant price premium over fast 486s. The average price of the ISA-based 486DXs in our test sample is approximately $3500, while the average cost of an ISA-based Pentium system is about $1000 more.

To help you find the best high-performance PC for your application, we tested 60- and 66-MHz Pentiums and 66-MHz 486DX2s with ISA and EISA buses and with VL-Bus, PCI (Peripheral Component Interconnect), or proprietary local-bus implementations. We ranked the systems with the best mix of performance, price, features, and ease of use for Windows, Unix, and DOS applications. We also identified the system designs that offered the most room for expansion, as well as the models that boasted the lowest prices while still delivering a high level of quality.

Among the Pentium systems we ranked for Best Overall status, PCI local-bus dominated: Six of these 10 systems were based on this design, while three of the remaining Pentiums used VL-Bus and the fourth relied on a proprietary local bus. PCI has also come down to the 486 platform, and although only three systems used this design, two of them—American Microsystems' Info Gold and MicroSource's Tempest IV—made it into Best Overall rankings. But VL-Bus continues to be the local-bus design of choice among 486 vendors.

How to use this guide

To find the best Pentium or 486 system for you, follow the main headings until you come to the applications category that most closely matches your own. Then look to the Best Overall, Most Expandable, or Low Cost summaries to find the appropriate models.

List prices are for the as-tested configuration.

Speed scores are calculated from Windows, Unix, and DOS tests. Higher numbers indicate better performance.

BEST OVERALL Dell OmniPlex 566

The fastest Windows performer among all the systems we tested, the OmniPlex 566 is also among the easiest-to-use systems we evaluated. Dell's comprehensive documentation includes a separate bound manual for diagnostics and troubleshooting. Three hand-tightened screws hold the system's cover in place, so you don't require tools when opening the chassis. Inside, the system offers three EISA and two EISA/PCI slots. The compartment for expansion boards is separated from the drive bays (for three 5¼-inch and two 3½-inch drives) and six SIMM sockets. You can easily remove the expansion card cage to access the system board.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Dell OmniPlex 566	$6917		3.12	▲▲▲▲	4.74	EISA/PCI	32/192	1024/SCSI	12	ATI 68800
RUNNER UP	ALR Evolution V-Q/66	$9765		2.83	▲▲▲	6.20	EISA/VL	32/1024	1370/SCSI	60	ATI Mach 32
RUNNER UP	DEC DECpc XL 560	$5436		2.82	▲▲▲▲	4.32	ISA/PCI	16/192	525/IDE	36	S3 928
RUNNER UP	Insight PCI P60	$3219		2.61	▲▲▲▲	5.37	ISA/PCI	16/128	540/IDE	12	ATI Mach 32
RUNNER UP	Intl Instr Business Partner	$4447		3.06	▲▲▲▲	5.12	ISA/VL	32/128	544/SCSI	12	Eagle Tseng 4000

Rates how easily you can configure the system and the quality of its documentation.

Points awarded for presence of important features; higher numbers mean better scores.

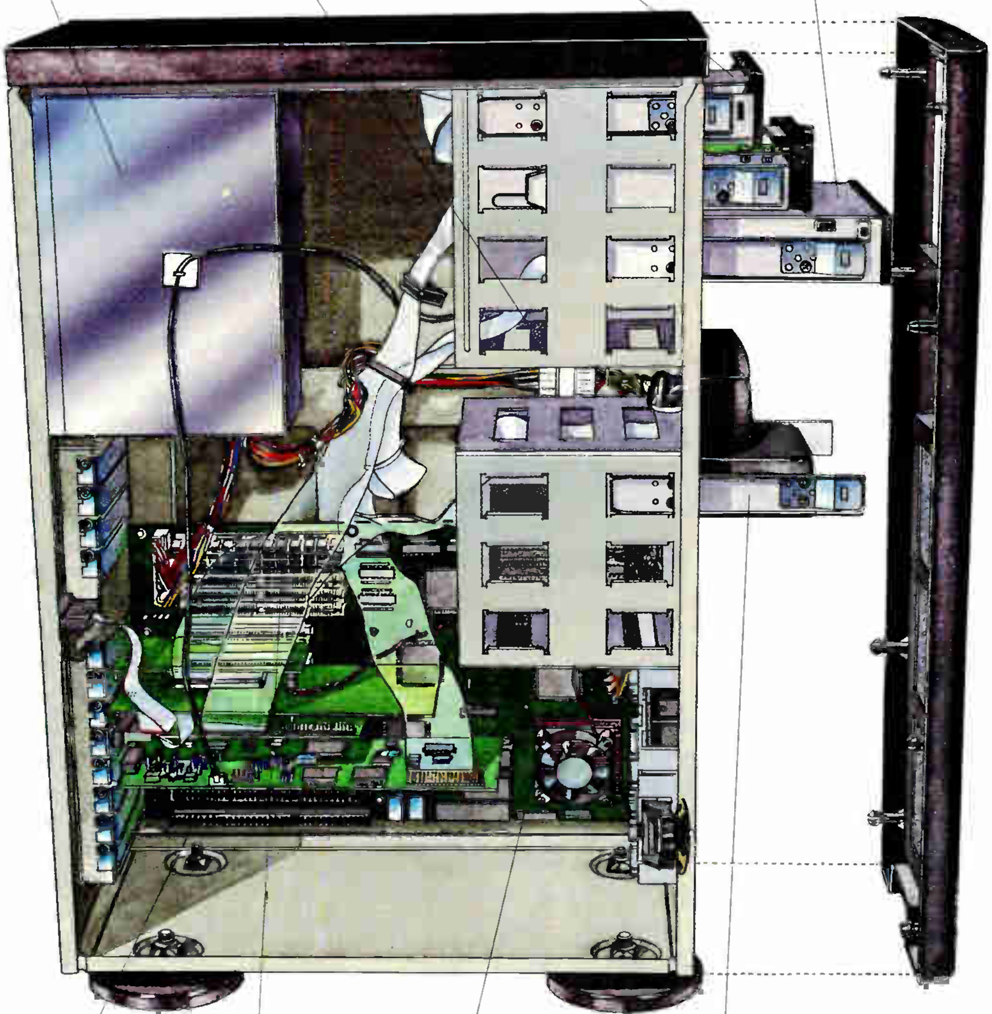
What to Look For

POWER SUPPLY
Pentium and fast 486 systems are meant to be workhorses, so you should specify a power supply that is at least 200 watts.

DRIVE BAYS
Choose a tower-case if you will be using the system as a server or in applications that require multiple drives (the roomiest designs in this roundup had five or more available bays).

FLOPPY DRIVES
The standard floppy configuration for most systems is a 1.44-MB, 3½-inch floppy drive. If the system will be used to transfer data from older machines, it is wise to also buy a 5¼-inch drive or choose dual drives that support both sizes of floppy drives but use only one drive bay.

CD-ROM
Buy a double-speed CD-ROM drive or faster. One distinguishing factor in choosing a drive is the manner in which the system will stand. If the system will stand on its side, choose a CD-ROM drive that has a caddy load.



EXPANSION SLOTS
If you plan to use the system for disk- or video-intensive applications, look for available local-bus slots, since local bus offers a higher throughput rate than ISA or EISA.

MEMORY
Most Pentium and high-end 486 systems we tested use standard SIMMs. When choosing a system, consider the degree of difficulty you may encounter in trying to increase the amount of RAM in your system. Avoid systems that require you to remove the drive bays to add SIMMs.

CPU
Pentiums outperformed 66-MHz 486DX2 chips by about 30 percent in our Windows tests. Pentiums also generate a lot of heat, so you should make sure the system design provides adequate cooling. The chip should be mounted on a heat sink or next to a cooling fan, and there should also be plenty of room around the chip for air to circulate.

HARD DRIVE
The hard drive subsystem is often the bottleneck in high-end performance machines. Since speed is the trademark of Pentium and 486DX2/66 systems, choose a hard drive with a fast controller and access time at or below 11 milliseconds. Local-bus (VL or PCI) SCSI-2 drives usually offer the fastest data transfer rates. The drive itself should be at least 500 MB.

APRIL 1994 BYTE BEST HIGH-END SYSTEMS

BEST

Best Pentium for Windows
Dell OmniPlex 566
One of only two 66-MHz Pentiums that we tested, the OmniPlex was the fastest performer of all the systems in this report. Along with top speed, this desktop system also earned high marks for ease of use and features.
PAGE 209

Best Pentium for Unix
ALR Evolution V-Q/66
By far the fastest machine we tested under Unix, this huge tower also was among the most flexible for adding memory, mass storage, and adapter cards. **PAGE 211**

Best ISA 486 for Windows
Cornell Computer Systems Cornell Power Pak
This system has the fastest Windows scores in its class. It also outperformed some of the Pentiums. **PAGE 215**

Best EISA 486 for Windows
Cornell Computer Systems EISA-VL SCSI-2
Like its ISA counterpart, the Cornell EISA-VL SCSI-2 is the fastest system in its class. The roomy tower system is also among the least expensive EISA machines we tested. **PAGE 217**

Best 486 for Unix
IBM ValuePoint 6387-W90
Loaded with features and plenty of growing room, the IBM ValuePoint 6387-W90 is easily the Unix speed leader in its class. **PAGE 219**

Best 486 for DOS
Cornell Computer Systems EISA-VL SCSI-2
This system outperforms the competition in DOS speed tests. The Cornell EISA-VL SCSI-2 is loaded with features and is easily upgraded.
PAGE 221

ILLUSTRATION: BRUCE SANDERS © 1994

THE BEST

PENTIUMS FOR WINDOWS

The overall 30 percent Windows speed advantage of Pentiums over 486s isn't the whole story: The fastest Pentiums also provide a 40 percent increase over 486s in applications such as Windows spreadsheets, which rely on strong floating-point performance.

Of the 20 Pentiums we evaluated for this report, all but two use 60-MHz versions of the processor. The exceptions were Dell's OmniPlex 566 and Advanced Logic Research's Evolution V-Q/66. Each system ran a 66-MHz Pentium processor. This speed advantage helped the Dell win Best Overall honors and the ALR rank first for Most Expandable. However, speed wasn't the only factor in either selection (see page 209).

All the Pentiums we tested came with at least 256 KB of cache. Three Pentiums—including the Evolution V-Q/66—came with 512 KB of cache. Five others could be upgraded to at least this level, including the International Instrumentation Business Partner and the Micro Express MicroFlex-VL/Pentium, which can handle up to 2 MB of cache.

Pentiums offer significant performance gains compared to 486s, but the faster CPUs also present some design challenges for system vendors, thanks to the high heat Pentiums produce. We found a number of different solutions to the heat problem in our test sample. The Evolution V-Q/66 used multiple motherboard fans to cool the processor and system components. The Xinetron X/LAN 586 and Duracom Multimedia FilePro Pentium 60-PCI rely on fans attached adjacent to the CPU to keep things cool. DEC's DECpc XL 560 uses a plastic pipe to channel air directly onto the CPU.

Most of the systems in our sample came with at least 4 SIMM slots, which allow you to expand memory up to 128 MB. All the systems' SIMM slots accept the newer 72-pin, 32-bit SIMM packages. Although these sockets let you fit more memory into less space, you won't be able to move memory from older systems to your new Pentium.

Three of the five systems ranked for Best Overall use PCI (Peripheral Component Interconnect) local bus, and three of the top Pentium systems use video chip sets from ATI (the others use S3's and Tseng Labs' chips).

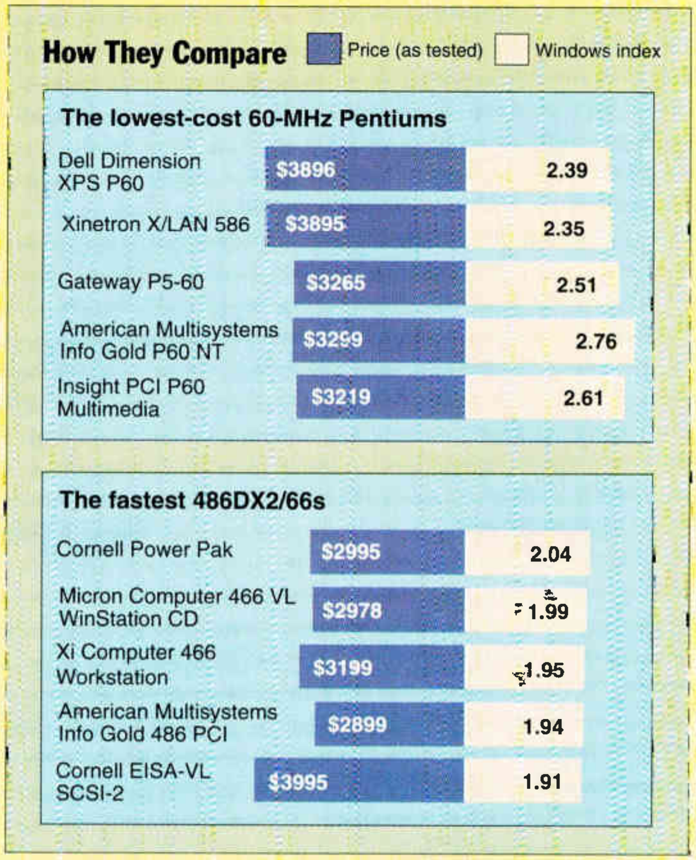
Among the Best Overall systems, International Instrumentation's 60-MHz Business Partner scored the second-highest Windows scores, beating out even the 66-MHz ALR Evolution. What's more, its fast video subsystem helped the system finish ahead of the 66-MHz Dell OmniPlex 566 (an EISA machine) in the BYTE low-level Windows benchmarks. The ISA-based Business Partner sells for

PENTIUM VS. 486: POWER OR PRICE?

PC buyers have long faced the question of whether to buy economical systems with the current standard CPU or pay premium prices for the fastest technology. When we first compared the price and performance of 486s and Pentiums, we saw wide differences (see "90 High-Speed 486 Systems," December 1993 BYTE). The market has changed quickly in that short time.

Today, our comparisons of price and performance indicate that you can get outstanding speed and economical prices in a Pentium. The chart compares the five fastest 486DX2/66 performers in our Windows tests against the five lowest-cost Pentiums. Each of these Pentiums outperformed the fast 486s.

Is there still any reason to buy a fast 486? You can save money with a 486: about 30 percent on average. Also, if your applications stress hard disk or network performance, Pentiums won't benefit you like they will if you need fast computational speeds and floating-point processing.



The bars on the right indicate the performance of each product in the Windows tests as indexed against a Compaq Deskpro 4/33i. Longer bars represent better performance. The bars on the left represent the cost of the systems as tested. (Note: Most Pentiums had 32 MB of RAM and 1-GB hard drives. The 486s were equipped with 16 MB of RAM and 500-MB hard drives). Shorter bars indicate lower cost.

$2500 less than the OmniPlex 566, and the Business Partner is one of the lowest-priced Pentiums in our entire sample. Unfortunately, its documentation is incomplete and the fit-and-finish of the machine is rough. In particular, we were troubled by the poor ways in which the heat sink and the parallel-port cover were attached (see Dubious Achievements on page 222). If International Instrumentation solves its quality problems, the Business Partner can be a contender for Best Overall honors, thanks to its fine performance. Until then, however, we can only consider it a runner-up.

For Most Expandable, we only ranked full-size tower designs. Among the leaders in this group, Insight Direct's Insight PCI P60 Multimedia places second from the top thanks to its $3219 price (the lowest price in this group) and Windows performance, which places it second among the 60-MHz machines ranked here. The Insight also offers an impressive 10 available drive bays and five available slots in a design that keeps them free from wiring and cables.

American Multisystems' Info Gold P60 PCI won Low Cost honors (Pentium systems priced below the $5200 average, including ISA and EISA machines) thanks to its $3300 price and quality design, which included PCI local bus, a chassis that accommodates seven 5¼-inch drives, and the second fastest Windows score.

Rankings for This Category Considered

KEY

Ease of Use:

Poor ▲ Fair ▲▲

Good ▲▲▲ Excellent ▲▲▲▲

Case:

Desktop ▬ Tower ▮

Mini-tower ▯

Prop = proprietary.

BYTE BEST — PENTIUMS FOR WINDOWS

Want the fastest for Windows?

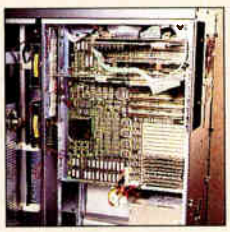
BEST OVERALL **Dell OmniPlex 566**

The fastest Windows performer among all the systems we tested, the OmniPlex 566 is also among the easiest-to-use systems we evaluated. Dell's comprehensive documentation includes a separate bound manual for diagnostics and troubleshooting. Three hand-tightened screws hold the system's cover in place, so you don't require tools when opening the chassis. Inside, the system offers three EISA and two EISA/PCI slots. The compartment for expansion boards is separated from the drive bays (for three 5¼-inch and two 3½-inch drives) and six SIMM sockets. You can easily remove the expansion card cage to access the system board.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Dell OmniPlex 566[1]	$6917	▬	3.12	▲▲▲▲	4.74	EISA/PCI	32/192	1024/SCSI	12	ATI 68800
RUNNER-UP	ALR Evolution V-Q/66[1]	$9765	▮	2.83	▲▲▲	6.20	EISA/VL	32/1024	1370/SCSI	60	ATI Mach 32
RUNNER-UP	DEC DECpc XL 560	$5436	▮	2.82	▲▲▲▲	4.32	ISA/PCI	16/192	525/IDE	36	S3 928
RUNNER-UP	Insight PCI P60	$3219	▮	2.61	▲▲▲▲	5.37	ISA/PCI	16/128	540/IDE	12	ATI Mach 32
RUNNER-UP	Int.'l Instr. Business Partner	$4447	▮	3.06	▲▲▲▲	5.12	ISA/VL	32/128	544/SCSI	12	Eagle Tseng 4000

Need speed and room to grow?

MOST EXPANDABLE **Advanced Logic Research Evolution V-Q/66**



This EISA/VL-Bus tower offers the greatest expansion potential of any system we tested—for a price: This $9765 system is the most expensive machine in this roundup. Easy-to-remove side panels let you access 11 5¼-inch and two 3½-inch drive bays (all with frontal exposure). A large fan cools the drives, and there is ample room for wiring. Two additional fans cool the motherboard. Six available slots (five EISA and one VL-Bus) and 16 SIMM sockets (supporting 1 GB of RAM) are free from obstructions. Thanks to its 66-MHz Pentium CPU and an ATI Mach 32 video adapter, the Evolution provides excellent Windows performance on both the applications and low-level tests, for a combined score of third-best among all systems tested in this report. For towers that have slightly less room for growth but have solid speed and are a third of the cost, consider the Insight PCI P60 and the Gateway P5-60.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	OPEN BAYS 3½/5¼	AVAILABLE SLOTS	VIDEO
BEST	ALR Evolution V-Q/66[1]	$9765	▮	2.83	▲▲▲	6.20	EISA/VL	32/1024	1/8	6	ATI Mach 32
RUNNER-UP	Insight PCI P60	$3219	▮	2.61	▲▲▲▲	5.37	ISA/PCI	16/128	7/3	5	ATI Mach 32
RUNNER-UP	Gateway P5-60	$3265	▮	2.51	▲▲▲▲	5.19	ISA/PCI	32/128	3/3	6	ATI Mach 32
RUNNER-UP	EasternTech ET P60-PCI	$4995	▮	2.47	▲▲▲▲	5.16	ISA/PCI	32/192	2/1	4	S3 805
RUNNER-UP	AMS Info Gold P60 PCI	$3299	▮	2.76	▲▲▲	4.35	ISA/PCI	32/192	0/3	3	Weitek P9001

For Pentium power and economy...

LOW COST **American Multisystems Info Gold P60 PCI**

With a suggested price of just $3299, the Info Gold P60 PCI is a good value in a Pentium system. The trade-off for low cost is only average Pentium speed. Nevertheless, the Info Gold outran most 486s and cost less than 22 of them.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	AMS Info Gold P60 PCI	$3299	▮	2.76	▲▲▲	4.35	ISA/PCI	32/192	540/SCSI	12	Weitek P9001
RUNNER-UP	Insight PCI P60	$3219	▮	2.61	▲▲▲▲	5.37	ISA/PCI	16/128	540/IDE	12	ATI Mach 32
RUNNER-UP	Gateway P5-60	$3265	▮	2.51	▲▲▲▲	5.19	ISA/PCI	32/128	540/IDE	12	ATI Mach 32
RUNNER-UP	Int.'l Instr. Business Partner	$4447	▮	3.06	▲▲▲▲	5.12	ISA/VL	32/128	544/SCSI	12	Eagle Tseng 4000
RUNNER-UP	Dell Dimension XPS P60	$3896	▬	2.39	▲▲▲▲	4.81	ISA/PCI	16/128	450/IDE	12	S3

[1] 66-MHz Pentium

How We Tested

Testing Team (from left): Stephen Platt, Anthony Lennon, Alan Joch, Tom McAndrew (seated), Siva Kumar, Jim Kane, and Helen Holzbaur.

We tested each Pentium and 486 system under Windows 3.1, DOS 6.0, and SCO Unix ODT (Open Desktop) 3.0. DOS and Windows suites consisted of BYTE low-level tests and NSTL application tests.

The BYTE DOS low-level tests evaluate system performance by isolating CPU, FPU, memory, video, and hard disk subsystems. The BYTE Windows low-level tests exercise the Windows GDI (Graphical Device Interface) to determine how well a system can execute basic Windows graphics tasks, such as drawing a line, displaying text, or executing BitBlt operations.

The NSTL application tests use popular business applications that give a real-world representation of system performance. The DOS performance suite includes WordPerfect 5.1, Lotus 1-2-3 release 2.4, and FoxPro 2.0. The Windows tests consist of Microsoft Excel 4.0a, Microsoft Word 2.0b, and Lotus 1-2-3 for Windows 1.1. All applications execute macros that exercise common areas of each application. For instance, the Word for Windows test includes a number of subtests that measure a variety of activities, including accessing files, performing search-and-replace functions, changing fonts, scrolling by page and line, checking the spelling, previewing print jobs, and printing to a file.

All Windows tests were executed in 1024- by 768-pixel resolution with 256 colors. The DOS tests ran in the standard VGA resolution (640 by 480 pixels at 16 colors). The BYTE Windows low-level tests ran in both modes.

For comparison, we scaled all Windows and DOS test scores against a Compaq Deskpro 4/33i, a 33-MHz 486DX system, whose performance results equal a 1.0 in our index. Thus, a system with a performance index of 1.5 executed our tests 50 percent faster than the baseline Deskpro 4/33i.

Our Unix tests used SCO ODT 3.0, a Unix implementation incorporating the X Window System user interface. The tests covered processor, disk, and display-intensive activities, including both application-based and low-level benchmarks. The SPEC92 test suite consists of a variety of scientific and engineering applications. We used the integer-oriented CINT92 group for 486 workstations and both the CINT92 and CFP92 groups for Pentium workstations. A DEC VAX 11/780 equals 1.0 in our SPEC92 index. Additionally, we tested systems using BYTE's low-level Unix benchmarks. The BYTE Unix scores were indexed against the Deskpro 4/33i. The Unix test suite evaluated each system as a graphics workstation for typical computation and display-intensive activities, not as a file server or database query processor.

FEATURES

We considered the following features most important for 486DX2/66 and Pentium systems:

- **32 MB or more of memory capacity for 486s**
- **64 MB or more of memory capacity for Pentiums**
- **Bundled software that includes DOS and Windows**
- **Flash ROM BIOS**
- **16550 UART (universal asynchronous receiver/transmitter) for optimal serial communication**
- **Available adapter slots and drive bays**
- **Display resolution of 1280 by 1024 pixels**
- **Security features**
- **Free lifetime technical support**
- **A minimum of one-year parts-and-labor warranty**

EASE OF USE

We also evaluated systems for design and documentation. We considered several factors when we looked at system design: How easy was it to open the system and install an adapter? Were any slots obstructed? Were the I/O ports labeled? Could the subsystems be disabled?

We gave points to systems that came with clear, well-indexed documentation. We also gave points if specifications were provided for the video and disk subsystems. Additionally, we considered whether jumpers and DIP switch settings were adequately detailed.

Although keyboard feel is important, evaluating keyboards is subjective and thus was not part of our scoring. We also did not evaluate monitors for this report. However, prices listed here are for as-tested configurations that include either a 14- or 15-inch, 1024- by 768-pixel (noninterlaced) monitor. Prices also include keyboard, mouse, CD-ROM drive, and sound card.

CONFIGURATION

Our testing was open to all 486-class systems with a 66-MHz DX2 processor as well as 60- and 66-MHz Pentiums, with ISA and EISA buses. We requested that all 486 systems have 16 to 20 MB of RAM and that Pentiums have 32 to 46 MB of RAM. We specified hard drives of at least 510 MB, using a controller that had no more than 1 MB of cache. Each system had at least a megabyte of video memory and supported 1024- by 768-pixel resolution at 256 colors. Finally, each system was equipped with a CD-ROM and a sound card.

Contributors

Helen E. Holzbaur, *Project Manager/NSTL, was a network manager and systems administrator at Temple University for 10 years before joining NSTL.*

Alan Joch, *Senior Editor/BYTE, coordinates the combined testing between the BYTE Lab and NSTL.*

Jim Kane, *Technical Analyst/NSTL, has tested network hardware and software, high-end systems, and peripherals during the past three years at NSTL.*

Siva Kumar, *Technical Analyst/NSTL, specializes in hardware and network-operating systems testing.*

Anthony Lennon, *Technical Editor/NSTL, tests systems, notebooks, and peripherals.*

Tom McAndrew, *Technical Analyst/NSTL, evaluates high-end PCs, operating systems, and peripherals.*

Stephen M. Platt, *Manager of Unix Development/NSTL, has a doctorate in computer science/computer graphics.*

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.

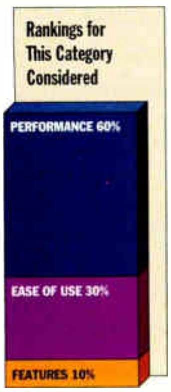
BYTE BEST

PENTIUMS FOR UNIX

Results from the BYTE Unix benchmarks (which were run under SCO Unix ODT 3.0) further illustrate the Pentium's overall speed advantages compared to the 486's. The top five Pentium systems ranked for Best Overall have an average BYTE Unix score of 2.15. By comparison, the 486 systems that ranked Best Overall for Unix achieved an average of 1.56. Much of the speed advantage of the Pentium rests with improve floating-point processing power over the 486.

Of the 20 Pentium systems we received, 14 used PCI local bus. But Pentium vendors' reliance on the PCI made Unix testing difficult because during our test cycle, we found little support for PCI video in the SCO Unix kernel. We found no such problems with VL-Bus display cards.

Advanced Logic Research's Evolution V-Q/66 and DEC's DECpc 560ST outpaced the other Pentiums ranked for Best Overall by almost 50 percent. These two systems, priced at over $9100 in our test configuration, also took honors for being the most expensive systems in our sample. For those who can accept average Unix performance, consider the Gateway and Dell runners-up, which sell for $3265 and $3896, respectively.



KEY

Ease of Use:

Poor ▲ Fair ▲▲

Good ▲▲▲ Excellent ▲▲▲▲

Case:

Desktop ▬ Tower ▮

Mini-tower ▯

Prop = proprietary.

For the Unix speed leader . . .

BEST OVERALL — Advanced Logic Research Evolution V-Q/66

For Unix-based scientific, engineering, and graphics applications, this EISA system led all other Pentiums in the SPEC integer and floating-point scores (61.5 and 52.0, respectively, compared to averages of 48.3 and 42.7). The system's graphics performance was also among the best, thanks to the ATI Mach 32 controller and VL-Bus implementation. The 1.3-GB SCSI hard drive includes 4 MB of cache. Other nice features include the advanced 16550 UARTs (universal asynchronous receiver/transmitters) on the serial port, which is essential for high-speed communications.

		PRICE	CASE TYPE	UNIX SPEED SPECINT	SPECFP	BYTE	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	ALR Evolution V-Q/66[1]	$9765	▮	61.49	52.07	2.46	▲▲▲	6.20	EISA/VL	32/1024	1370/SCSI	60	ATI Mach 32
RUNNER-UP	DEC DECpc 560ST	$9131	▮	53.19	46.59	2.43	▲▲▲▲	5.18	EISA/Prop.	32/192	1024/SCSI	36	Amer. Meg.
RUNNER-UP	Dell Dimension XPS P60	$3896	▬	47.42	41.80	1.99	▲▲▲▲	4.81	ISA/PCI	16/128	450/IDE	12	S3
RUNNER-UP	Insight PCI P60	$3219	▮	47.04	41.41	1.90	▲▲▲▲	5.37	ISA/PCI	16/128	540/IDE	12	ATI Mach 32
RUNNER-UP	Gateway P5-60	$3265	▮	45.44	41.40	1.96	▲▲▲▲	5.19	ISA/PCI	32/128	540/IDE	12	ATI Mach 32

Need a tower of power?

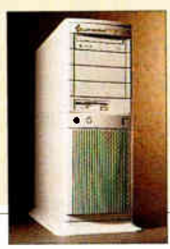
MOST EXPANDABLE — Advanced Logic Research Evolution V-Q/66

In addition to its high-performance design, this tower is built with expansion (see details in the Most Expandable category on page 209). Unlike other towers, the interior of the Evolution V-Q/66 is clean and open, so you won't have to contend with cables and wires to access expansion slots.

		PRICE	CASE TYPE	UNIX SPEED SPECINT	SPECFP	BYTE	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	OPEN BAYS 3½/5¼	AVAILABLE SLOTS	VIDEO
BEST	ALR Evolution V-Q/66[1]	$9765	▮	61.49	52.07	2.46	▲▲▲	6.20	EISA/VL	32/1024	1/8	6	ATI Mach 32
RUNNER-UP	DEC DECpc 560 ST	$9131	▮	53.19	46.59	2.43	▲▲▲▲	5.18	EISA/Prop.	32/192	1/1	3	Amer. Meg.
RUNNER-UP	Insight PCI P60	$3219	▮	47.04	41.41	1.90	▲▲▲▲	5.37	ISA/PCI	16/128	7/3	5	ATI Mach 32
RUNNER-UP	Gateway P5-60	$3265	▮	45.44	41.40	1.96	▲▲▲▲	5.19	ISA/PCI	32/128	3/3	6	ATI Mach 32
RUNNER-UP	Duracom Multimedia FilePro	$5649	▮	46.62	41.74	1.79	▲▲▲	4.77	ISA/PCI	32/128	3/0	5	S3 #9GXE

When price matters . . .

LOW COST — Gateway 2000 P5-60



This excellent, entry-level Pentium system is built around a large tower case that can grow over time: as your applications demand more memory, you'll be able to add up to a maximum of 128 MB. There's also room for nine drives. The documentation is geared toward novice users and is well organized, containing everything you'll need to configure and run the system. Make no mistake, the Gateway P5-60 isn't a barn-burner among Pentiums, but at $3265, it is priced less than most of the 486-based systems in this report.

		PRICE	CASE TYPE	UNIX SPEED SPECINT	SPECFP	BYTE	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Gateway P5-60	$3265	▮	45.44	41.40	1.96	▲▲▲▲	5.19	ISA/PCI	32/128	540/IDE	12	ATI Mach 32
RUNNER-UP	Dell Dimension XPS P60	$3896	▬	47.42	41.80	1.99	▲▲▲▲	4.81	ISA/PCI	16/128	450/IDE	12	S3
RUNNER-UP	Xinetron X/LAN 586	$3895	▮	45.36	38.75	1.86	▲▲▲	4.76	ISA/VL	32/128	520/SCSI	36	Tseng W32
RUNNER-UP	Micro Express MicroFlex-VL	$4699	▮	44.19	38.54	1.65	▲▲▲▲	4.48	ISA/VL	32/128	500/SCSI	24	Tseng W32I

[1] 66-MHz Pentium

PACKAGE 1

- **486SX-25** .... **$1195** — Lease $50/month
- **486DX-33** .... **$1395** — Lease $59/month
- **486DX2-50** .... **$1495** — Lease $63/month
- **486DX2-66** .... **$1595** — Lease $58/month
- **486DX4-75** .... **$1795** — Lease $65/month
- **486DX4-100** .... **$1995** — Lease $72/month

- **Intel Verified:** for the Pentium™ OverDrive™ Processor
- 2MB high-speed RAM
- 107MB local bus hard drive w/32K cache
- 3.5" floppy drive
- Diamond SpeedStar Pro Windows-accelerated local bus video with 1MB RAM
- 14" 1024 NI SVGA color monitor, .28mm dot pitch
- On-board SCSI socket
- Two VESA local bus, five 16-bit and one 8-bit expansion slots
- Six-bay desktop w/2 cooling fans
- 101-key space-saving keyboard
- MS-DOS 6.2 w/Tools

PACKAGE 2

- **486SX-25** .... **$1395** — Lease $59/month
- **486DX-33** .... **$1595** — Lease $58/month
- **486DX2-50** .... **$1695** — Lease $61/month
- **486DX2-66** .... **$1795** — Lease $65/month
- **486DX4-75** .... **$1995** — Lease $72/month
- **486DX4-100** .... **$2195** — Lease $79/month

- **Intel Verified:** for the Pentium™ OverDrive™ Processor
- 4MB high-speed RAM
- 214MB local bus hard drive w/32K cache
- 3.5" floppy drive
- Diamond SpeedStar Pro Windows-accelerated local bus video with 1MB RAM
- 14" 1024 NI SVGA color monitor, .28mm dot pitch
- On-board SCSI socket
- Two VESA local bus, five 16-bit and one 8-bit expansion slots
- Six-bay desktop w/2 cooling fans
- 101-key space-saving keyboard
- Microsoft Mouse
- MS-DOS 6.2 w/Tools, Windows for Workgroups 3.11

PACKAGE 3

- **486SX-25** .... **$1795** — Lease $65/month
- **486DX-33** .... **$1995** — Lease $72/month
- **486DX2-50** .... **$2095** — Lease $76/month
- **486DX2-66** .... **$2195** — Lease $79/month
- **486DX4-75** .... **$2395** — Lease $87/month
- **486DX4-100** .... **$2595** — Lease $94/month

- **Intel Verified:** for the Pentium™ OverDrive™ Processor
- 8MB high-speed RAM
- 426MB local bus hard drive w/128K cache
- **2X CD-ROM** and 3.5" FDD
- Diamond SpeedStar Pro Windows-accelerated local bus video with 1MB RAM
- 14" 1024 NI SVGA color monitor, .28mm dot pitch
- On-board SCSI socket
- Two VESA local bus, five 16-bit and one 8-bit expansion slots
- Six-bay desktop w/2 cooling fans
- 101-key space-saving keyboard
- Microsoft Mouse
- MS-DOS 6.2 w/Tools, Windows for Workgroups 3.11
- Choice of Lotus Application

PACKAGE 4

- **486SX-25** .... **$2195** — Lease $79/month
- **486DX-33** .... **$2395** — Lease $87/month
- **486DX2-50** .... **$2495** — Lease $90/month
- **486DX2-66** .... **$2595** — Lease $94/month
- **486DX4-75** .... **$2795** — Lease $101/month
- **486DX4-100** .... **$2995** — Lease $108/month

- **Intel Verified:** for the Pentium™ OverDrive™ Processor
- 16MB high-speed RAM
- 528MB local bus hard drive w/256K cache
- **2X CD-ROM** and 3.5" FDD
- Diamond SpeedStar Pro Windows-accelerated local bus video with 1MB RAM
- 14" 1024 NI SVGA color monitor, .28mm dot pitch
- On-board SCSI socket
- Two VESA local bus, five 16-bit and one 8-bit expansion slots
- Six-bay desktop w/2 cooling fans
- 101-key space-saving keyboard
- Microsoft Mouse
- MS-DOS 6.2 w/Tools, Windows for Workgroups 3.11
- Choice of Lotus Application

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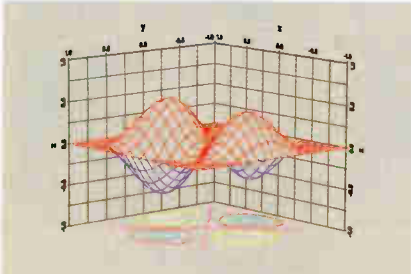
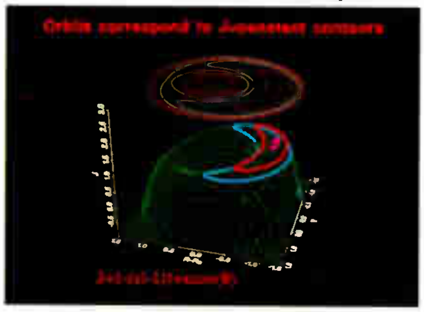
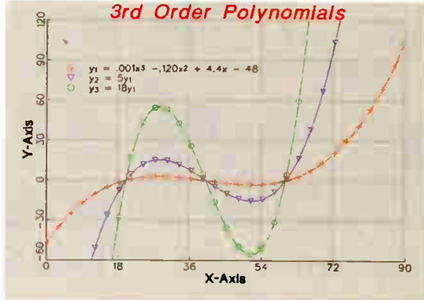


Bessel Function J_{21} * Cos (2*theta)





DOS

NDP Fortran has come with DOS screen graphics since it was introduced in 1987. The problem with this approach today is that just writing to the screen is not enough. You also have to be able to interface the 32-bit API that comes with your OS and possibly other API's. However, taking advantage of a single API is a time consuming tedious task.

OS/2

VGP solves the API interface problem with a universal vector output format that can be converted into EPS, TIF, GEM, HPGL2, CGM, WMF, etc. You create plots or graphics with calls to NDP Fortran or C. Included with the compiler is a DISPLAY program that runs on the OS you ordered. If you want to export your work, import PS or TT fonts or do real time screen plots by

Windows

binding **VGP** into your program, you can purchase one of several upgrades, or the source! Best of all, you get the same output independent of the OS you are using and **VGP** supports over 20 different types of plots, making it easy to create displays which communicate your ideas.
DISPLAY Export Extensions..................$145
Binary/C Source library................$395/695

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DOS Pentium version............................$995
OS/2 Developer's Pack includes IBM OS/2 WorkFrame and Toolkit. These tools use the IBM Linker. Deduct $100 if you don't need the Workframe. 386,486.................................$595
Pentium..$795
UNIX 386/486 use the native tools and are available for **SCO** or **ISC** UNIX............... $1195
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486-BX Workstations - a Microway Tower is the ideal solution to your 486/Pentium needs. They feature industrial grade American power supplies, heavy duty cooling and easy access. All motherboards are carefully burned in and equipped with 50 Amp connectors. Some of our motherboards can be upgraded or purchased with Pentiums. Our BX Towers make great Workstations, file servers, and CAD/CAM stations. They were originally engineered to house i860 arrays, configured as NFS computational servers. Each system is customized with the OS of your choice, including ISC UNIX, OS/2, DOS and Windows. What differentiates Microway towers is our ability to integrate the peripherals you need, including SCSI tape drives and CD-ROMs, network cards and high quality hard disk and graphics adapters. 486-BX systems are used worldwide performing demanding tasks from testing jet engines to searching for oil. Call today for our BX Catalogue.

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NAG Microway compiled and validated Foundation x86/i860.........................$1195/1995
FortLP..$1195/1995
Workstation.......................................$2995/3995
KUCK & ASSOCIATES hand coded i860 libraries. DSP library does 1024 real FFT in 500 microseconds!
DSP......................$750 **BLAS**......................$500
LAPACK and BLAS, sources included. 386/486................$195 i860......................$295

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BYTE BEST

ISA 486S FOR WINDOWS

For fast performance and economy in high-end systems, ISA-based 486DX2s continue to set the standard for Windows applications. The 26 ISA-based 486 systems we tested average about $3500 in our test configuration.

Out of the five Best Overall systems, American Multisystems' Info Gold 486 PCI (which also ranked in Most Expandable and Low Cost) uses PCI, and Hewlett-Packard's Vectra 486 66/XM uses a proprietary local-bus design. Also, the PCI-based MicroSource Tempest IV/IPCI-66 qualified as a runner-up in Most Expandable and Low Cost, and Zenon's $1995 Z-Novus PCI, the lowest-price system ranked here, is also PCI-based.

Cornell Computer Systems' Power Pak, a VL-Bus system, swept all three Windows categories. Nevertheless, several runners-up also offered a good mix of performance and price. For example, in Most Expandable, the Info Gold 486 PCI scored nearly as fast as the Power Pak and costs $100 less than the Cornell system. Close behind is the MicroTech Ultima XV2/66, which has one drawback: Its four SIMM sockets are positioned near the expansion slots, which makes it difficult to install some full-length boards.

KEY

Ease of Use:

Poor ▲ Fair ▲▲

Good ▲▲▲ Excellent ▲▲▲▲

Case:

Desktop ▬ Tower ▮

Mini-tower ▯

Prop = proprietary.

Want the fastest Windows 486?

BEST OVERALL Cornell Power Pak

This ISA-based tower's Windows speed was the highest among all the 486 systems we tested, while its $3000 price tag ranks with the least expensive 486 systems. The Cornell Power Pak uses the Weitek P9000 video accelerator (which powered the top four Windows performers) and a Western Digital IDE hard drive. Micron's 466 VL WinStation CD Windows performance fell just shy of the Power Pak's and like the Cornell system, earned high marks for its ease of use. The Gateway 4DX2-66V's Windows performance was above the class average of 1.63 and like the Hewlett-Packard Vectra 486 66/XM, leads the Best Overall pack for systems designed in a desktop case.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Cornell Power Pak	$2995	▮	2.04	▲▲▲▲	5.77	ISA/VL	16/128	420/IDE	36	Weitek P9000
RUNNER-UP	Micron 466 VL WinStation	$2978	▬	1.99	▲▲▲▲	4.66	ISA/VL	16/64	340/IDE	Lifetime	Weitek P9000
RUNNER-UP	Gateway 4DX2-66V	$2795	▬	1.78	▲▲▲▲	5.48	ISA/VL	16/64	424/IDE	12	ATI Mach 32
RUNNER-UP	AMS Info Gold 486 PCI	$2899	▮	1.94	▲▲▲	5.15	ISA/PCI	16/128	540/SCSI	12	Weitek P9001
RUNNER-UP	HP Vectra 486 66/XM	$4757	▬	1.78	▲▲▲▲	5.78	ISA/Prop.	16/64	450/IDE	36	S3 928

Need speed and space?

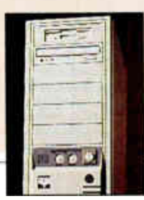
MOST EXPANDABLE Cornell Power Pak

This system's large tower case holds four 5¹/₄-inch and two 3¹/₂-inch disk drives. Four 16-bit ISA and one VL-Bus slot are available for additional boards. The four SIMM sockets are easily accessible on the motherboard. However, a cooling fan on top of the processor obstructs access to cache memory slots. The first runner-up, American Multisystems' Info Gold 486 PCI, conveniently has its power, turbo, and reset switches in the front panel.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	OPEN BAYS 3½/5¼	AVAILABLE SLOTS	VIDEO
BEST	Cornell Power Pak	$2995	▮	2.04	▲▲▲▲	5.77	ISA/VL	16/128	2/4	5	Weitek P9000
RUNNER-UP	AMS Info Gold 486 PCI	$2899	▮	1.94	▲▲▲	5.15	ISA/PCI	16/128	0/3	5	Weitek P9001
RUNNER-UP	MicroTech Ultima XV2/66	$3999	▮	1.82	▲▲▲	5.10	ISA/VL	16/64	1/1	5	ATI Mach 32
RUNNER-UP	Data Storage DataStor	$4575	▮	1.71	▲▲▲▲	4.36	ISA/VL	16/128	4/1	3	S3 P86C928
RUNNER-UP	MicroSource Tempest IV	$2825	▮	1.72	▲▲▲	4.79	ISA/PCI	16/256	3/1	4	S3 805

Cost-conscious?

LOW COST Cornell Power Pak



By far the speed leader among low-cost 486s, the Power Pak offers a lengthy 36-month warranty. The Zenon Z-Novus PCI offers the lowest price in this category (and a warranty double the Power Pak's), but it has a slower Windows score than the Gateway 4DX2-66V, which offers the second lowest pace here and is the only other desktop design ranked for low cost.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Cornell Power Pak	$2995	▮	2.04	▲▲▲▲	5.77	ISA/VL	16/128	420/IDE	36	Weitek P9000
RUNNER-UP	Zenon Z-Novus PCI	$1995	▬	1.65	▲▲▲	5.47	ISA PCI	16/128	420/IDE	72	S3 428
RUNNER-UP	AMS Info Gold 486 PCI	$2899	▮	1.94	▲▲▲	5.15	ISA/PCI	16/128	540/SCSI	12	Weitek P9001
RUNNER-UP	Gateway 4DX2-66V	$2795	▬	1.78	▲▲▲▲	5.48	ISA/VL	16/64	424/IDE	12	ATI Mach 32
RUNNER-UP	MicroSource Tempest IV	$2825	▮	1.72	▲▲▲	4.79	ISA/PCI	16/256	425/IDE	12	S3 805

NSTL

PC Digest RATINGS REPORT

NSTL Extends Coverage into the Far East

NSTL extends its coverage of computer products to the Far East with its testing partner LANBIT of Taiwan R.O.C. Using NSTL's proven testing methodology LANBIT provides an accurate and detailed look at leading notebook computers from Far Eastern suppliers. Look for an upcoming report on 16-bit Ethernet adapters, available in the Far East, in the April issue of ***PC Digest Ratings Report.***

National Software Testing Laboratories is the world's leading microcomputer and LAN hardware and software testing company. Publishers of ***Software Digest and PC Digest Rating Reports,*** NSTL accepts no advertising and provides completely objective comparisons of computer systems, peripherals, and software from the industry's leading suppliers.

NSTL provides a detailed review of 12 notebook computers comparing performance, battery life, screen quality, ease of use and quality.

- Two of the products use a DX4- 75MHz clock speed 80486 microprocessor, four use a 486 DX/66 two the 50MHz version, one a 486 DX/40, two the 33MHz 486 chip while just one uses a 486 SX/25.
- Although five of the twelve products use an Intel 3.3 volt microprocessor the products with the best battery life used 5 volt versions.
- Products with active matrix color displays generally produced the best screen quality test scores. Only one of the twelve products used a monochrome display.
- Hard disk capacity ranged from 80 MB to 250 MB, all but two products provided internal 3.5-inch floppy disk drives.

For the full PC Digest report with complete features listing and test results call 1-800 220 NSTL. (Outside the USA call 1-610-941-9600) or Fax 1-610-941-9952

Comparison of 12 Notebook Computers

PC Digest Rating	Overall Evaluation	System	Processor	Monitor	Performance	Usability	Features	Battery	Screen
★★★★	8.7	Compal TS30AT	486DX/66	Color	▲	▲	▲	▲	▲
★★★★	8.7	Arima NotePro 486	486DX/66	Color	▲	▲	▲	▲	▲
★★★★	8.4	First Computer LEO DESIGNote	486DX/33	Color	■	▲	▲	▲	▲
★★★	7.8	Compal TS30MC	486DX/75	Color	▲	▲	▲	▲	■
★★★	7.6	AUVA NBE Plus 486C	486DX/75	Color	▲	▲	▲	▼	▲
★★★	7.5	Philips NB-402CT	486DX/66	Color	▲	■	■	■	▲
★★★	7.4	Jetta J-book 486	486DX/66	Color	▲	▲	▲	■	▲
★★★	7.3	Acer AcerNote 760CX	486DX/50	Color	■	▲	■	▲	▲
★★	6.9	Veridata JemPower 486E	486DX/50	Mono	■	▲	▲	■	■
★★	6.7	Arima Compact Note	486SX/25	Color	▼	▲	▲	■	▲
★★	6.6	Sunrex InnoVACE Hyperbook 320PEN	486DX/40	Color	■	▲	■	■	▲
★★	6.3	DTK DSN-3340C0	486DX/33	Color	■	▲	■	■	▲

Ratings Key

(On a scale of 0 to 10)

OVERALL EVALUATION

★★★★★ 9.0 or higher
★★★★ 8.0-8.9
★★★ 7.0-7.9
★★ 6.0-6.9
★ 5.0-5.9

ALL OTHER RATINGS

▲ 7.0-9.9
■ 5.0-6.9
▼ under 5.0

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BYTE BEST

EISA 486S FOR WINDOWS

Out of the 37 486s we tested, 11 came with an EISA-bus architecture. EISA systems cost an average of $1400 more than a similarly equipped ISA system (however, some EISA prices reflect a configuration of 32 MB versus 16 MB in the ISA category). The high-performance EISA 486s even averaged about $500 more than ISA-based Pentiums. (EISA Pentiums cost $8000, on average.)

Also, out of the 11 EISA-based machines, 10 supported VL-Bus; the exception was AST Research's Premmia 4/66d, Model 343M, the first runner-up in Best Overall, which uses a proprietary local-bus design.

Despite the higher cost of EISA systems, we found little performance advantage in our Windows tests. For example, Cornell Computer Systems sent 486s that outran all others in our ISA and EISA Windows tests. The ISA-based Cornell Power Pak posted a Windows score of 2.04 versus the Cornell EISA-VL SCSI-2's leading score of 1.91. The faster speed overall in the ISA systems may be attributed partly to faster video systems in those machines. (The Weitek P9000 powered the Cornell ISA-based system and the Tseng Labs W32i accelerated the Cornell EISA system.)

KEY

Ease of Use:

Poor ▲ Fair ▲▲
Good ▲▲▲ Excellent ▲▲▲▲

Case:

Desktop ▬ Tower ▮
Mini-tower ▯

Prop = proprietary.

For the best in speed and usability...

BEST OVERALL Cornell EISA-VL SCSI-2

This EISA system earned a Windows performance index of 1.91, the highest among systems ranked in this category and almost twice as fast as our baseline system. Besides scoring high in our performance tests, this system is also easy to use and offers a 16550 UART (universal asynchronous receiver/transmitter) for fast serial communication, as well as flash ROM for easy BIOS updates. The system sells for an economical price under $4500. The AST Premmia's Windows score of 1.87 nearly matches the Cornell's, and the Premmia also earned the best features rating in the category. This is the EISA machine to buy if you're looking for the best desktop-case system.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Cornell EISA-VL SCSI-2	$3995	▮	1.91	▲▲▲▲	6.14	EISA/VL	32/256	1024/SCSI	36	Tseng W32i
RUNNER-UP	AST Premmia 4/66d	$6862	▬	1.87	▲▲▲▲	6.25	EISA/Prop.	32/128	1024/SCSI	36	ATI Mach 32
RUNNER-UP	Micron 466 VLE WinServer	$4498	▮	1.80	▲▲▲▲	5.29	EISA/VL	32/64	540/SCSI	Lifetime	Weitek P9000
RUNNER-UP	CompuAdd C466De	$5806	▮	1.78	▲▲▲	4.88	EISA/VL	16/128	1024/SCSI	12	ATI Mach 32
RUNNER-UP	MIS Computer Systems M466EV	$4451	▮	1.76	▲▲▲	4.81	EISA/VL	32/64	1024/SCSI	12	Weitek

Need growth potential?

MOST EXPANDABLE Cornell EISA-VL SCSI-2

In addition to its superior performance, this huge tower also supplies growing room: It offers two 3½-inch drive bays and four 5¼-inch drive bays, along with three available EISA slots and one VL-Bus slot. CompuAdd's C466De Mini Tower posted the second-highest speed scores. Its sturdy tower chassis supports four 3½-inch and three 5¼-inch drives. Five 32-bit EISA and one VL-Bus expansion slot were available for additional cards.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	OPEN BAYS 3½/5¼	AVAILABLE SLOTS	VIDEO
BEST	Cornell EISA-VL SCSI-2	$3995	▮	1.91	▲▲▲▲	6.14	EISA/VL	32/256	2/4	4	Tseng W32i
RUNNER-UP	CompuAdd C466De	$5806	▮	1.78	▲▲▲	4.88	EISA/VL	16/128	2/2	6	ATI Mach 32
RUNNER-UP	Micro Express MicroFlex	$4800	▮	1.76	▲▲▲▲	3.51	EISA/VL	32/128	4/4	8	Tseng W32i
RUNNER-UP	MIS Computer Systems M466EV	$4451	▮	1.76	▲▲▲	4.81	EISA/VL	32/64	2/4	4	Weitek
RUNNER-UP	DEC DECpc 466 MTE	$5715	▮	1.67	▲▲▲▲	5.56	EISA/VL	32/128	0/2	4	N/A

When you need speed and economy...

LOW COST Cornell EISA-VL SCSI-2

Fast performance, excellent features, and a price below the average of $4900 enabled this system to sweep our categories for EISA-based 486s. If your budget requires an EISA system that is less expensive than the Cornell and you can settle for slower Windows performance, consider the American Multisystems' Info Gold E-Server, the least expensive system we ranked in this class.

		PRICE	CASE TYPE	WINDOWS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Cornell EISA-VL SCSI-2	$3995	▮	1.91	▲▲▲▲	6.14	EISA/VL	32/256	1024/SCSI	36	Tseng W32i
RUNNER-UP	AMS Info Gold E-Server	$3499	▮	1.66	▲▲▲	4.30	EISA/VL	32/256	1024/SCSI	12	S3 805
RUNNER-UP	MIS Computer Systems M466EV	$4451	▮	1.76	▲▲▲	4.81	EISA/VL	32/64	1024/SCSI	12	Weitek
RUNNER-UP	Micro Express MicroFlex	$4800	▮	1.76	▲▲▲▲	3.51	EISA/VL	32/128	1024/SCSI	24	Tseng W32i

N/A = not available.

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BYTE BEST

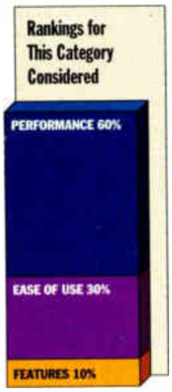
486S FOR UNIX

For Unix-based scientific and engineering applications, the Pentium systems we tested provided the fastest processing (see "Pentiums for Unix" on page 211). For example, IBM's ValuePoint 6387-W90 was the fastest 486 we ranked for Unix; its BYTE Unix benchmark score of 1.64 was almost 15 percent slower than the slowest Best Overall Pentium for Unix.

However, high-end speed comes at a high price: The average of Pentiums ranked for Best Overall was $5855. By contrast, the 486s we rank here for Best Overall offer solid Unix scores and an average price of $4183.

The IBM ValuePoint, a VL-Bus/ISA design, topped our tests, but we also discovered that Cornell's VL-Bus/EISA machine offers comparable Unix speed. Each of these machines come in tower cases. For top Unix speed in a desktop format, we recommend Hewlett-Packard's Vectra 486 66/XM, a $4757 ISA system.

Dyna Micro's 486 Business System, which sells for $3006, is the highest-priced system among the Low Cost 486s, but it offers the second fastest BYTE Unix score among these contenders. The Quantex Q486 is the lowest-priced system here.



KEY

Ease of Use:

Poor ▲ Fair ▲▲
Good ▲▲▲ Excellent ▲▲▲▲

Case:

Desktop ▬ Tower ▮
Mini-tower ▯

Prop = proprietary.

Want the best all-around performer?

BEST OVERALL IBM ValuePoint 6387-W90

The fastest 486 system in the BYTE Unix benchmarks, the ValuePoint 6387-W90 also ranked among the fastest systems for SPEC integer scores. In addition, its S3 805 video and Maxtor hard disk systems were among the fastest tested. This ISA/VL-Bus tower accommodates up to 64 MB of RAM. (This system's keyboard uses the Trackpoint pointing device found in IBM's ThinkPad portables.) In addition, the ValuePoint earned among the highest scores for ease of use. If you require a desktop case, choose the Hewlett-Packard Vectra 486 66/XM, an ISA system that uses a proprietary local-bus design and a video system built around the S3 928 accelerator. The Vectra was also the only system we received that came with an integrated Ethernet port.

		PRICE	CASE TYPE	UNIX SPECINT	UNIX BYTE	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	IBM ValuePoint 6387-W90	$4994	▮	33.60	1.64	▲▲▲▲	6.26	ISA/VL	16/64	527/IDE	12	S3 805
RUNNER-UP	Cornell EISA-VL SCSI-2	$3995	▮	33.15	1.62	▲▲▲▲	6.14	EISA/VL	32/256	1024/SCSI	36	Tseng W32i
RUNNER-UP	HP Vectra 486/66XM	$4757	▬	32.63	1.51	▲▲▲▲	5.78	ISA/Prop.	16/64	450/IDE	36	S3 928
RUNNER-UP	Cornell Power Pak	$2995	▮	34.37	1.59	▲▲▲▲	5.77	ISA/VL	16/128	420/IDE	36	Weitek P9000
RUNNER-UP	ALR-Flyer VL 4/66d	$4174	▯	29.14	1.46	▲▲▲▲	5.19	ISA/VL	20/36	540/IDE	60	WD90C33

Want fast Unix and room to grow?

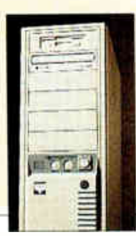
MOST EXPANDABLE Cornell EISA-VL SCSI-2

This EISA/VL-Bus tower provides the fastest performance in this category in the BYTE Unix tests, along with plenty of room to grow. It can hold up to eight drives, and it offers 16 SIMM sockets for up to 256 MB of RAM. The internal cabling is well placed, so you can access all internal components without a fight. Cornell's ISA-based cousin was the second-fastest most expandable system in BYTE's Unix tests.

		PRICE	CASE TYPE	UNIX SPECINT	UNIX BYTE	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	OPEN BAYS 3½/5¼	AVAILABLE SLOTS	VIDEO
BEST	Cornell EISA-VL SCSI-2	$3995	▮	33.15	1.62	▲▲▲▲	6.14	EISA/VL	32/256	2/4	4	Tseng W32i
RUNNER-UP	Data Storage DataStor (ISA)	$4575	▮	30.87	1.40	▲▲▲▲	4.36	ISA/VL	16/128	4/1	3	S3 P86C928
RUNNER-UP	Cornell Power Pak	$2995	▮	34.37	1.59	▲▲▲▲	5.77	ISA/VL	16/128	2/4	5	Weitek P9000
RUNNER-UP	MicroTech Ultima XV2/66	$3999	▮	32.87	1.55	▲▲▲	5.10	ISA/VL	16/64	1/1	5	ATI Mach 32
RUNNER-UP	Data Storage DataStor (EISA)	$5595	▮	33.59	1.42	▲▲▲▲	4.34	EISA/VL	32/128	2/1	3	S3 P86C928

A speed leader for under $3000...

LOW COST Cornell Power Pak



Only eight of the 37 systems we tested cost less than the Cornell Power Pak, which also posted the fastest (by up to 30 percent) BYTE Unix score among systems ranked for low cost. This solid tower holds up to six storage devices and four SIMM sockets for up to 128 MB of memory. If you need a desktop case, choose the Dyna Micro 486 Business System, which offers the second fastest BYTE Unix speed and a $3000 price. Gateway's 4DX2-66V was the only other desktop design ranked here; it sells for $200 less than the Business System.

		PRICE	CASE TYPE	UNIX SPECINT	UNIX BYTE	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Cornell Power Pak	$2995	▮	34.37	1.59	▲▲▲▲	5.77	ISA/VL	16/128	420/IDE	36	Weitek P9000
RUNNER-UP	Dyna Micro Business System	$3006	▬	30.51	1.40	▲▲▲	4.61	ISA/VL	16/32	546/IDE	12	S3 805
RUNNER-UP	Quantex Q486 DX2/66	$2699	▮	20.24	1.00	▲▲▲▲	5.36	ISA/VL	16/N/A	425/IDE	12	Weitek 9000
RUNNER-UP	Mitsuba MIT486/66V	$2900	▮	26.90	1.24	▲▲▲	4.38	ISA/VL	16/32	544/IDE	24	Cirrus Logic 5428
RUNNER-UP	Gateway 4DX2-66V	$2795	▬	29.49	0.50	▲▲▲▲	5.48	ISA/VL	16/64	424/IDE	12	ATI Mach 32

N/A = not available.

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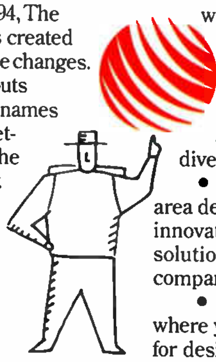

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- *Internet Showcase,*™ where you can learn about the richness and diversity of the Internet.
- *Start-Up City,*™ an exhibit area dedicated to showcasing innovative new products and solutions from emerging companies.
- *Configuration Clinic,*™ where you can get suggestions for designing and configuring your network from the best in the business.
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BYTE BEST

486S FOR DOS

When we tested EISA and ISA 486s for DOS, we found that the best machines for Windows weren't necessarily the best 486s for the more venerable operating system.

The Cornell EISA-VL SCSI-2 continued its winning ways (see page 217) with a pace-setting DOS score of 2.19. Also, in the Best Overall competition, IBM's ValuePoint 6387-W90 offered only average performance, but its range of features made it a strong contender. It offers flash ROM and a 16550 UART (universal asynchronous receiver/transmitter) for fast serial communication. Its internal design has no obstructed slots and its documentation is among the most complete we saw. However, ValuePoint didn't include a reset switch.

The strengths of the MicroSource Tempest IV/IPCI-66, which ranked as first runner-up in Most Expandable and as the leader for Low Cost, are its speed and price. Compared to the ValuePoint and the Premmia 4/66d, however, the Tempest received an inferior ease-of-use score. This was partly due to incomplete documentation that could force you to call the company's technical-support line to solve hardware problems.

KEY

Ease of Use:

Poor ▲ Fair ▲▲

Good ▲▲▲ Excellent ▲▲▲▲

Case:

Desktop ▬ Tower ▮

Mini-tower ▯

Prop = proprietary.

If you need the fastest DOS machine...

BEST OVERALL Cornell EISA-VL SCSI-2

This EISA/VL-bus tower ran our DOS tests faster than any other 486 we tested. It flew through the DOS application benchmarks 2.19 times faster than the baseline computer. The Cornell accepts a Pentium CPU upgrade, and it is one of a handful of 486s that can hold a megabyte of secondary cache. The Cornell uses a 16550 UART (universal asynchronous receiver/transmitter) that allows for much faster data transfers than the old 8550 version did, which much of the competition still uses. The prime drawback to the Cornell is that you must tie up one of the serial ports with a mouse because the system lacks a mouse port (it includes a 9- and 25-pin serial port, however). For the best ISA system for DOS, choose IBM's ValuePoint 6387-W90, a roomy tower that posted the fourth fastest DOS scores among the systems ranked here. AST's Premmia 4/66d, Model 343M is the top choice among desktop designs.

		PRICE	CASE TYPE	DOS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	Cornell EISA-VL SCSI-2	$3995	▮	2.19	▲▲▲▲	6.14	EISA/VL	32/256	1024/SCSI	36	Tseng W32i
RUNNER-UP	Micro Express Microflex-VE/66	$4800	▮	2.09	▲▲▲▲	3.51	EISA/VL	32/128	1024/SCSI	24	Tseng W32i
RUNNER-UP	IBM ValuePoint 6387-W90	$4994	▮	1.82	▲▲▲▲	6.26	ISA/VL	16/64	527/IDE	12	S3 805
RUNNER-UP	AST Premmia 4/66d	$6862	▬	1.70	▲▲▲▲	6.25	EISA/Prop.	32/128	1024/SCSI	36	ATI Mach 32
RUNNER-UP	MicroSource Tempest IV/IPCI-66	$2825	▮	1.96	▲▲▲	4.79	ISA/PCI	16/256	425/IDE	12	S3 805

For growth without compromise...

MOST EXPANDABLE Micro Express MicroFlex-VE/66

The MicroFlex-VE/66 is a roomy tower with a total of six 32-bit slots and two VL-Bus slots. There are 16 SIMM sockets that are conveniently placed on the motherboard away from the adapter slots, so you can easily upgrade the system to its maximum 128 MB of RAM. The system also accommodates four 5¼-inch and three 3½-inch mass-storage devices.

		PRICE	CASE TYPE	DOS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX.	OPEN BAYS 3½/5¼	AVAILABLE SLOTS	VIDEO
BEST	Micro Express MicroFlex-VE/66	$4800	▮	2.09	▲▲▲▲	3.51	EISA/VL	32/128	3/4	8	Tseng W32i
RUNNER-UP	MicroSource Tempest IV/IPCI-66	$2825	▮	1.96	▲▲▲	4.79	ISA/PCI	16/256	3/1	4	S3 805
RUNNER-UP	AMS Info Gold 486 PCI	$2899	▮	1.73	▲▲▲	5.15	ISA/PCI	16/128	0/3	5	Weitek P9001
RUNNER-UP	Data Storage DataStor (ISA)	$4575	▮	1.69	▲▲▲▲	4.36	ISA/VL	16/128	4/1	3	S3 P86C928
RUNNER-UP	Acma Computers 486	$3295	▮	1.57	▲▲▲▲	5.06	ISA/VL	16/64	1/3	5	Cirrus Logic

When price matters...

LOW COST MicroSource Tempest IV/IPCI-66

This tower is almost twice as fast as the baseline system, while its price comes in under $3000. The trade-offs it makes for low cost include the slow 8550 UART (universal asynchronous receiver/transmitter) and the lack of flash ROM. Also, the machine's disk and video subsystems scores couldn't compete with the more expensive models listed in Best Overall. Dyna Micro's 486 Business System offers the fastest DOS performance among desktop systems ranked for low cost.

		PRICE	CASE TYPE	DOS SPEED	EASE OF USE	FEATURES SCORE	BUS	RAM (MB) STD./MAX	HARD DRIVE (MB)	WARRANTY (MONTHS)	VIDEO
BEST	MicroSource Tempest IV/IPCI-66	$2825	▮	1.96	▲▲▲	4.79	ISA/PCI	16/256	425/IDE	12	S3 805
RUNNER-UP	Zenon Computer Z-Novus	$1995	▬	1.42	▲▲▲	5.47	ISA/PCI	16/128	420/IDE	72	S3 428
RUNNER-UP	Dyna Micro Business System	$3006	▬	1.69	▲▲▲	4.61	ISA/VL	16/32	546/IDE	12	S3 805
RUNNER-UP	AMS Info Gold 486 PCI	$2899	▮	1.73	▲▲▲	5.15	ISA/PCI	16/128	540/SCSI	12	Weitek P9001
RUNNER-UP	Gateway 4DX2-66V	$2795	▬	1.58	▲▲▲▲	5.48	ISA/VL	16/64	424/IDE	12	ATI Mach 32

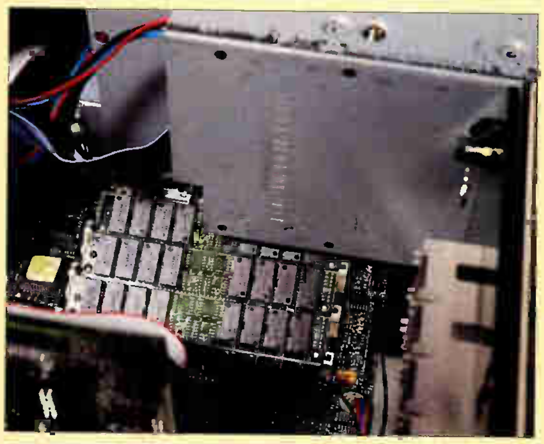
HONORABLE MENTIONS

The IBM ValuePoint 6387-W90 and the IBM ValuePoint P60/D offer an innovative idea in keyboard design: The integrated Trackpoint pointing device allows you to navigate graphical applications without taking your hands off the keyboard to use a mouse.

If you have a CD-ROM drive that loads CDs directly without a caddy, the drive must lie horizontally, unless your system uses Toshiba's XM-4101B CD-ROM drive, as do the Pentiums and 486s we received from DEC. This unique drive design uses three spring-backed ball bearings to hold a CD in place.

Dubious Achievements

International Instrumentation's Business Partner is one of the fastest machines we tested; unfortunately, the company needs to be more careful during the assembly process. The glue that fastens the heat sink to the CPU leaked into an unsightly mess on the motherboard. Also, this system's parallel-port casing is attached upside down.



To upgrade the RAM on the Ambra Computer DP60 PCI, you must dismantle the entire floppy drive bay. Once the drives are disconnected, you must remove the bay housing to reach the SIMM slots. ▷

The Acma 486 Tower includes both a 3½-inch and 5¼-inch floppy drive. Unfortunately, the manufacturer doesn't follow the convention of designating the 3½-inch drive as the A drive. We couldn't reverse drive designations from within the BIOS setup since both drives are on the same ribbon cable connector, and the documentation did not provide any information on changing jumpers.

The EasternTech ET P60-PCI, Mega Computer Systems Impact 486 DX2/66DT, and Xinetron X/LAN 586 each have the same basic design flaw: The shelf behind the expansion slots is too close to the chassis to connect a portable network adapter directly into the parallel port. We had to use extensions to install the adapters.

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VENDOR	MODEL	PRICE	BUS TYPE	LOCAL BUS	CASE TYPE	PERFORMANCE: DOS	PERFORMANCE: WINDOWS	PERFORMANCE: UNIX SPECINT	PERFORMANCE: UNIX SPECFP	PERFORMANCE: UNIX BYTE	EASE OF USE	INSTALLED RAM (MB)[7]
Advanced Logic Research, Inc.	**Evolution V-Q/66[1]**	**$9765**	**EISA**	**VL-Bus**	▮	**2.43**	**2.83**	**61.49**	**52.07**	**2.46**	▲▲▲	**32**
Ambra Computer Corp.	DP60 PCI	$4977	ISA	PCI	▬	2.01	2.76	45.56	42.00	1.97	▲	32
American Multisystems	Info Gold P60 PCI	$3299	ISA	PCI	▮	2.15	2.76	—[2]	—[2]	—[2]	▲▲▲	32
Dell Computer Corp.	Dimension XPS P60	$3896	ISA	PCI	▬	2.03	2.39	47.42	41.80	1.99	▲▲▲▲	16
Dell Computer Corp.	**OmniPlex 566[1]**	**$6917**	**EISA**	**PCI**	▬	**2.49**	**3.12**	—[3]	—[3]	—[3]	▲▲▲▲	**32**
Digital Equipment Corp.	DECpc 560ST	$9131	EISA	Proprietary	▮	2.06	2.23	53.19	46.59	2.43	▲▲▲▲	32
Digital Equipment Corp.	DECpc XL 560	$5436	ISA	PCI	▮	2.05	2.82	46.90	43.57	2.01	▲▲▲▲	16
Duracom Computer Systems	Multimedia FilePro Pentium 60-PCI	$5649	ISA	PCI	▮	1.93	2.44	46.62	41.74	1.79	▲▲▲	32
EasternTech Corp.	ET P60-PCI	$4995	ISA	PCI	▮	2.17	2.47	—[2]	—[2]	—[2]	▲▲▲▲	32
Gateway 2000	Gateway P5-60	$3265	ISA	PCI	▮	2.10	2.51	45.44	41.40	1.96	▲▲▲▲	32
IBM Personal Computer Co.	ValuePoint P60/D	$6075	ISA	PCI	▬	2.26	2.65	45.67	41.11	1.98	▲▲▲	16
Insight Direct	Insight PCI P60 Multimedia	$3219	ISA	PCI	▮	2.23	2.61	47.04	41.41	1.90	▲▲▲▲	16
International Instrumentation, Inc.	Business Partner	$4447	ISA	VL-Bus	▮	1.67	3.06	—[2]	—[2]	—[2]	▲▲▲▲	32
Micro Express	MicroFlex-VL/Pentium	$4699	ISA	VL-Bus	▮	1.88	2.41	44.19	38.54	1.65	▲▲▲▲	32
Micron Computer, Inc.	P60 PCI PowerStation CD	$5338	ISA	PCI	▬	2.14	2.43	45.78	41.69	1.93	▲▲▲	32
MIS Computer Systems	M560P	$4280	ISA	PCI	▬	1.75	2.27	—[4]	—[4]	—[4]	▲▲▲	32
Unisys Corp.	PW^2 Advantage Plus 5606	$6211	EISA	None	▬	2.19	2.54	—[5]	—[5]	—[5]	▲▲▲	32
Xi Computer Corp.	Xi P60 NTower	$5199	ISA	PCI	▮	1.85	2.30	—[2]	—[2]	—[2]	▲▲▲▲	32
Xinetron, Inc.	X/LAN 586	$3895	ISA	VL-Bus	▮	2.02	2.35	45.36	38.75	1.86	▲▲▲	32
Zenon Computer	Z-Optimus	$2645	ISA	PCI	▮	2.00	2.78	—[3]	—[3]	—[3]	▲▲▲	16

486DX2/66

VENDOR	MODEL	PRICE	BUS TYPE	LOCAL BUS	CASE TYPE	PERFORMANCE: DOS	PERFORMANCE: WINDOWS	PERFORMANCE: UNIX SPECINT	PERFORMANCE: UNIX SPECFP	PERFORMANCE: UNIX BYTE	EASE OF USE	INSTALLED RAM (MB)[7]
Access Computers Technologies	ACT 486-66MHz	$3499	ISA	VL-Bus	▮	1.31	1.49	—[4]	—[6]	—[4]	▲▲▲	16
Acma Computers, Inc.	486 Tower	$3295	ISA	VL-Bus	▮	1.57	1.49	26.68	—[6]	1.28	▲▲▲▲	16
Advanced Logic Research, Inc.	Flyer VL 4/66d	$4174	ISA	VL-Bus	▯	1.61	1.27	29.14	—[6]	1.46	▲▲▲▲	20
American Multisystems	Info Gold 486 PCI	$2899	ISA	PCI	▮	1.73	1.94	—[2]	—[6]	—[2]	▲▲▲	16
American Multisystems	Info Gold E-Server	$3499	EISA	VL-Bus	▮	1.43	1.66	29.72	—[6]	1.44	▲▲▲	32
AST Research, Inc.	Premmia 4/66d, Model 343M	$6862	EISA	Proprietary	▬	1.70	1.87	32.33	—[6]	1.63	▲▲▲▲	32
Compaq Computer Corp.	Prolinea MT 4/66 Model 340/CDS	$3859	ISA	Proprietary	▮	1.51	1.42	25.10	—[6]	1.20	▲▲▲▲	20
CompuAdd Computer Corp.	C466D Mini Tower	$4062	ISA	VL-Bus	▯	1.73	1.83	32.99	—[6]	1.60	▲▲▲	16
CompuAdd Computer Corp.	C466De Mini Tower	$5806	EISA	VL-Bus	▯	1.79	1.78	—[5]	—[6]	—[5]	▲▲▲	16
Cornell Computer Systems	**Cornell EISA-VL SCSI-2**	**$3995**	**EISA**	**VL-Bus**	▮	**2.19**	**1.91**	**33.15**	—[6]	**1.62**	▲▲▲▲	**32**
Cornell Computer Systems	**Cornell Power Pak**	**$2995**	**ISA**	**VL-Bus**	▮	**1.59**	**2.04**	**34.37**	—[6]	**1.59**	▲▲▲▲	**16**
Data Storage Marketing, Inc.	DataStor 486-66 DX2 EISA VL	$5595	EISA	VL-Bus	▮	1.64	1.78	33.59	—[6]	1.42	▲▲▲▲	32
Data Storage Marketing, Inc.	DataStor 486-66 DX2 ISA VL	$4575	ISA	VL-Bus	▮	1.69	1.71	30.87	—[6]	1.40	▲▲▲▲	16
Dell Computer Corp.	Dimension XPS 466V	$3543	ISA	VL-Bus	▬	1.71	1.76	32.84	—[6]	1.58	▲▲▲▲	16
Digital Equipment Corp.	DECpc 466 MTE	$5715	EISA	VL-Bus	▮	1.63	1.67	31.42	—[6]	1.42	▲▲▲▲	32
Digital Equipment Corp.	DECpc 466d2 LPx	$4455	ISA	VL-Bus	▬	1.70	1.72	32.54	—[6]	1.51	▲	16
Dyna Micro, Inc.	486 Business System	$3006	ISA	VL-Bus	▬	1.69	1.57	30.51	—[6]	1.40	▲▲▲	16
Dyna Micro, Inc.	486 EISA Business System	$3115	EISA	VL-Bus	▬	1.49	1.44	28.84	—[6]	1.30	▲▲▲	16
Gateway 2000	Gateway 4DX2-66V	$2795	ISA	VL-Bus	▬	1.58	1.78	29.49	—[6]	0.50	▲▲▲▲	16
Hertz Computer Corp.	Hertz 486/D66X2e	$3595	ISA	VL-Bus	▬	1.50	1.38	26.83	—[6]	1.21	▲▲▲▲	16
Hewlett-Packard Co.	Vectra 486 66/XM	$4757	ISA	Proprietary	▬	1.68	1.78	32.63	—[6]	1.51	▲▲▲▲	16
IBC/Integrated Business Computers	EISA AD System	$5995	EISA	VL-Bus	▮	1.70	1.76	32.36	—[6]	1.64	▲▲▲	32
IBM Personal Computer Co.	**ValuePoint 6387-W90**	**$4994**	**ISA**	**VL-Bus**	▮	**1.82**	**1.65**	**33.60**	—[6]	**1.64**	▲▲▲▲	**16**
Insight Direct	Insight VL 486DX2-66MM	$3499	ISA	VL-Bus	▮	1.55	1.44	27.40	—[6]	1.38	▲▲▲▲	16
Mega Computer Systems	Impact 486 DX2/66DT	$3195	ISA	VL-Bus	▬	1.53	1.32	26.51	—[6]	1.27	▲▲	16
Micro Express	MicroFlex -VE/66	$4800	EISA	VL-Bus	▮	2.09	1.76	31.61	—[6]	1.46	▲▲▲▲	32
Micron Computer, Inc.	466 VL WinStation CD	$2978	ISA	VL-Bus	▬	1.59	1.99	34.05	—[6]	1.58	▲▲▲▲	16
Micron Computer, Inc.	466 VLE WinServer CD	$4498	EISA	VL-Bus	▮	1.46	1.80	30.98	—[6]	1.08	▲▲▲▲	32
MicroSource	Tempest IV/IPCI-66	$2825	ISA	PCI	▮	1.96	1.72	—[3]	—[6]	—[3]	▲▲▲	16
MIS Computer Systems	M466EV	$4451	EISA	VL-Bus	▮	1.08	1.76	22.52	—[6]	1.03	▲▲▲	32
MicroTech Computer Corp.	Ultima XV2/66	$3999	ISA	VL-Bus	▮	1.66	1.82	32.87	—[6]	1.55	▲▲▲	16
Mitsuba Corp.	MIT486/66V	$2900	ISA	VL-Bus	▮	1.52	1.43	26.90	—[6]	1.24	▲▲▲	16
NCR Corp.	NCR 3333	$4505	ISA	VL-Bus	▯	1.70	1.52	31.38	—[6]	1.43	▲▲▲▲	16
Quantex Microsystems, Inc.	Q486 DX2/66	$2699	ISA	VL-Bus	▮	1.09	1.13	20.24	—[6]	1.00	▲▲▲▲	16
Wyse Technology, Inc.	Decision 486GSI	$3400	ISA	VL-Bus	▯	1.47	1.32	25.52	—[6]	1.23	▲▲▲▲	16
Xi Computer Corp.	Xi 466 Workstation	$3199	ISA	VL-Bus	▬	1.65	1.95	32.47	—[6]	1.64	▲▲▲▲	16
Zenon Computer	Z-Novus PCI	$1995	ISA	PCI	▬	1.42	1.65	—[3]	—[6]	—[3]	▲▲▲	16

= BYTE Best. ✔ = yes.

Desktop ▬ Tower ▮ Mini-tower ▯

[1] 66-MHz Pentium

[2] Unable to complete Unix tests because system lacked 3½-inch boot-time-loadable driver disk

[3] Unable to run Unix tests because PCI video drivers weren't available for SCO Unix

[4] Could not complete tests, problem unresolved at press time

[5] Unable to install Unix; problem unresolved at press time

[6] Memory required to run SPECFP tests exceeded testing configuration for 486DX2 systems

[7] Prices reflect RAM amount listed; during testing, all 486 systems contained 16 MB of RAM, all Pentiums contained 32 MB

FEATURES CONTINUE ON NEXT PAGE

MAXIMUM RAM (MB)	HARD DRIVE INTERFACE	SIZE (MB)	VENDOR	VIDEO ADAPTER	MAX. RESOLUTION (NONINTERLACED)	WARRANTY (MONTHS)	ENERGY STAR COMPLIANT?	TOLL-FREE PHONE	PHONE NUMBER	INQUIRY NUMBER
1024	SCSI	1370	Maxtor	ATI	1280×1024	60		(800) 444-4257	(714) 581-6770	1105
128	IDE	540	Western Digital	Diamond	1280×1024	12	✔	(800) 465-2227	(919) 713-1550	1106
192	SCSI	540	Maxtor	Weitek	1280×1024	12		(800) 888-6615	(408) 524-9091	1107
128	IDE	450	Seagate	S3	1280×1024	12		(800) 289-3355	(512) 338-4400	1108
192	SCSI	1024	DEC	ATI	1280×1024	12		(800) 289-3355	(512) 338-4400	1109
192	SCSI	1024	DEC	American Meg.	1280×1024	36		(800) 722-9332	(508) 493-5111	1110
192	IDE	525	Quantum	S3	1280×1024	36		(800) 722-9332	(508) 493-5111	1111
128	IDE	420	Western Digital	S3	1600×1200	12		(800) 551-9000	(214) 518-1200	1112
192	SCSI	1024	Micropolis	S3	1280×1024	24		(800) 289-8128	(718) 459-1407	1113
128	IDE	540	Western Digital	ATI	1024×768	12		(800) 846-2000	(605) 232-2000	1114
128	IDE	527	Maxtor	ATI	1280×1024	12		(800) 426-2968	(914) 766-1900	1115
128	IDE	540	Maxtor	ATI	1024×768	12		(800) 927-7848	(602) 902-1176	1116
128	SCSI	544	Conner	Eagle Mountain	1024×768	12	—[a]	(800) 543-3475	(805) 495-7673	1117
128	SCSI	500	Conner	Tseng Labs	1024×768	24	—[a]	(800) 989-9900	(714) 852-1400	1118
128	IDE	540	Maxtor	Weitek	1280×1024	12		(800) 347-3490	(208) 465-3434	1119
128	IDE	525	Quantum	Weitek	1280×1024	12		(800) 733-9188	(408) 730-9188	1120
192	SCSI	1024	Seagate	ATI	1024×768	12	—[a]	(800) 874-8647	(215) 986-4011	1121
192	IDE	520	Quantum	Diamond	1600×1280	12		(800) 432-0486	(714) 498-0858	1122
128	SCSI	520	Fujitsu	Tseng Labs	1280×1024	36	✔	(800) 345-4415	(408) 727-5509	1123
192	IDE	540	Maxtor	Matrox	1280×1024	72	—[a]	(800) 899-6119	(818) 935-1828	1124
32	IDE	540	Quantum	Diamond	1280×1024	12		None	(408) 247-4444	1125
64	IDE	540	Conner	Cirrus Logic	1280×1024	12		(800) 786-6888	(510) 623-1212	1126
36	IDE	540	Conner	Western Digital	1024×768	60	✔	(800) 444-4257	(714) 581-6770	1127
128	SCSI	540	Maxtor	Weitek	1280×1024	12		(800) 888-6615	(408) 524-9091	1128
256	SCSI	1024	Conner	S3	1024×768	12		(800) 888-6615	(408) 524-9091	1129
128	SCSI	1024	Quantum	ATI	1024×768	36		(800) 876-4278	(714) 727-4141	1130
64	IDE	340	Seagate	Cirrus	1024×768	36	—[a]	(800) 345-1518	(713) 378-8820	1346
64	IDE	525	Quantum	ATI	1280×1024	12	✔	(800) 999-7103	(512) 250-2930	1347
128	SCSI	1024	Quantum	ATI	1280×1024	12		(800) 999-7103	(512) 250-2930	1348
256	SCSI	1024	Toshiba	Tseng Labs	1280×1024	36		(800) 886-7200	(909) 594-5848	1349
128	IDE	420	Western Digital	Weitek	1280×1024	36		(800) 886-7200	(909) 594-5848	1350
128	SCSI	1325	Seagate	S3	1280×1024	36	✔	(800) 543-6098	(303) 442-4747	1351
128	IDE	540	Maxtor	S3	1280×1024	36	✔	(800) 543-6098	(303) 442-4747	1352
64	IDE	450	Seagate	#9GXE	1024×768	12		(800) 289-3355	(512) 338-4400	1353
128	SCSI	1024	DEC	S3	1280×1024	36		(800) 722-9332	(508) 493-5111	1354
64	IDE	525	Quantum	S3	1280×1024	36		(800) 722-9332	(508) 493-5111	1355
32	IDE	545.9	Conner	S3	1280×1024	12		(800) 336-3962	(408) 943-0100	1356
128	IDE	545.9	Conner	S3	1280×1024	12		(800) 336-3962	(408) 943-0100	1357
64	IDE	424	Western Digital	ATI	1280×1024		✔	(800) 846-2000	(605) 232-2000	1358
32	IDE	542	Micropolis	Weitek	1280×1024	12		(800) 232-8737	(212) 684-4141	1359
64	IDE	450	Seagate	S3	1280×1024	36	✔	(800) 752-0900	(408) 553-2922	1360
256	SCSI	540	Quantum	Tseng Labs	1280×1024	12	—[a]	(800) 468-5847	(818) 882-9007	1361
64	IDE	527	Maxtor	S3	1280×1024	12		(800) 426-2968	(914) 766-1900	1362
128	IDE	420	Western Digital	Cirrus Logic	1024×768	12		(800) 927-7848	(602) 902-1176	1363
32	IDE	540	Conner	Cirrus Logic	1280×1024	12	✔	(800) 438-6268	(619) 487-8888	1364
128	SCSI	1024	Maxtor	Tseng Labs	1024×768	24	—[a]	(800) 989-9900	(714) 852-1400	1365
—[a]	IDE	340	Conner	Weitek	1280×1024	Lifetime	—[a]	(800) 347-3490	(208) 465-3434	1366
64	SCSI	540	Maxtor	Weitek	1280×1024	12	—[a]	(800) 347-3490	(208) 465-3434	1367
256	IDE	425	Western Digital	S3	1280×1024	12	—[a]	(800) 848-5161	(818) 858-5161	1368
64	SCSI	1024	DEC	Weitek	1280×1024	12		(800) 733-9188	(408) 730-9188	1369
64	IDE	452.4	Seagate	ATI	1280×1024	12		(800) 342-6508	(404) 345-6508	1370
32	IDE	544	Conner	Cirrus Logic	1024×768	24	—[a]	(800) 648-7822	(909) 392-2000	1371
64	IDE	520	Conner	Cirrus Logic	1280×1024	36		(800) 225-5627	(513) 445-5000	1372
—[a]	IDE	425	Western Digital	Weitek	1024×768	12	—[a]	(800) 288-0566	(908) 563-4166	1373
64	IDE	424	Seagate	Cirrus Logic	1280×1024	12		(800) 438-9973	(408) 473-1200	1374
64	IDE	520	Quantum	Diamond	1600×1280	12		(800) 432-0486	(714) 498-0858	1375
128	IDE	420	Western Digital	S3	1280×1024	72	—[a]	(800) 899-6119	(818) 935-1828	1376

[a] Information not available at press time
N/A = not applicable.

Poor ▲ Fair ▲▲ Good ▲▲▲ Excellent ▲▲▲▲

ROLL CALL OF SYSTEMS TESTED

VENDOR	MODEL	MAXIMUM CACHE (KB)	FLASH ROM	EXPANSION SLOTS 16-BIT	EISA	VL-BUS	PCI	TOTAL	UART	SCSI PORT
PENTIUM										
Advanced Logic Research, Inc.	Evolution V-Q/66[1]	512	✔	0	5	1	0	6	16550	
Ambra Computer Corp.	DP60 PCI	256	✔	4	0	0	3	7	16550	
American Multisystems	Info Gold P60 PCI	512	✔	3	0	0	0	3	8250	✔
Dell Computer Corp.	Dimension XPS P60	256	✔	4	0	0	2	6	16550	
Dell Computer Corp.	OmniPlex 566[1]	256	✔	0	3	0	1	4	16550	
Digital Equipment Corp.	DECpc 560ST	256	✔	0	3	0	0	3	16550AF	✔
Digital Equipment Corp.	DECpc XL 560	256	✔	3	0	0	2	5	—[2]	✔
Duracom Computer Systems	Multimedia FilePro Pentium 60-PCI	256	✔	3	0	0	2	5	16550	
EasternTech Corp.	ET P60-PCI	512	✔	3	0	0	1	4	16450	✔
Gateway 2000	Gateway P5-60	256	✔	4	0	0	2	6	16550AF	
IBM Personal Computer Co.	ValuePoint P60/D	256	✔	2	0	0	2	4	16550	
Insight Direct	PCI P60 Multimedia	256	✔	3	0	0	2	5	16550	
International Instrumentation, Inc.	Business Partner	2048	✔	3	0	1	0	4	16550	✔
Micro Express	MicroFlex-VL/Pentium	2048		3	0	1	0	4	8250	✔
Micron Computer, Inc.	P60 PCI PowerStation CD	256	✔	3	0	0	1	4	16550	
MIS Computer Systems	M560P	256	✔	3	0	0	2	5	16450	
Unisys Corp.	PW^2 Advantage Plus 5606	—[2]	—[2]	0	3	0	0	3	8250	✔
Xi Computer Corp.	Xi P60 NTower	512	✔	3	0	0	1	4	8250	
Xinetron, Inc.	X/LAN 586	512		3	0	1	0	4	—[2]	✔
Zenon Computer	Z-Optimus	512	✔	3	0	0	1	4	16450	
486DX2/66										
Access Computers Technologies	ACT 486-66MHz	256		4	0	0	0	4	16550	
Acma Computers, Inc.	486 Tower	256		4	0	1	0	5	—[2]	
Advanced Logic Research, Inc.	Flyer VL 4/66d	256	✔	1	0	1	0	2	16450	
American Multisystems	Info Gold 486 PCI	512	✔	3	0	0	2	5	16550	
American Multisystems	Info Gold E-Server	512		0	2	2	0	4	8250	✔
AST Research, Inc.	Premmia 4/66d, Model 343M	512	✔	0	3	0	0	3	16550	
Compaq Computer Corp.	Prolinea MT 4/66 Model 340/CDS	128		4	0	0	0	4	16450	
CompuAdd Computer Corp.	C466D Mini Tower	256	✔	5	0	0	0	5	16550AF	
CompuAdd Computer Corp.	C466De Mini Tower	1024	✔	0	5	1	0	6	16550AF	
Cornell Computer Systems	Cornell EISA-VL SCSI-2	1024	✔	0	3	1	0	4	16550	✔
Cornell Computer Systems	Cornell Power Pak	256	✔	4	0	1	0	5	16550	
Data Storage Marketing, Inc.	DataStor 486-66 DX2 EISA VL	256		0	2	1	0	3	16450	
Data Storage Marketing, Inc.	DataStor 486-66 DX2 ISA VL	256		3	0	0	0	3	16450	
Dell Computer Corp.	Dimension XPS 466V	256	✔	4	0	1	0	5	16650	
Digital Equipment Corp.	DECpc 466 MTE	256	✔	0	3	1	0	4	16550AF	✔
Digital Equipment Corp.	DECpc 466d2 LPx	256		3	0	1	0	4	16550AF	
Dyna Micro, Inc.	486 Business System	256		3	0	0	0	3	16450	
Dyna Micro, Inc.	486 EISA Business System	256		0	4	0	0	4	16450	
Gateway 2000	Gateway 4DX2-66V	256	✔	5	0	0	0	5	16550AF	
Hertz Computer Corp.	Hertz 486/D66X2e	256		3	0	0	0	3	16550	
Hewlett-Packard Co.	Vectra 486 66/XM	256	✔	2	0	0		2	16550	—[3]
IBC/Integrated Business Computers	EISA AD System	1024		0	3	1	0	4	16450	✔
IBM Personal Computer Co.	ValuePoint 6387-W90	256	✔	5	0	0	0	5	16550	
Insight Direct	Insight VL 486DX2-66MM	256		2	0	0	0	2	16450	
Mega Computer Systems	Impact 486 DX2/66DT	256		3	0	0	0	3	8250	
Micro Express	MicroFlex -VE/66	512		0	6	2	0	8	8250	✔
Micron Computer, Inc.	466 VL WinStation CD	256	✔	4	0	1	0	5	16550	
Micron Computer, Inc.	466 VLE WinServer CD	512	✔	0	0	0	0	0	16550	✔
MicroSource	Tempest IV/IPCI-66	512		2	0	0	2	4	8250	
MIS Computer Systems	M466EV	512	✔	0	3	1	0	4	16550	✔
MicroTech Computer Corp.	Ultima XV2/66	256	✔	4	0	1	0	5	16550	
Mitsuba Corp.	MIT486/66V	256		1	0	0	0	1	8250	
NCR Corp.	NCR 3333	256	✔	4	0	0	0	4	16450	✔
Quantex Microsystems, Inc.	Q486 DX2/66	256		2	0	1	0	3	16550	
Wyse Technology, Inc.	Decision 486GSI	256		4	0	0	0	4	8250	
Xi Computer Corp.	Xi 466 Workstation	256		2	0	1	0	3	8250	
Zenon Computer	Z-Novus PCI	512	✔	1	0	0	3	4	16550	

= BYTE Best. ✔ = yes.

[1] 66-MHz Pentium
[2] Information not available at press time
[3] Includes Ethernet port; no SCSI

N/A = not applicable.
(2x) = double space.

FEATURES CONTINUE ON NEXT PAGE

FLOPPY DRIVES		AVAILABLE BAYS		POWER SUPPLY			CD-ROM		
3½-INCH	5¼-INCH	3½-INCH	5¼-INCH	OUTPUT (WATTS)	AC VOLTS IN	SWITCHABLE?	VENDOR	MODEL	FCC RATING
1	0	1	8	415	110/120, 220/240	✔	Texel	DM-3028	A
1	0	1	3	200	220/240	✔	LMSI	CM206	B
1	1	0	3	230	110/120, 220/240	✔	Sony	CDU 31A-3	Pending
1	1	1	1	200	90/130, 180/265	✔	Panasonic	CR563B	B
1	1	1	1	224	115/230	✔	Toshiba	XM3401B	B
1	0	1	1	254	110/120	—[2]	Toshiba	XM-4101B	B
1	0	0	2	300	110/120	—[2]	Toshiba	XM-4101B	B
1	1	3	0	250	110/120, 220/240	✔	Texel (Plextor)	DM-3028	Pending
1	1	2	1	250	110/120	✔	NEC	3xi	B
1	0	3	3	300	110,220	✔	Mitsumi	FX0010 (2x)	B
1	1	1	0	200	110/120, 220/240	✔	Panasonic	CR 563 BIA	B
1	0	7	3	230	220/240	✔	Mitsumi	FX001D	B
1	0	0	3	250	110/120	✔	Toshiba	3401	A
1	0	2	3	250	110/120, 220/240	✔	Toshiba	3401B	B
1	1	2	1	230	110/220	—[2]	Mitsumi	FX0010 (2x)	Pending
1	0	1	0	250	110/120	✔	Panasonic	562	Pending
1	0	0	2	—[2]	—[2]	—[2]	N/A	N/A	B
1	1	2	4	300	110/120	✔	Toshiba	SCSI-2	A
1	1	1	0	250	110/120	✔	Toshiba	340 LB	A
1	1	3	4	250	110/220	✔	Toshiba	3401	A
1	1	3	1	200	220/240	—[2]	Toshiba	3401	B
1	1	1	3	300	110/120	✔	TEAC	CDR-510	B
1	0	0	0	200	110/120, 220/240	✔	Texel	DM-3028	B
1	1	0	3	230	110/120, 220/240	✔	Sony	CDU 31A-3	B
1	1	0	3	230	110/120, 220/240	✔	Sony	561	B
1	0	1	1	200	110/220	✔	Toshiba	3401B (2x)	B
1	0	0	2	200	120/220	✔	Compaq	N/A	B
1	0	0	2	200	110/120	✔	Toshiba	3401B-S	B
1	0	2	2	200	110/120	✔	Toshiba	3401B-S	B
1	0	2	4	300	110/120	✔	Sony	31A-03	B
1	0	2	4	300	110/120	✔	Sony	31A-03	B
1	1	2	1	300	110/120	✔	Toshiba	3401A	B
1	1	4	1	300	110/120	✔	Toshiba	3401A	B
1	1	1	1	200	90/130, 180/265	✔	Panasonic	CR 563B	B
1	0	0	2	200	110/120	—[2]	Toshiba	4101	B
1	0	0	1	200	110/120	✔	Toshiba	XM-4101B	B
1	0	1	1	200	110/120	✔	Panasonic	CR-562-B	B
1	0	1	1	200	110/120	✔	Panasonic	CR-562-B	B
1	0	2	2	145	110/120	✔	Mitsumi	—[2]	B
1	1	0	0	200	110/120	✔	Panasonic	CR562-B	B
1	0	1	0	85	110/120, 220/240	✔	NEC	55	B
1	1	0	5	300	110/220	✔	Toshiba	MK3401B	A
1	1	0	1	200	110/120, 220/240	✔	Panasonic	CR 563 BIA	B
1	1	0	2	250	220/240	✔	Texel	3028	B
1	0	0	2	250	110/120, 220/240	✔	Toshiba	XM3401B	A
1	1	4	4	250	110/120, 220/240	✔	Toshiba	3401B	B
1	0	1	1	200	110/220	✔	Mitsumi	FX0010 (2x)	B
1	0	0	4	250	110/220	✔	Mitsumi	FX0010 (2x)	B
1	1	3	1	250	110/120, 220/240	✔	Toshiba	3401	B
1	0	2	4	300	110/120	✔	Panasonic	562	B
1	1	1	1	300	110/120	✔	NEC	3Xi	B
1	1	4	1	230	110/120, 220/240	✔	Mitsumi	CRMC-LU0055.35MS	B
1	0	1	1	200	110/120, 220/240	✔	Sony	CD ROM M CDU-561	B
1	1	4	2	200	110/120	✔	Sony	CDU-31A-03 (2x)	B
1	0	1	1	200	110/120	✔	Toshiba	3401B	B
1	1	1	1	224	110/120	✔	Mitsumi	(2x)	B
1	0	1	1	200	110/220	✔	Mitsumi	CRMC-FX001D	A

ROLL CALL OF SYSTEMS TESTED

PENTIUM

VENDOR	MODEL	DISTRIBUTION CHANNEL: DIRECT	DEALER	SUPERSTORES	FREE TECH. SUPPORT	MONITOR: MAX. RES. NONINTERLACED	VENDOR	MODEL	SCREEN SIZE (INCHES)
Advanced Logic Research, Inc.	Evolution V-Q/66	✔	✔	—[1]	Lifetime	1280×1024	TECO	FlexView 3xNI	14
Ambra Computer Corp.	P60 PCI	✔			Lifetime	1280×1024	Acer	7076L	17
American Multisystems	Info Gold P60 NT	✔	✔		Lifetime	1280×1024	AMS	IG3000	14
Dell Computer Corp.	Dimension XPS P60	✔			Lifetime	1280×1024	Dell	15FS	15
Dell Computer Corp.	OmniPlex 566	✔		✔	Lifetime	1280×1024	Dell	15FS	15
Digital Equipment Corp.	DECpc 560 ST	✔	✔		Lifetime	1280×1024	Capetronics	—[1]	14
Digital Equipment Corp.	DECpc XL 560	✔	✔	—[1]	Lifetime	1280×1024	Capetronics	—[1]	14
Duracom Computer Systems	Multimedia FilePro Pentium		✔	✔	Lifetime	1600×1200	ADI	3E+	14
EasternTech Corp.	ET P60-PCI	✔	✔		Lifetime	1280×1024	Samsung	3N	14
Gateway 2000	Gateway P5-60	✔			1 month	1024×768	Gateway 2000	Crystal Scan 1572 fs	5
IBM Personal Computer Co.	ValuePoint P60/D	✔	✔	✔	1 month	1280×1024	IBM	6324	14
Insight Direct	PCI P60 Multimedia	✔			Lifetime	1024×768	CTX	1561 LR	15
International Instrumentation, Inc.	Business Partner	✔	✔		Lifetime	1024×768	Samsung	CSJ 4927A	14
Micro Express	MicroFlex-VL/Pentium	✔			Lifetime	1024×768	Micro Express	FM-370	14
Micron Computer, Inc.	P60 PCI PowerStation CD	✔			Lifetime	1280×1024	Mag	LX1564	15
MIS Computer Systems	M560P	✔	✔		Lifetime	1280×1024	CTX	CVP-5468NI	1
Unisys Corp.	PW² Advantage Plus 5606	—[1]	—[1]	—[1]	—[1]	—[1]	—[1]	—[1]	—[1]
Xi Computer Corp.	Xi P60 NTower	✔			Lifetime	1600×1280	KFC	1428N	14
Xinetron, Inc.	X/LAN 586	✔			Lifetime	1280×1024	Socos	1488	14
Zenon Computer	Z-Optimus	✔			Lifetime	1280×1024	Mag Innovision	17 MXF MA	17

486DX2/66

VENDOR	MODEL	DISTRIBUTION CHANNEL: DIRECT	DEALER	SUPERSTORES	FREE TECH. SUPPORT	MONITOR: MAX. RES. NONINTERLACED	VENDOR	MODEL	SCREEN SIZE (INCHES)
Access Computers Technologies	ACT 486-66MHz	✔			None	1280×1024	NEC	3FGe	15
Acma Computers, Inc.	486 Tower	✔	✔		12 months	1280×1024	Mag Innovision	MX 15	15
Advanced Logic Research, Inc.	Flyer VL 4/66d	✔	✔	—[1]	Lifetime	1024×768	TECO	FlexView 3xNI	14
American Multisystems	Info Gold 486 PCI	✔	✔		Lifetime	1280×1024	AMS	IG3000	1
American Multisystems	Info Gold E-Server	✔	✔		Lifetime	1024×768	AMS	IG3000	14
AST Research, Inc.	Premmia 4/66d, Model 343M		✔		Lifetime	1024×768	Daewoo	ASTVision S	1
Compaq Computer Corp.	Prolinea MT 4/66 Model 340/CDS		✔	✔	Lifetime	1024×768	Compaq	1024 Color Monitor	14
CompuAdd Computer Corp.	C466D Mini Tower	✔			Lifetime	1280×1024	CompuAdd	14" Color	14
CompuAdd Computer Corp.	C466De Mini Tower	✔			Lifetime	1280×1024	CompuAdd	14" Color	14
Cornell Computer Systems	Cornell EISA-VL SCSI-2	✔			Lifetime	1280×1024	ADI	3G	1
Cornell Computer Systems	Cornell Power Pak	✔	✔		1 month	1280×1024	ADI	3G	14
Data Storage Marketing, Inc.	DataStor 486-66 DX2 EISA VL	✔	✔		1 month	1280×1024	Phillips	Spectra III	14
Data Storage Marketing, Inc.	DataStor 486-66 DX2 ISA VL	✔	✔		1 month	1280×1024	Phillips	Spectra III	14
Dell Computer Corp.	Dimension XPS 466V			✔	Lifetime	1024×768	Dell	15FS	15
Digital Equipment Corp.	DECpc 466 MTE	✔	✔		Lifetime	—[1]	—[1]	—[1]	—[1]
Digital Equipment Corp.	DECpc 466d2 LPx	✔	✔		Lifetime	1280×1024	Capetronics	—[1]	14
Dyna Micro, Inc.	486 Business System	✔			Lifetime	1280×1024	Fora International	Addonics	14
Dyna Micro, Inc.	486 EISA Business System	✔			Lifetime	1280×1024	Fora International	Addonics	14
Gateway 2000	Gateway 4DX2-66V	✔			1	—[1]	Gateway 2000	Crystal Scan 1572 fs	15
Hertz Computer Corp.	Hertz 486/D66X2e	✔				1280×1024	Mag	1450	1
Hewlett-Packard Co.	Vectra 486 66/XM		✔		36	1280×1024	—[1]	—[1]	—[1]
IBC/Integrated Business Computers	EISA AD System		✔		Lifetime	1280×1024	CTX	1450	14
IBM Personal Computer Co.	ValuePoint 6387-W90	✔	✔	✔	1 month	1280×1024	IBM	6324	14
Insight Direct	Insight VL 486DX2-66MM				Lifetime	1024×768	CTX	561 LR	15
Mega Computer Systems	Impact 486 DX2/66DT	✔	✔		Lifetime	1280×1024	MGC	1402N	14
Micro Express	MicroFlex -VE/66	✔			Lifetime	1024×768	Micro Express	FM-370	14
Micron Computer, Inc.	466 VL WinStation CD	✔			Lifetime	1280×1024	Mag	LX1564	15
Micron Computer, Inc.	466 VLE WinServer CD	✔			Lifetime	1280×1024	Mag	LX1564	15
MicroSource	Tempest IV/IPCI-66	✔			Lifetime	1280×1024	Tystar	3448	14
MIS Computer Systems	M466EV	✔	✔		Lifetime	1280×1024	C	CVP-5468NI	14
MicroTech Computer Corp.	Ultima XV2/66	✔			Lifetime	1280×1024	Proton	PM 1448A	14
Mitsuba Corp.	MIT486/66V		✔		Varies	1024×768	Mitsuba	M710VS	14
NCR Corp.	NCR 3333	✔	✔		36 months	1280×1024	NCR	3297-0271	14
Quantex Microsystems, Inc.	Q486 DX2/66	✔			Lifetime	024×768	Goldsta	GS 151	15
Wyse Technology, Inc.	Decision 486GSI		✔		Lifetime	1280×1024	Wyse Technology	WY-670	14
Xi Computer Corp.	Xi 466 Workstation	✔			Lifetime	1600×1280	KFC	1428N	14
Zenon Computer	Z-Novus PCI	✔			Lifetime	—[1]	Mag Innovision	LX 1564	15

= BYTE Best. ✔ = yes.

[1] Information not available at press time

22 New Ethernet Cards

These 16-bit NICs are the latest to enter the Asian market. Our exclusive network tests identify the top performers.

Since our last Lab Report on network interface cards ("Network Connections: 100 Ethernet Cards," August 1993 BYTE), a number of new 16-bit Ethernet NICs have been introduced in Asia. Some of these cards may be available only in that market, but others are sold internationally. In either case, this group represents the latest levels of price and performance for 16-bit NICs.

LANBit Computer, an independent testing lab that licenses methodologies from BYTE's Lab Report collaborator NSTL, recently tested 22 new NICs. The Taipei, Taiwan–based lab found Accton's new EN1650 to be the performance leader. This card also earned an ease of use rating of excellent, thanks to its comprehensive documentation and easy configurability, among other factors.

Although the EN1650 led the way in speed, performance scores for the cards in this group didn't vary dramatically. For example, the slowest card in the Workgroups and Large Networks benchmarks, Info-Net's E2000WDC+, lagged behind the EN1650 by only 12 percent.

While the methodologies used for this NIC update were the same as in the original Lab Report, scores are not directly comparable. Differences in test-bed equipment resulted in the latest scores averaging approximately 12 percent higher for the Workgroups and Large Networks components, and 25 percent higher for the Transaction-Based Networks tests. However, the test suite does provide a relative ranking of speed within this group. Performance evaluations used nine tests to simulate six different applications. Five of the tests were Microsoft Windows–based, and the remainder ran under MS-DOS.

Tests ran with and without simulated network loads. For the latter, a traffic generator sent data packets using 25 percent of the network's bandwidth (about 2.5 Mbps). In the table below, the Workgroups scores are a composite of tests run without network traffic, while the Large Networks scores are results generated with the network load. The Transaction-Based Networks scores are based on tests that consist of small files (128 to 1024 bytes) and are meant to simulate large database-search applications (e.g., a request for an airline ticket).

Ease-of-use evaluations considered hardware configuration, driver installation, and the quality of technical documentation. ■

ROLL CALL OF NICS TESTED

COMPANY	MODEL	PRICE[1] ($US)	SPEED RATINGS (TPM)[2] WORKGROUPS	LARGE NETWORKS	TRANSACTION-BASED NETWORKS	EASE OF USE	PHONE	FAX	INQUIRY NUMBER
Accton Technolog	EN1650	$128	32.	31.82	614.87	Excellent	+886 35 770270	+886 35 770267	1000
Addtron Technology	AE-200LC	$89	29.59	28.86	563.90	Fair	+886 2 4514507	+886 2 4514614	1001
Addtron Technology	AE-200JL	$109	29.60	28.88	564.71	Good	+886 2 4514507	+886 2 4514614	1002
CNet	CN600E	$89	29.24	28.52	554.76	Fair	+886 35 782211	+886 35 782458	1003
CNet	CN650E+	$99	29.51	28.82	563.11	Good	+886 35 782211	+886 35 782458	004
CT Continental	CT-16TB	$52	29.54	28.75	558.25	Good	+886 2 7913812	+886 2 7912685	1005
Grand Computer	TE-2000AD	$79	30.05	29.2	568.38	Good	+886 2 7859197	+886 2 7855724	1006
GVC	NIC-2003	$45	29.54	28.82	563.22	Good	+886 2 7552226	+886 2 7552413	1007
Info-Net	E2000C	$79	29.96	29.18	568.65	Good	+886 2 7647786	+886 2 7647166	1008
Info-Net	E2000WDC+	$99	29.10	28.33	567.95	Good	+886 2 7647786	+886 2 7647166	1009
Katron Computers	ET-200T/X	$85	29.66	28.90	566.94	Good	+886 2 7991064	+886 2 7994020	1010
Katron Computers	ET-16TB	$59	29.24	28.55	551.76	Good	+886 2 7991064	+886 2 7994020	1011
Lantech Compu er	LTC EN2000/CT	$79	30.09	29.31	7.14	Good	+886 2 7667088	+886 2 7666892	1012
Lantech Computer	LTC E-NET/21CT	$89	30.76	30.08	591.33	Poor	+886 2 7667088	+886 2 7666892	1013
Longshine	LCS-8634L-TBA	$8	9.67	28.93	562.47	Good	+886 2 3634958	+886 2 3626810	1014
Pheecom	PTC-1001SCT	$59	29.62	28.91	561.53	Fair	+886 2 7613142	+886 2 7615764	1015
R.P.T.I. International	E2003UC	$49	29.77	28.99	563.10	Fair	+886 2 9183006	+886 2 9183096	1016
R.P.T.I. International	E2015WC	$59	29.85	29.08	565.61	Good	+886 2 9183006	+886 2 9183096	1017
Surecom	NE-12	$70	29.75	28.98	562.71	Fair	+886 2 5922327	+886 2 5912675	1018
Surecom	EP301	$95	30.33	29.54	575.76	Good	+886 2 5922327	+886 2 5912675	1019
Zero One	N2000E3+	$60	29.47	28.74	566.85	Good	6 2 5652323	+886 2 5714698	1103
Zero One	N2000E2/M	$50	29.21	28.52	557.41	Good	+886 2 5652323	+886 2 5714698	1104

[1]Estimated Taiwanese street price [2]Transactions per minute

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Developing Applications in Perl

This public domain language now runs on every major operating system and has solved countless problems for developers

TOM CHRISTIANSEN

Perl, an interpreted programming language originally designed for text processing and manipulation of files and processes, provides a rich environment for systems programming. While the language was originally written by Larry Wall, then a harried Unix system administrator, as an alternative to the Unix shell for high-level systems programming, it turns out that many general programming problems of short to medium degrees of complexity can be easily expressed in Perl.

By combining the high-level primitives of several Unix workhorses into one easy-to-use, highly efficient, interpreted language, Perl provides a versatile power tool for crafting a custom solution with a minimum of time and effort. It is an effective way to manipulate text, data, files, and even processes. While it was first developed for Unix and runs on virtually any Unix system, Perl now also runs on a multitude of operating systems, including VMS, MS-DOS, Windows NT, and the Amiga and Apple Macintosh operating systems.

Although users of Unix systems will be quick to pick up much of the philosophy and style of approach embodied by Perl due to its roots in Unix shell and C programming, users of other operating systems stand to gain even more. That's because non-Unix systems seldom come with a good tool set for crafting quick solutions to the myriad little text-related problems that crop up. Once you put Perl on your system, you've got everything you need for such tasks in just one application.

With Perl, those two hobgoblins of programming, data typing and memory allocation, disappear as issues. Data typing is trivial because everything in Perl is a string. You can, however, have lists and tables of strings to build up more complex data types. If you perform a numeric or Boolean operation on a Perl value, it gets converted for you automatically. No more remembering whether a variable is a string, a character, a byte, a short integer, or a double-precision floating-point number. For example,

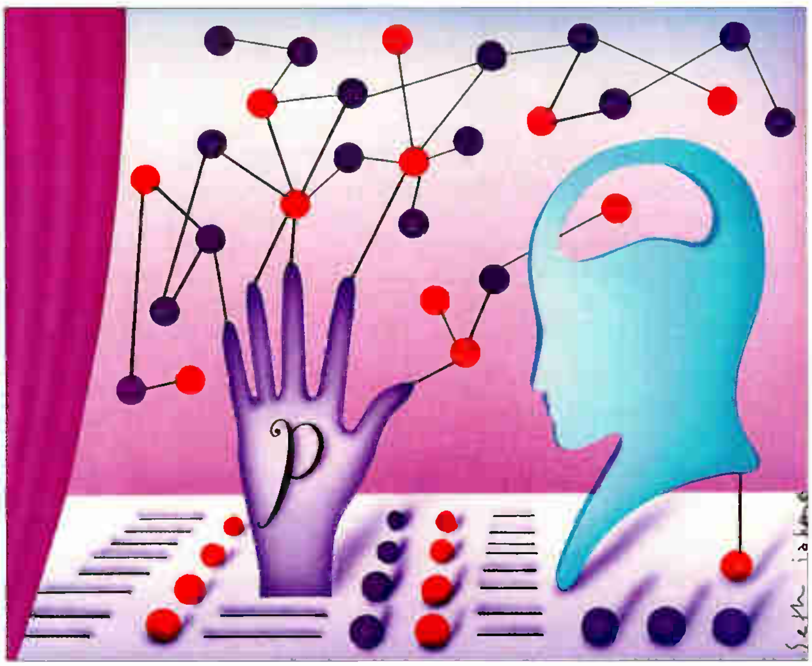
```
print "How many days? ";
$days = <STDIN>;
$months = $days / 30;
print "That's around $months months\n";
```

Notice that you can operate directly on the `$days` variable without first converting the string just read into a numeric value.

The interpreter takes care of all memory handling. You don't have to declare anything if you don't want to, since variables spring into existence when you first mention them—although, as you'll see, there may be times when you'll want to use local variables. You don't have to concern yourself with whether a string is long enough to hold a value or whether an array has enough elements in it. You just do whatever you want, and Perl automatically allocates (and later deallocates, if necessary) any memory needed.

That means it's perfectly fine to do something like this as the first line in your program:

```
$a[500] = "hello";
```



SETH JABEN © 1994

You never bothered to declare any array, but right away you assign to the 500th element of it. The procedure couldn't be easier.

Rapid Prototyping

One thing that Perl is great for is rapid prototyping. It provides an easy way to take care of your quick-and-dirty programming. This is an attractive aspect of interpreter programming that users of BASIC will recognize

PHOTOGRAPHY: GEOFFREY WHEELER PHOTOGRAPHY © 1994 and appreciate. You simply think about what you need to do to solve the problem, and then you type it in using straightforward but high-level constructs. You needn't be a systems programming wizard to do pretty sophisticated systems programming.

A program may take a bit longer to run in Perl than in C—usually around e times longer (e = 2.71828...)—but it takes only one-tenth the time to write it. You're trading cheap machine cycles for expensive people cycles. The flexibility of interpreted languages makes them an easier medium than compiled languages for quickly developing application code.

When prototyping, don't get bogged down with little details, efficiency concerns, or aesthetic appeal. The most important thing about your prototype is that it should work. It doesn't have to be particularly efficient, nor particularly pretty. And it certainly doesn't need to be clever—that just gets in the way. After all, it's just a prototype. In writing, you often throw away the first draft or two; you should consider doing the same thing with most programs. By the second rewrite, you'll have code that's cleaner, more efficient, and more maintainable than your first stabs at sketching out the problem.

Once you're done with your prototype, you may choose to convert into C (this has to be done by hand) and then compile it all the way into machine code. Or maybe not—it may well be that you'll decide it's plenty fast enough as it is, or that a bit of performance tuning in Perl will suffice to make it so.

Even if you do choose to convert your code into C, you'll find you've spared yourself most of the laborious effort of developing and debugging your original algorithm. Because Perl is not only an interpreter but also a forgiving one, it's easy to make small changes in your program and quickly find out what effect they have on its overall behavior.

In developing your prototype, there's no reason not to continue to use a reasonable amount of software engineering. By this I mean, to use a bit of structured programming: Break up your large problem into smaller, manageable problems and then put each of these into its own subroutine. Even when you aren't going to call a function more than once, you should still put it into its own routine to abstract out the low-level stuff; that's what prototyping is about. For example,

```
sub do_it_all {
  &do_this();
  &do_that();
  &do_the_other_thing();
}
sub do_this {}
sub do_that {}
sub do_the_other_thing {}
```

Notice that I haven't filled in what those other subroutines do. That's OK. When first sketching out how the program works, it's more important to figure out what happens when than to know the low-level details of precisely *how* something's happening. Those you can fill in later.

At the topmost level, it's perfectly all right to have functions without parameters; these might adjust some global variables and then call things further down. But at the lower-level functions, you really should pass each routine its own arguments and have those routines maintain their own local variables. Avoid even looking at global variables if you can help it, and if you can't, make sure they're clearly marked out. In small programs, this doesn't matter so much; in larger ones, it's essential.

Perl has a notion of global versus local variables that may seem curious at first but actually makes things easier for the kind of programming you're most likely to use it for. All variables are global unless declared local, and global variables themselves aren't declared at all: Variables just spring into existence when first mentioned. This makes it much easier to sketch out your quick-and-dirty program than if you had to declare every possible variable. But it means it's easy to touch a global variable even if you don't mean to.

Another thing that may surprise you about Perl's local variables is that they are dynamically scoped, not lexically scoped. That means that a subroutine inherits all the local variables that were visible in its caller. In practice, this feature should get you into trouble only if you're intentionally modifying global variables while at the same time creating local variables named exactly the same as the global ones—hardly a good idea in anyone's book.

All in all, Perl is just trying to be helpful and convenient, letting you create and access variables without a lot of the rigmarole you have to go through in more exacting languages. But if this fast-and-loose sort of programming puts pitfalls in your path, there are some strategies you can use to help you through it without mishap.

By far the most important way you can help yourself is by using Perl's `-w` flag. It catches semantic mistakes and error-prone constructs that you might otherwise miss, such as using a variable before you've assigned a value to it or trying to write to a file that isn't open. It gives both compile-time warnings when the program is first parsed and run-time warnings while it's executing. If you're a C programmer, think of it as a `lint` for Perl—except it's a `lint` that's resident during program execution as well as at compile time. This allows Perl to catch mistakes that `lint` never could. The number of bewildered programmers who come to me with Perl problems that the `-w` flag would have instantly alleviated is lamentably large.

Another simple mechanism you can use to help you (and more important, those who come after you) know which variables are doing what is to use the variables' case to provide a clue to their intended scope. This technique is sometimes used in large C programs (in C++, it's not really necessary). Since case is significant in identifiers, use all uppercase to indicate a constant and sometimes use all lowercase to indicate a local variable, with mixed case indicating a global variable. Thus, `$START` would be something that doesn't ever change in the program, `$tempfile` would be some local variable, and `$Update_Time` would be a global variable.

Which particular scheme (if any) you select for this is much less important than simply being consistent about it. While you shouldn't become overly complacent and assume that case always conveys scope as defined by the language, it can be a useful style for helping readers of your program understand its structure.

This strategy is probably less important in rapid prototypes (that's manager talk for *quick hacks*) than in larger programs. It may also make sense in a program that's going to be sticking around for a while and needs to be maintained by other folks—and remember that, three years down the road, you yourself might as well be another person.

A more sophisticated technique for controlling access to identifiers is to employ packages. Perl packages provide for module initializations, variables and functions private to a function or set of functions, and static variables. This last group consists of

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variables whose values don't change between the function's invocations. You'll often see these used in robust library code. They help assure you that you aren't messing with someone else's variables and someone else isn't messing with yours. A package also lets you define code to be executed at run time before any routines in that package can be called—something you can't guarantee in C (although you can in C++).

Using a Library Function

```
&Getopts("vnf:") ||
  die "usage: $0 [-v] [-n] [-f configfile] [files ...]\n";

if ($opt_v) { $verbose++;           }
if ($opt_n) { $fakeit++;            }
if ($opt_f) { $config = $opt_f; }
```

Now that Perl has taken care of your need to worry about nitty-gritty, low-level programming matters like typing and allocation, you can get down to the business at hand: coding up your problems. As you do this, though, you're likely to make some small but mysterious mistakes along the way whose nature won't be immediately obvious. When that happens, you'll want to debug your program.

If you're programming in the shell, that means inserting `echo` commands. If it's an `awk` program you're coding up, then you'll probably be using print statements. Unfortunately, neither of these methods helps much—at least, not when you compare them to a real debugger.

One of the tremendous advantages of using Perl over shell scripts for many programs is that Perl comes with a full-fledged, integrated symbolic debugger. It's so integrated into the language that it isn't even a separate process: It's just a compilation mode and customizable library file (enabled by the `-d` switch) of the existing interpreter.

Combine this with the way the Perl interpreter allows you to access much of its internal state (e.g., symbol tables) through special variables, and you can get at everything right from the debugger. You can set breakpoints, examine and change variables, search for source lines with regular expressions, get stack backtraces, and do pretty much everything that you're used to doing in a C-level debugger like `dbx` or `gdb`. Because you're running with the full Perl interpreter under your belt, you can type in any legal Perl code and have it executed on the fly for you—a convenient way to test out new constructs.

Perusing the Perl Library

While a rapid prototype is all well and good, there's no reason to rewrite everything from scratch every time you code up an application. Use existing wheels, don't reinvent them. As you become more experienced, you will want to extract your most useful subroutines and place them in your own private library. Then later you can load your archived function into your new application to use as though it were from a system-supplied library.

But before you write your own library functions, you should know that the Perl distribution already comes with a fair allotment of standard libraries. These include functions for handling option processing, unlimited precision numbers, screen manipulations, binary searches on sorted files, and recursive directory processing.

Just how do you get at these libraries from Perl? The basic statement to load a library from within your program is `require`, as in

```
require 'getopts.pl';
```

Findbig.pl

```
require 'find.pl';
&find('/');
sub wanted {
  if ( (-s $name) > (100 * 2**10) ) {
  print "$name\n";
  }
}
```

Once this is done, you're free to call any functions loaded by that library, although you do have to know the name of the function or functions that you have just loaded. In the above case, the function will not automatically be called `getopts`—in fact, it will be called `Getopts` (remember that, as in C, identifiers are case-sensitive). The listing "Using a Library Function" shows how to use `&Getopts()`.

Like nearly everything in the language (including local variable "declarations"), `require` is a run-time event, not a compile-time one. Perl loads the required file only once, no matter how many times you ask for it. This is a feature, because it lets you write code that includes library routines willy-nilly. You don't have to worry that you're doing extra work if the routines you've required have themselves already required something you're about to load: It won't get loaded twice.

`Requires` don't always succeed. The `require` will fail by raising a trappable but otherwise fatal exception if any of these occur: The file can't be found in your include path (the @INC variable); the code in the required file has syntax errors in it; or the file doesn't return a true value. This last may need a little explaining. It's there so that you can try to run some routine-specific start-up code and have a clean way to indicate whether it has succeeded or failed. In practice, few library functions take advantage of this; they just finish off the file with a line containing a `1;`, which is certainly a true value.

One standard routine that is worth special note is the `find.pl` library. Its entry point is the `&find()` function, as you might have predicted. This library is used by the standard Perl utility `find2perl`.

You invoke `find2perl` as you would the regular Unix `find` utility, just changing the name of the command, and it outputs Perl code to do exactly the same thing as the equivalent `find` command. It even knows about the special GNU `find` options. You can then inspect this output to learn how you might, from a Perl perspective, do the things that the `find` program does. On systems without a `find` program or with an inadequate one, `find2perl` and `find.pl` become even more useful.

Pass the `&find()` function a list of directories to traverse. Then for each file in that directory, `&find()` calls a user-defined function of yours called `&wanted()`. If it encounters a directory, it recurses down the directory. Your routine gets called with two variables set: `$name` is the full path name, whereas `$_` is just the filename component.

The program in the listing "Findbig.pl" goes through your whole file system and prints out the full name of any file greater than 100 KB in length. It is a simple example of how to use the `&find` library function. If you're on a Unix system, the following is also an interesting `&wanted()` function; it prints out any path names of files that are symbolic links pointing to nonexistent files:

```
sub wanted {
  if (-e && !-l) {
    print "$name\n";
  }
}
```

continued

Perl Jamming

OK, I think you're ready for this month's application. I call it the `lst` program. It's supposed to work something like the Unix command `ls -Rt`, which recursively lists out all files sorted by modification time. The problem is that `ls` sorts the files within each directory separately, whereas what you often really want is to have all files sorted against each other irrespective of which directory they occur in. That way you can tell what is the newest file in an entire subtree. So the goal here is to make something like a recursive `ls` but which does sorting on the whole subtree.

The Core of lst Program

```
if ($opt_i) {
  local(*name) = *_;  # $name is now an alias for $_
    warn "file args ignored due to -i" if @ARGV;
    while (<STDIN>) { chop; &wanted; }
}  else {
  require 'find.pl';
  &find(@ARGV);
}

@sorted_names = sort { $time{$b} <=> $time{$a} }
                     keys %time;
@sorted_names = reverse @sorted_names if $opt_r;

foreach (@sorted_names) {
  if ($opt_l) {
    @stats = split(' ',$stat{$_});
    chop($now = &ctime($stats[$TIME_IDX]));
    printf "%6d %04o %6d %8s %8s %8d %s %s\n",
      $stats[$ST_INO],
      $stats[$ST_MODE] & 07777,
      $stats[$ST_LINK],
      &user($stats[$ST_UID]),
      &group($stats[$ST_GID]),
      $stats[$ST_SIZE],
      $now,
      $_;
    } else {
    print "$_\n";
  }
}
```

Instead of writing the whole thing from scratch, you'll use several well-known, standard Perl libraries that are included with every Perl distribution. This will shorten the code considerably.

Here's how the program works. First, require some standard Perl library files. Next, use one of the routines loaded from them to check what options were given. If you didn't get a good option, abort the program with a long usage message. Examine the set of options given to determine what kind of sorting the user wants. Then, you either process the files given on standard input, passing each file off to `&wanted()` for further processing, or else call the `&find()` function, which in turn calls `&wanted` indirectly.

The Wanted Subroutine

```
sub wanted {
  @stats = stat($_);
  -f _ || return;
  $time{$name} = $stats[$IDX];
  $stat{$name} = "@stats" if $opt_l;
}
```

So in either case it's `&wanted` that's doing the work (see the listing "The Wanted Subroutine"). What it does is `stat` each file that comes into it in `$_`, skipping it unless it's a plain file (as opposed to, for example, a directory). Inside the `%time` associative array (i.e., hash table), squirrel off the thing you're going to be sorting on, and save off all the `stats` you got into another table if you're going to be making a long listing. Both of these hash tables are indexed by the full path name of the file.

Since the long output format (to be compatible with `ls`) is going to print out the user and group ownerships on the file, you needed to convert these from their internal numeric form to their more frequently used text version; for example, `uid 0` should print out as "root," not "0." To do this, call the C library routines `getpwuid()` and `getgrgid()`, which are available directly through Perl. But you don't want to call them every time you need that information; that would be far too inefficient. Instead, remember that you already did the conversion by storing the returned value in a Perl array and just fetch the cached name on any subsequent calls that use the same numeric ID.

Back in the main routine, all that's left to do is sort and print. Sort the keys (i.e., indexes) of the `%time` table, which are the names of the files given. Reverse the resulting list of sorted keys if the user selected the `-r` option. If what's wanted is a long listing, then retrieve the saved `stat` information and split it up again into a list. Convert the correct time to print in standard form and then dump out the whole thing using a `printf()`, as in C. If all that's wanted is a short listing, just print the filename directly, remembering to add the trailing new line. ■

Editor's note: *The* `lst` *program runs under version 4.036 of Perl, which is the current release and is available for many kinds of operating systems and hardware. The full text is available electronically. See page 5 for details.*

Tom Christiansen is a freelance consultant living in Boulder, Colorado. He serves on the board of directors for the USENIX Association. When he's not on the road lecturing on Perl, he's getting the libraries, utilities, and documentation for the 5.0 release of Perl into production shape. Tom also maintains the Frequently Asked Questions list for the USENET newsgroup comp.lang.perl. He can be reached on the Internet at tchrist@usenix.org or on BIX c/o "editors."

For More About Perl

If you want to learn more about Perl and you have access to USENET, then you should check out the USENET comp.lang.perl newsgroup for discussions on the Perl language, bugs, features, history, humor, and trivia. It's the best place for the latest information on Perl.

The Frequently Asked Questions list (which I maintain) for that newsgroup contains a wealth of information, ranging from the mundane to the esoteric. This list is retrievable via anonymous FTP from the host rtfm.mit.edu (currently 18.70.0.209) in /pub/usenet/comp.lang.perl/*. It includes information on where to get Perl binaries for some non-Unix architectures.

The ports most likely to be of interest to you are those for MS-DOS, Windows NT, and the Mac. The DOS version is called "bigperl" (actually, BIGPERL4). It's Perl 4.036 that has been compiled using the Watcom C/386 compiler (a 32-bit, flat-memory-model C compiler). It's packed with useful features, including support for up to 32 MB of virtual memory, debugger support, and support for gdbm (the GNU database management routines) for the newer BSD 4.4 db package. A 386/486 with at least 4 MB of RAM is required, and a third-party memory manager is strongly recommended. This version passes those Perl regression tests that do not depend on Unixisms, and it comes complete with full source code, all freely distributable.

The NT version of Perl is also alleged to work well (I have no personal experience with it). It includes support for getting at sockets from Perl, so even on non-Unix systems you can use Perl for networking applications. The source code builds out of the box and contains some NT-specific tests.

Both of these ports, along with the Macintosh version, are available via FTP from ftp.cis.ufl.edu (128.227.100.252) in the /pub/perl directory. Here you'll find a veritable treasure trove of Perl tidbits. Inside that directory, look in the src/ subdirectory for other subdirectories called 4.0/, 5.0/, macperl/, msdos/, and ntperl/.

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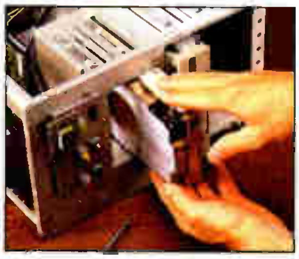

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Essential Reading

Four recommended books on Windows NT, Win32, and OLE 2

JON UDELL

Among the recent profusion of Windows NT books are four that I've found especially interesting: Martin Heller's *Advanced Win32 Programming*, Jeffrey Richter's *Advanced Windows NT*, Russ Blake's *Optimizing Windows NT*, and Kraig Brockschmidt's *Inside OLE 2*.

Heller Investigates Win32

Advanced Win32 Programming by Martin Heller, John Wiley & Sons, $44.95, 463 pp., ISBN 0-471-59245-5 (one disk).

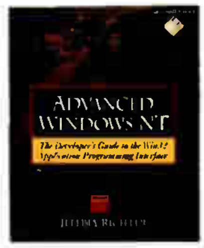
Advanced Win32 Programming isn't a Win32 encyclopedia. Instead, it's a personal memoir that chronicles how a seasoned Windows programmer—Martin Heller—evolved into a Win32 programmer. Because C++ is fast becoming the lingua franca of Windows, he investigates that as well. "I'm the last person who should teach C++," Heller says, "as I've fought it, kicking and screaming, for years."

That's precisely what makes his assessment of C++ so intriguing. Like many Windows programmers, he's torn between wanting to learn object-oriented programming and having to get software out the door. The tension between desire and duty yields a refreshingly candid analysis of the benefits of C++. Because this is, after all, a book about porting from Win16 to Win32, the discussion leads naturally to MFC (Microsoft Foundation Classes), which hide many differences between the two.

One of the book's core examples is an image-viewing program that first appeared in Heller's earlier *Advanced Windows Programming*. A first pass through that code yields a quick-and-dirty Win32 version of the program. A second pass turns it into a quick-and-dirty C++ version. A third pass, intended to make it a truly object-oriented program, wanders entertainingly around in the MFC framework exploring document and view classes and their bit-map-related derivatives. However, it ultimately never delivers the promised object-oriented result. A cop-out? "I learned an awful lot along the way," Heller says now. So does the reader.

Other topics are advanced graphics (i.e., Bézier curves, paths, and world transforms), thread synchronization, Win32s and universal thinking, the multimedia subsystem, enhanced metafiles, and networking (i.e., WNet APIs, named pipes, NetDDE, sockets, and RPCs [remote procedure calls]). Heller picks an eclectic variety of subjects and dissects them in a literate and engaging way.

Richter on Win32



Advanced Windows NT by Jeffrey Richter, Microsoft Press, $39.95, 700 pp., ISBN 1-55615-567-0 (one disk).

Advanced Windows NT by Jeffrey Richter *is* a Win32 encyclopedia, more specifically a detailed guide to the most interesting and important Win32-only APIs. Highlighted subjects include thread synchronization, heap and virtual memory management, memory-mapped files, DLLs, asynchronous I/O, structured exception handling, and Unicode. Every chapter is enlightening, and the book is packed with concise code samples that isolate the APIs of interest.

How does the multithreaded C run-time library work, and why are both single-threaded and multithreaded versions necessary? Why are the heap APIs useful? When should you use sparse virtual memory? Richter's methodical research yields authoritative answers to these and many other questions.

The best client of the Win32 services is Windows NT itself, and Richter often motivates the discussion by showing how NT uses Win32 features to get its job done. Memory-mapped files and thread-local storage, for example, aren't just conveniences for the applications programmer. NT uses memory-mapped files to optimize program loading; thread-local storage is used so the multithreaded C run-time library can store per-thread data. Insights like these make *Advanced Windows NT* more than an API cookbook. It greatly enriched my understanding of the base operating system as well.

Two extended examples will prove especially valuable to students of Win32. A supermarket simulation nicely demonstrates the use of both semaphores and mutexes in a complex synchronization scenario involving lots of threads. A file-copying example highlights NT's potent asynchronous I/O features, contrasting the extended (i.e., alertable) read, write, and wait functions with their standard (i.e., nonalertable) counterparts.

Much of this Win32 exegesis applies not only to NT, but also to Chicago. So even if Windows NT isn't part of your current plan, there are still compelling reasons to get up to speed on threads, sparse virtual memory, memory-mapped files, and other Win32 features common to NT and Chicago. Richter offers comprehensive and reliable guidance.

Blake on Performance Monitoring

Optimizing Windows NT documents the use of the NT Performance Monitor in exhaustive detail. That's a subject Russ Blake knows intimately—he not only wrote the book, but also the tool itself. On another level, the book is a profound meditation on how to identify and eliminate performance bottlenecks in computer systems. Finally, it's a tribute to the first-class instrumentation that's built into Windows NT.

The object-based architecture of NT gave its designers convenient hooks on which to hang counters that monitor the system's vital signs as it runs. For each class of system object—processor, process, thread, cache, disk, network transport, and others—NT maintains a variety of counters that measure the usage of objects of that class. Performance Monitor retrieves the numbers and displays them as charts and tables.

***Optimizing Windows NT* by Russ Blake, Microsoft Press, $34.95, 581 pp., ISBN 1-55615-600-6 (one disk).**

Optimizing Windows NT shows how a savvy user of Performance Monitor can gain extraordinary insight into the dynamics of a running NT system. In Blake's hands, the data clearly exposes system bottlenecks and enables him to state with certainty that a given system's upgrade dollars should be spent on a faster disk, more disks, more memory, or a better network adapter. To show the rest of us how to interpret the data as effectively, Blake works through dozens of examples. Along the way, he teaches an entire methodology of performance analysis and animates the inner workings of NT: the working set tuner, the cache manager, and the scheduler.

Applications can create their own counters for use by Performance Monitor—SQL Server does, for example. The ability to unify application and system counters is one of the things that makes Windows NT such a compelling platform for high-performance applications. To illustrate how to create application-specific counters, Blake modifies the sample VGA driver from the DDK (Device Driver Development Kit), adding counters for BitBlt and text operations.

The technique is relatively arcane. While Performance Monitor queries the registry to collect data (other applications can, too), those queries vector through "performance library" DLLs that in turn communicate with applications. The sample code provides a framework that will make adding your own counters doable, although admittedly not trivial.

I hope Microsoft generalizes this technique at some point, perhaps as part of MFC. Widespread use of such a framework would usher in a generation of applications that benchmark themselves continuously, as NT does, and that would be invaluable.

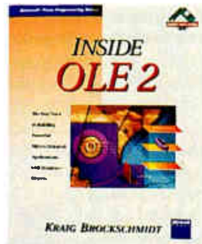
You wouldn't think that hundreds of pages of NT performance analysis would make for a readable book. Surprisingly it does, thanks in part to Blake's irrepressible humor. "To determine the precise location of the bottleneck in your computer, you must become as one with the computer," he jests. "To achieve this state requires years of meditation, prayer, and insanity." He goes on to say that NT's careful instrumentation lays the foundation for a sane approach to the analysis of system and application performance. I wholly agree.

Brockschmidt on OLE 2

Inside OLE 2 can't really be considered an NT book, because the NT version of OLE 2 has yet to ship. On the other hand, OLE plays an even bigger role in Cairo (NT's successor) than in Chicago (Windows 3.1's replacement). Cairo's shell is made up entirely of user-modifiable OLE objects. Initially pegged as a compound-document technology, OLE 2 turned out to be some-

thing far more ambitious: Microsoft's foundation for object-oriented Windows.

The design of object-oriented operating systems is a hot topic right now. Taligent, IBM, Sun, Next, and Hewlett-Packard are advancing their own initiatives and forming alliances with one another. Thus, Kraig Brockschmidt's thousand-page manifesto is essential reading not only for the Windows crowd, but for anyone who needs to evaluate the kind of object system Windows is becoming.



***Inside OLE 2* by Kraig Brockschmidt, Microsoft Press, $49.95, 977 pp., ISBN 1-55615-618-9 (two disks).**

OLE 2 is big and scary, and Brockschmidt doesn't pretend otherwise. Undaunted, he lays out the architecture of the Component Object Model at the heart of OLE 2 and then explores key interfaces, including structured storage, data transfer, embedding, and in-place activation.

A controversial aspect of the OLE 2 Component Object Model is that it tosses inheritance in favor of an alternative scheme called *aggregation*. Brockschmidt's argument for aggregation—that it's the most reliable way to preserve rigorous contracts among components—will receive close scrutiny. Microsoft's approach to reusable components could well prove out. The current plan reflects important lessons learned from the VBX (Visual Basic extensions) experiment, arguably the most successful component architecture to date.

But I'm not yet wholly convinced, in part because Brockschmidt's explanation of the rules for implementing aggregation makes my head spin. Significant encapsulation of that mechanism will be required before most programmers will be able to consider using it. Of course, C++ will be the most likely means of encapsulation. He shows how C++ and OLE 2 can work together. The sample applications that evolve chapter by chapter from straight Windows to OLE 2 are written in terms of a homegrown C++ application framework and, in fact, make good use of inheritance.

When you control the source code, inheritance works well, Brockschmidt argues. But when you don't, inheritance cannot support effective reuse. Perhaps when some future version of MFC does for aggregation what MFC 2.5 now does for in-place activation and OLE automation, we'll find out whether aggregation works as advertised.

The book does make a convincing case for less abstract OLE 2 technologies that you can apply now. If you use the structured-storage interfaces, you can tap features of a next-generation file system, including transactioning and object persistence. If you implement data objects, they will unify Clipboard, drag-and-drop, and other modes of data transfer.

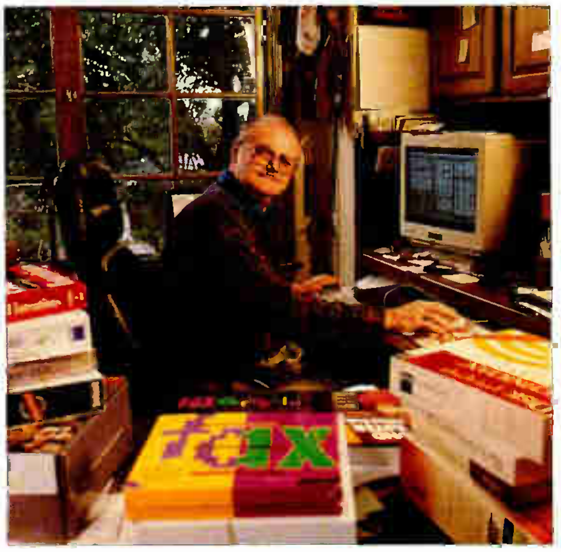
Detailed explanations show how to convert standard Windows code into OLE 2 code. The mechanics of DLL versus .EXE object implementations, and the merits of object handlers and in-process servers (both DLL-based), and local servers (.EXE-based), are also explored in detail.

Does anyone need to know all this, given that frameworks like MFC 2.5 will hide this complexity from even experienced programmers? Yes. Competent users of an abstraction need to know what lies behind it. Also, the technologies that make up OLE 2 define the future of Windows as an object-oriented operating system. That future is clearly discernible in *Inside OLE 2*. ■

Jon Udell is a BYTE senior technical editor at large. You can reach him on the Internet or BIX at judell@bix.com.

JERRY POURNELLE

What's Hot, What's Not



AMY ETRA © 1994

It's January. Because I stubbornly insist that a year ends on 31 December, not when the deadline for the January issue comes around, it's now time for the annual User's Choice Awards, and the Chaos Manor Orchid and Onion Parade. Usual warning: although BYTE distributes the award certificates, the Chaos Manor User's Choice Awards are entirely my responsibility. My ground rules are that, with very rare exceptions, I won't endorse a product I haven't used; and since it's impossible for any person or committee to look at everything going on in this industry, I can't guarantee there aren't better products. I can guarantee that the ones I give awards to are good enough because I've used them to do productive work.

Let's start with video boards. Provided that you have a reasonably fast system, nothing will speed up Windows operations like a good video board. Top honors this year go to the Hercules Dynamite VL Pro (for the VESA Local Bus, alias VL-Bus): in SuperCow, the Gateway 2000 486DX2/66, we got an astounding score of 58.49 with the Win Tachometer benchmark.

The annual Orchid and Onion Parade issues forth from Chaos Manor

Moreover, installation was simple and easy, and so far we have found no incompatibilities: SuperCow has the Maximum Storage Duette optical drive and a Creative Labs Digital Edge Multimedia Kit with CD-ROM, all buffered by Norton Speedrive. It all works splendidly.

The Dynamite VL Pro board makes Microsoft Video for Windows tolerable. We're getting quite acceptable full-screen, full-motion video off a CD-ROM, along with other miracles. Blazing speed, great color, sharp images: this is where the video world is headed, and we're pleased to give the Hercules Dynamite VL Pro a User's Choice Award as the Video Board of 1993.

The previous speed record (see last month's column) was held by the Number Nine #9GXE Professional Graphics Accelerator in exactly the same slot in SuperCow that the Hercules Dynamite VL Pro now occupies; but the #9GXE is not a VL-Bus board, so it used only the (16-bit) ISA portion of the slot. The #9GXE had a Win Tachometer benchmark score of 42.57, which earned it a "Wow!" when we first saw it; prior to that we thought a Win Tachometer score of 30 or more was impressive.

We couldn't test the #9GXE's performance with externally supplied video because the model we have doesn't have a VGA feature connector (as used by Creative Labs' Video Spigot, Sigma Design's ReelMagic, and the like). Future models of the #9GXE will, and you should be sure that the one you get has that feature; you may not think you'll need it, but chances are good that one day you will. If you don't have local-bus video and you need superspeed performance from your 486, the #9GXE is the way to go. It gets a User's Choice Award in the ISA video board category.

I mentioned Norton Speedrive: this is one great program, and unlike many cache programs it will work not only with CD-ROM drives, but with external hard drives working through the parallel port. It speeds up disk operations something fierce, it's easy to install, and it just plain works. We're happy to give

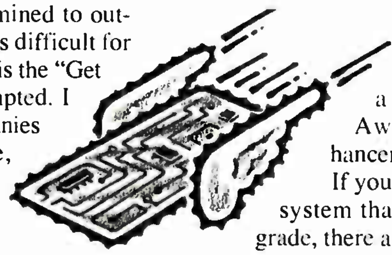
ILLUSTRATIONS: HENRIK LANGSDORF © 1994

Symantec's Norton Speedrive a User's Choice Award.

I can't give it an award because I don't use it, but one of the most important computer programs of the year was Integrated's Matrix X, a "connect the boxes" CASE tool that allowed the McDonnell Douglas team to write the flight-control software for the DC/X rocket ship on time and within budget. The resulting program had enough flexibility to allow the flight controllers to recover from a near disaster when one of the engines didn't perform properly on takeoff.

The DC/X is a one-third-scale model of the SSX spaceship that Max Hunter, General Daniel O. Graham, and I proposed to National Space Council Chairman Dan Quayle back in 1989; Mr. Quayle caused the ship to be built and tested. Bureaucratic hassles delayed the program's start for a couple of years, but then it rolled out in March, flew in August, and so far has done everything expected of it. I truly believe that if we can get funding for the full-scale SSX we'll revolutionize access to space. A large Chaos Manor Orchid to the McDonnell Douglas DC/X team headed by Dr. William Gaubatz, another to the USAF management team of Peter Worden and Jess Sponable, and one to Integrated's Matrix X.

The Onion of the Year goes to the Novell-versus-Microsoft wars, in which each company seems determined to outdo the other in making things difficult for users. Alex suggests I call this the "Get a Life Award," and I'm tempted. I really, truly wish both companies would stop this nonsense, which does neither of them any good and harms the growth of the industry.



The Crystal Ball Award goes to Sigma Designs for their ReelMagic video board. This thing works extremely well, and it shows just what MPEG compression can accomplish when fed into a really good video board. Since the ReelMagic runs through the VGA feature connector, it works well with any VGA card; since the decompression happens on the ReelMagic board, it's not I/O bound by an ISA machine.

There is still a dearth of MPEG images available; while the ReelMagic board can decompress video images on the fly, the compression still takes quite a lot of computing power as well as time. That, too, will change as really powerful systems become more common and MPEG is used in more consumer-oriented systems. The ReelMagic board is out there at the edge of video technology, and it gets a User's Choice Award for video enhancement.

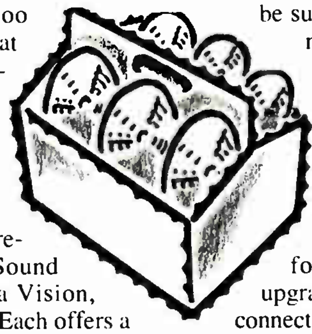
If you have an older 386 system that you want to upgrade, there are several possible routes, including using one of Texas Instruments' new replacement motherboards, but about the simplest is to get the less-than-$300 Cyrix CX486SRX2 chip, which converts a 20- or 25-MHz 386 to a 40- or 50-MHz 486SX. The chip is simplicity to install, and it really works. I haven't tried a Number Nine #9GXE board in a Cyrix-upgraded 386, but I suspect it will fly; then, later, when you get a real 486 system, you can keep the upgraded 386 as a net asset (that's what we've done with our old Cheetah 386) and put the #9GXE board in your new machine. The CX486SRX2 conversion chip from Cyrix gets a User's Choice Award; it really works.

This was the year that video hardware became good enough that multimedia could go from potential to reality. There's still a little fear, uncertainty, and doubt in the video standards, although they're settling out. Alas, there's far more FUD, etc., on the sound side of multimedia: things are really up in the air, there are almost no agreed-upon (as opposed to de facto) standards, and there are a number of competing products, many good, and some excellent.

I can offer some guidelines. First, most games are written in DOS, and while you may not be interested in games, you need to know the reason most are in DOS: Windows is a very discouraging (and slow) environment for game programmers—and the game programmers are the leading edge in multimedia effects. What gamers do this year becomes the technology for other multimedia in the future, and this is especially true for educational software.

This means that for the next couple of years, DOS multimedia software will be at the leading edge; that means your soundboard equipment had better be able to handle DOS sound standards. On the other hand, there is some Windows multimedia software, and the best of it is pretty good. You'll want to run that, too.

You will also want a good CD-ROM player. The big sellers are double-speed (300-Kbps) CD-ROM devices. Triple- and quad-speed systems are just coming out; the only one I have is the new Pioneer DRM-604X, the six-pack CD-ROM player. Double-speed systems can throw out video images faster than most video boards—especially if there is a lot of processing required. We did note that, with the Hercules Dynamite VL Pro, the limiting factor seemed to be how fast we could get data off the double-speed CD-ROM drive.



Get a triple-speed device if you don't have to pay too much, but understand that for most applications double-speed devices will be good enough for the equipment you have.

There are two major companies making multimedia upgrade kits: Creative Labs, with their Sound Blaster line, and Media Vision, with their Pro 16 series. Each offers a number of choices: Creative Labs offers a bewildering variety of kits and boards. The basic components of the kits are a double-speed CD-ROM drive; a sound board, which will also run the CD-ROM drive; and a lot of software. Some of the bundled-in third-party software is spectacular, with combined list prices that are nearly as much as the street price of the upgrade kit.

Some of the older kits have single-speed CD-ROM drives. I don't recommend single-speed drives unless you have an older, slow computer and don't intend to upgrade it. Some of the multimedia kits offer "full standard SCSI," which includes the ability to run your computer's hard disk. There was a time when I thought that that would be a good thing, but I no longer believe it. My advice is not to get one of the "full standard SCSI" kits unless special circumstances dictate it. Instead, figure that your multimedia upgrade kit is for that job and that one alone, and if you need additional standard SCSI devices, get an Adaptec or Future Domain SCSI board, or a DPT SCSI drive controller.

Be sure to get a 16-bit sound card, and be sure it has a Wave Blaster connector. Wave Blaster is Creative Labs' wave-sound add-on, but the connector has become standard; nearly the same add-in board is available for The One-Stop Music Shop on an Amiga. Wave input greatly enhances music performance: think of this as an upgrade path like the VGA feature connector on your video board. With a Wave Blaster connector, you'll be able to buy the best sound libraries (in ROM) for at least the next year, and probably longer.

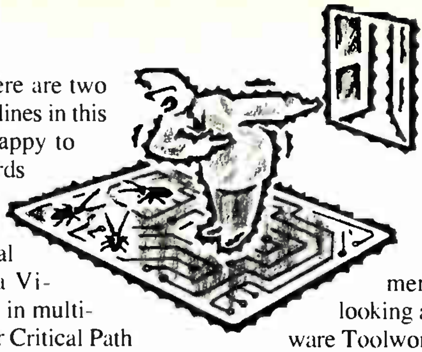
Both Creative Labs and Media Vision offer kits with surprisingly good small speakers. If you care about sound at all, you'll find these worthwhile: I'm partly deaf, and I can very much hear the difference between those and the inexpensive Radio Shack speakers I used to use. The kits offer good speakers at a fair price.

There are kits with and without microphones, kits with more and less MIDI connector cables, and a bewildering amount of software. The microphones are pretty good, and if you don't have one you may want one, although just now there isn't a lot of use for them.

You do want to pay attention to the bundled-in software. You'll want a good multimedia encyclopedia. Compton's Interactive Encyclopedia for Windows (also available for the Mac) is quite good, and it comes with some Media Vision kits. You'll also want a good dictionary and thesaurus. Microsoft Bookshelf, one of the original CD-ROMs and still one of the best (it includes *The American Heritage Dictionary*, *Roget's Thesaurus*, *Bartlett's Familiar Quotations*, and more), is bundled with many Creative Labs packages and runs seamlessly with many Microsoft products, including Word.

We have both the Creative Labs and Media Vision kits installed on a variety of machines, and we've had no problems with either; and in my judgment you won't go wrong with either company. Media Vision has a chip deal with Logitech, ensuring support from that fine company; Media Vision also has aggressive marketing and is doing some very innovative things in multimedia (see below). On the other hand, *everyone* supports Creative Labs and their Sound Blaster line; you're extremely unlikely to encounter a program you can't run in a Creative Labs multimedia system.

Look at both and think about what you want to do; be sure to get 16-bit, dual-speed CD-ROM and a Wave Blaster connector, and make your own decision. Me, I'm tickled pink that there are two good competing product lines in this critical area, and I'm happy to give User's Choice Awards to both Creative Labs and Media Vision.



One reason for this dual award has been Media Vision's innovative efforts in multimedia. In particular, their Critical Path game, while in a genre I'm not fond of, breaks considerable new ground: live actors, real scripts, and smooth transitions within story lines. If you haven't seen this, you certainly should: it's more than just a game—it's a good indicator of things to come.

While we're discussing sound, let me renew the User's Choice Award for The Software Toolworks' Miracle Piano Teaching System. This is a no-nonsense, very good keyboard that will play through your computer system, and it comes with some really excellent software for teaching piano. Every music teacher we know who has seen this product has recommended it. With that, and a Wave Blaster, you can buy all kinds of music sounds and control them with the Miracle Piano Teaching System's keyboard; some of the wave-sound recordings are really splendid. Highly recommended. While you're looking at this, get The Software Toolworks' CD-ROM catalog: they publish a line of really good educational and reference CD-ROMs.

I have several useful peripherals on my network, but the most useful one I've acquired this year is the Pioneer DRM-604X six-pack CD-ROM player. It's very fast, speedy at changing from one disk to another, and really fast in peeling data off the CD-ROM; it works on the network just fine; and it has given me very little trouble.

CD-ROM has become an absolutely vital part of the modern computer world, and it's extremely convenient to have more than one on-line. My usual practice is to keep Microsoft Bookshelf, Compton's Interactive Encyclopedia, DeLorme Mapping's Street Atlas USA, and a couple of other reference CD-ROMs on the DRM-604X and thus available at all times, leaving the CD-ROM player on my local machine for whatever I'm doing at the moment. The time saved by having all those resources instantly available is considerable: moreover, like most authors, I work in spurts, and when I'm really turning out the text, any glitch in the flow can be hideously expensive. At those times, anything that lets me keep working without interruption is worth a very great deal.

Pioneer has another winner in the DRM-604X player, and it gets the User's Choice Award for the most useful CD-ROM player of the year.

Microsoft has two "networks" that issue periodic CD-ROMs containing vital information: TechNet ((800) 344-2121 ext. 160, 24 hours a day, $295 per year for monthly CD-ROMs), which is the technical information network, and the Microsoft Developer CD network. If you're at all involved in developing applications for Windows, or enhancements or tools for any Microsoft application, you should run to enroll in the Developer CD network. It gives vital information about interfacing with Microsoft programs, and it's often the *only* source of such information. Whether you write Microsoft applications or write applications in competition with Microsoft, you need this bad.

In addition, if you install or maintain Microsoft products, you really can't afford not to be enrolled in TechNet. The TechNet CD-ROMs contain an organized database of technical-support information on all Microsoft products, from DOS to Windows NT to FoxPro and Word. Updated monthly, they contain all the information developed by the Microsoft technical-support people: answers to questions users ask. Now that Microsoft charges product managers for technical-support costs, it's much in the product manager's interest to see that the TechNet database is complete; and knowing what problems users have can't hurt either support or development people.

TechNet isn't for every casual user, but it's a natural for computer clubs and users groups, as well as those who install and maintain computer systems; and Microsoft deserves a User's Choice Award for this innovative addition to technical support.

Having said that, I'm still worried about technical-support trends. Software is getting more complicated, the interactions among programs can produce obscure and incomprehensible problems, and a lot of software doesn't know how to uninstall itself; nor does Windows know what has gone wrong. I have great sympathy for Microsoft when someone attempts to

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install some new Windows application, lets it write all over WIN.INI and SYSTEM.INI, and then panics when Windows won't come up.

On the other hand, I have a lot less sympathy for Microsoft when people try to

crosoft dealers would be a cost-effective, competitive move.

I also wish mightily that Microsoft would develop a good AI program to examine WIN.INI and SYSTEM.INI and make suggestions. Some of the TechNet

ter Windows, not merely an upgrade of W4WG; and OS/2 2.1, which is more than just an upgrade of OS/2.

There was also a dark horse: It's called OS/2 for Windows, but it ought to be called OS/2 for Windows Users; and if it

battery chargers weigh, and I very much like the convenience of a hard disk and a backlit screen. On the other hand, this means that I don't have Franklin Ascend with me outside my hotel room, because Ascend is a Windows program and the Gateway HandBook doesn't do Windows. [Editor's note: *The new Gateway HandBook 486 does support Windows.*]

I find now that I still carry the Mastersport to use in hotel rooms, and I carry the OmniBook where the Gateway HandBook used to go. This works very well, since I don't do a lot of writing or computing out on field trips, and when I come back to the hotel room where I do write a lot, I have the Mastersport with its nifty keyboard and backlit screen. It's the work of a moment to use LapLink to transfer any files I may have changed during the day.

Some friends really like the OmniBook 425, and others really hate it; it seems more a matter of temperament and ability to use that strange little mouse than anything else. Me, I like it just fine, and it gets a User's Choice Award in the portable category.

This year saw some important developments in computer languages. Most of my readers know that I am no great fan of the C programming language; and while C++ corrects some of C's deficiencies, it doesn't do anything about the worst problem of all—namely that C will compile nonsense, including unwanted type changes and pointers to nothing at all. C programmers have to simulate the compiler in their heads when they code; me, I prefer to have the computer catch my mistakes for me, meaning that I want a highly structured language with a compiler that complains when I do something stupid.

For years I thought that Modula-2 would evolve into the most important of the computer languages; then Turbo Pascal incorporated most of Modula-2's features. Alas, while Turbo Pascal still lives, even at Borland it takes a back seat to C++. Nowadays the only real rival to C++ is one or another form of compiled BASIC and/or Visual Basic.

There are two of these: Microsoft Visual Basic and Computer Associates' CA-Realizer. Both have strong points. Microsoft Visual Basic is compatible with their DOS Basic Compiler language, and their secret weapon is Crescent Tools, a line of assembly language routines that can be called in Visual Basic programs. CA-Realizer, on the other hand, comes with compilers for both Windows and OS/2—something you're unlikely to see in a Microsoft program for a while, and it has a wonderful programming environment. Both are surprisingly easy to learn.

I have dithered over this for a week, and it's time to make a choice: it's a pure judgment call, but I give the Chaos Manor Orchid to CA-Realizer, and the User's Choice

For More Information

We're pleased to give the **Hercules Dynamite VL Pro** (1 MB of DRAM, $249; 2 MB of DRAM, $299) a User's Choice Award. Contact **Hercules Computer Technology, Inc.,** 3839 Spinnaker Court, Fremont, CA 94538, (800) 532-0600 or (510) 623-6030; fax (510) 623-1112. **Circle 1313 on Inquiry Card.**

If you don't have local-bus video and you need superspeed performance from your 486, the **#9GXE Professional Graphics Accelerator** ($345 to $1095) is the way to go. Contact **Number Nine Computer Corp.,** 18 Hartwell Ave., Lexington, MA 02137, (800) 438-6463 or (617) 674-0009; fax (617) 674-2919. **Circle 1314.**

Norton Speedrive ($99) speeds up disk operations something fierce. Contact **Symantec Corp.,** 10201 Torre Ave., Cupertino, CA 95014, (800) 441-7234 or (408) 253-9600; fax (408) 252-4696. **Circle 1315.**

The **ReelMagic** board ($499) is out there at the edge of video technology. Contact **Sigma Designs, Inc.,** 47900 Bayside Pkwy., Fremont, CA 94538, (800) 845-8086 or (510) 770-0100; fax (510) 770-2640. **Circle 1316.**

The **Cyrix CX486SRX2** conversion chip (20-MHz 386 to 40-MHz 486SX, $269; 25-MHz 386 to 50-MHz 486SX, $299) is simplicity to install, and it really works. Contact **Cyrix,** 2703 North Central Expy., Richardson, TX 75080, (214) 994-8388; fax (214) 994-8764. **Circle 1317.**

You're extremely unlikely to encounter a program you can't run in a Creative Labs multimedia system (**Discovery CD16 Multimedia Kit,** $649.95; **Edutainment CD16 Multimedia Kit,** $749.95; **Digital Edge CD Multimedia Kit,** $999). Contact **Creative Labs,** 1901 McCarthy Blvd., Milpitas, CA 95035, (800) 998-5227 or (408) 428-6600; fax (408) 428-6611. **Circle 1318.**

We have the **Media Vision Pro 16 Multimedia System** upgrade kit (System 1, $1049; System 2, $1195) installed in a variety of machines, and we've had no problems. Media Vision's **Critical Path** ($79.95) game breaks considerable new ground: live actors, real scripts, and smooth transitions within story lines. Contact **Media Vision,** 47300 Bayside Pkwy., Fremont, CA 94538, (800) 348-7116 or (510) 770-8600; fax (510) 770-9146. **Circle 1319.**

The **Miracle Piano Teaching System** (IBM, $479.95; Mac, $499.94; software only, $149.95) is a no-nonsense, very good keyboard that will play through your computer system, and it comes with some really excellent software for teaching piano. Highly recommended. Contact **The Software Toolworks,** 60 Leveroni Court, Novato, CA 94949, (800) 234-3088 or (415) 883-3000; fax (415) 883-3303. **Circle 1320.**

Pioneer has another winner in the **DRM-604X** ($1795), and it gets the User's Choice Award for the most useful CD-ROM player of the year. Contact **Pioneer New Media Technologies, Inc.,** 2265 East 220th St., Long Beach, CA 90810, (800) 527-3766 or (310) 952-2111; fax (310) 952-2990. **Circle 1321.**

I am a fan of Windows for Workgroups 3.11 ($249.95). I like the 32-bit file and disk access. I very much like the improved File Manager. With **Crescent Tools, the Microsoft Visual Basic Programming System 3.0** (Standard Edition, $199; Professional Edition, $495) lets you write bigger and faster programs. Contact **Microsoft Corp.,** 1 Microsoft Way, Redmond, WA 98052, (800) 426-9400 or (206) 882-8080; fax (206) 883-8101. **Circle 1322.**

OS/2 2.1 (disk version, $179; CD-ROM version, $152) works, and for some users it's clearly the right choice. With **OS/2 for Windows** (disk version, $49; CD-ROM version, $39), you have your old Windows desktop and installed applications, and OS/2 as well. Contact **IBM Corp.,** 1 Old Orchard Dr., Armonk, NY 10504, (800) 342-6672 or (914) 765-1900; fax (313) 225-4020. **Circle 1323.**

Fargo gets a big Chaos Manor Orchid for the **Primera Color Printer** ($995). Contact **Fargo Electronic Services, Inc.,** 7901 Flying Cloud Dr., Eden Prairie, MN 55344, (800) 327-4622 or (612) 941-9470; fax (612) 941-7836. **Circle 1324.**

The advantages of the **OmniBook 425** (with 40-MB hard drive, $1795; with 10-MB flash disk, $2095) are its considerable power and light weight. Contact **Hewlett-Packard Co.,** 1000 Northeast Circle Blvd., Corvallis, OR 97330, (800) 433-1254 or (503) 757-2004; fax (800) 333-1917. **Circle 1325.**

CA-Realizer ($99) comes with compilers for both Windows and OS/2. Contact **Computer Associates International, Inc.,** 1 Computer Associates Plaza, Islandia, NY 11788, (800) 225-5224 or (516) 342-5224; fax (516) 342-5734. **Circle 1326.**

Masters of Orion ($59.95) is the best space strategy game I have ever encountered. Contact **Microprose,** 180 Lakefront Dr., Hunt Valley, MD 21030, (410) 771-1151; fax (410) 771-1174. **Circle 1327.**

Doom ($40) is so startlingly real and does such wonderful visual effects that you won't believe it. Contact **Id Software, Inc.,** 18601 LBJ Frwy., Suite 615, Mesquite, TX 75150, (800) 434-2637 or (214) 613-3589; fax (214) 686-9288. **Circle 1328.**

Award for Language of the Year to Microsoft Visual Basic, largely because Visual Basic with Crescent Tools lets you write bigger and faster programs. Both are excellent, and I encourage readers to look into one or the other. Get your hands dirty: programming can be fun, it's a lot easier to learn than you think, and a competent compiled BASIC programmer can turn out large programs that work *much* faster than C++ programmers can.

Every year I get bribes: chocolate, T-shirts, sweatshirts, coffee mugs, fruitcakes: but the oddest this year comes from Quanta Press, who publish a good line of CD-ROMs, often winning my CD-ROM of the month category; it's worth being on their mailing list. Anyway, these madmen (they must be mad: why else would their symbol be the Cow Ouroborous, which, like the Midgard Serpent, encircles the world holding its own tail in its mouth) sent me a hand-carved wooden plaque sporting a cut-out model guernsey cow and the legend "THIS HOUSE IS UDDER CHAOS."

Longtime readers may recall that BYTE headquarters in Peterborough occupies the building that was once the headquarters of the American Guernsey Cattle Club; for years, the editorial offices were decorated with pictures of cows, and I still have mine hanging on the office wall here in Chaos Manor, making Quanta's plaque the bribe of the year.

Which brings us to the Game of the Year: Masters of Orion, usually called MOO in on-line discussions. MOO is the best space strategy game I have ever encountered. It has some weaknesses. In particular, the battles (which, thank heaven, have no arcade elements whatever) tend to be limited, with little reward for tactical skill; but overall this is an excellent game, one that can be played over and over. If you like strategy games at all, you will love this one. MOO gets the User's Choice Award as Game of the Year.

Did you ever see Castle Wolfenstein? Originally done in assembly language on the Apple II, and ported amazingly well to the PC, it's a search-the-castle-and-kill-the-Nazis-in-real-time game, and with its follow-ons has an addicted throng. The same people have now produced Doom, a game that is so startlingly real and does such wonderful visual effects that you won't believe it.

Doom, like Castle Wolfenstein, is shareware, sort of: that is, you can download the first installment from most BBSes and run it for free. Register that, and you'll get more episodes. (Call it "heroinware"—the first dose is free....) Doom is dark and eerie, and realistic, and Rick Heimlich, who tests games for a living, reports that of all the thousands of games that have passed through his house, this is the first one his wife Cheryl has become addicted to. That should tell you something. Doom receives the User's Choice Award for Shareware of the Year.

I'm out of space, so next month more User's Choice Awards, including drive controllers, word processors, suites, and books; and the Orchid and Onion parade will continue. ■

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.

What's New Hardware

PLUG-AND-PLAY X TERMINALS

The HP Entria X graphical desktop systems (from $995) show

performance ratings of up to 104,000 Xstones. From Hewlett-Packard (Santa Clara, CA), the terminals are compliant with the Dynamic Host Configuration Protocol (i.e., plug-and-play), with the IP address automatically assigned to the terminal when the terminal is connected to the network. The HP Entria terminals have an intuitive start-up screen and include energy-saving features such as automatic shutdown after a period of inactivity. Other features include multiple keyboard support with a dynamic keyboard mapper and quiet, fan-free operation.
Phone: (800) 637-7740 or (415) 857-1501.
Circle 1063 on Inquiry Card.

RISC-BASED PRINTING

The NPS 530 multiprotocol Ethernet pocket print server ($599) from Axis Communications (Danvers, MA) has a data throughput of up to 1200 Kbps. The palm-size 32-bit RISC device simultaneously supports TCP/IP, NetWare, EtherTalk, LAN Manager, and LAN Server. It is based on the company's Etrax chip.
Phone: (800) 444-2947 or (508) 777-7957.
Circle 1068 on Inquiry Card.

CHANGE RESOLUTION ON THE FLY

Able to display 24-bit images at resolutions as high as 1152 by 882 pixels, the LeMansGT ($2999) has 3 MB of VRAM and a 72-Hz refresh rate in 24-bit mode at a resolution of 1280 by 1024 pixels. From Radius (San Jose, CA), the card's customized ASICs are designed to deliver 32-bit QuickDraw acceleration. The LeMansGT includes Dynamic Desktop software that lets you design in WYSIWYG mode, switch resolution for detailed work, and then change to two-page resolution to view the entire document.
Phone: (800) 227-2795 or (408) 434-1010.
Circle 1064 on Inquiry Card.

NETWORK SECURITY

The 12-port Online 10Base-T Security Module (Model 5112-TPLS, $1995) provides two levels of protection for your UTP Ethernet network. The Chipcom (Southborough, MA) module prevents unauthorized listening and keeps unauthorized users from accessing the network and transmitting information. Network managers can assign as many as four authorized addresses per port; the Security Module can automatically learn the authorized addresses.
Phone: (508) 460-8900.
Circle 1066 on Inquiry Card.

PUT PC PERIPHERALS ON YOUR MAC

KeyStone ($99) from Silicon Valley Bus (San Juan Bautista, CA) lets you use PC-compatible keyboards and mice with your Mac while continuing to use your Mac keyboard and mouse. The unit's Control Panel software lets you use three-button mice and trackballs and maps your custom commands to the three mouse buttons. KeyStone, which attaches to the Apple Desktop Bus socket, has a Start-up button and an extra ADB socket.
Phone: (408) 623-2300.
Circle 1070 on Inquiry Card.

A COLOR PRINTER TO BE SHARED

Designed for presentation graphics and color printing, the DECcolorwriter 1000 ($3999) directly connects to Macs and PCs with simultaneously active ports via its resident AppleTalk, serial, and parallel interfaces. From Digital Equipment Corp. (Maynard, MA), the printer has 8 MB of memory in addition to optional EtherTalk, LAT, NetWare, and TCP/IP interfaces. RISC processing provides a printing speed of 2 pages per minute; print resolution is 300 by 600 dpi.

Phone: (800) 777-4343 or (508) 493-5111.
Circle 1065 on Inquiry Card.

PARALLEL-PORT NETWORKING

Able to link 32 computers with as many as 16 printers at distances of up to 1200 feet, PrimaNet (starter kit, $329) has a data transfer rate as high as 1 Mbps. From Primax Electronics (Campbell, CA), PrimaNet provides file sharing, file transfer, E-mail, and chat capabilities. Multiple print jobs can be completed simultaneously on different computers; the network redirection TSR program provides networking capabilities such as remote file sharing, application launching, and disk operations.
Phone: (800) 338-3693 or (408) 364-2800.
Circle 1067 on Inquiry Card.

GAIN WIRELESS CONTROL OF YOUR PC

DOS- and Windows-compatible, the RediDockit wireless docking system gives you wireless remote control of your desktop computer's keyboard and screen. The system consists of an ISA-bus Ethernet adapter with an RF module installed in your desktop PC, a PCMCIA RediCardrf Ethernet adapter with an RF module installed in your notebook computer, and Inside/Out software. Operating at 2.4-GHz connectivity with a 9.5-MBps data transfer rate, the system has a modified collision-avoidance protocol at a range of 30 to 100 feet. The system lets you transfer and synchronize files and update or copy programs from the notebook to the desktop or vice versa. You also get wireless remote access of your LAN resources, such as printers and disk drives. Cost is $1299.

Contact: Data Race, San Antonio, TX, (800) 329-7223 or (210) 558-1900.
Circle 1060 on Inquiry Card.

A Wireless Interface for Your PC and Phone

DigiDial lets you auto-dial directly from your computer to your PBX-system phone. The wireless interface consists of a receiver that connects to the main circuit within your phone and a transmitter that connects to a 9- or 25-pin serial port on your computer. Since DigiDial responds to the standard Hayes-AT modem command set, it is compatible with contact-manager software programs that permit auto-dialing, such as PackRat, Cardfile for Windows, ACT, and TeleMagic. The interface is based on 315-MHz wireless RF technology. Cost is $139.

Contact: Datalogic, Grand Rapids, MI, (800) 397-2200 or (616) 698-3030.

Circle 1061 on Inquiry Card.

WAVES OF SOUND

SoundMan Wave ($349), from Logitech (Fremont, CA), is a 16-bit stereo card based on wave-table synthesis. Windows- and DOS-compatible, the card provides 44 wave-table and FM voices, full SoundBlaster and AdLib compatibility, 16- or 8-bit stereo or mono digital audio, 44-kHz sampling, MIDI support, a five-channel stereo mixer, and a SCSI CD-ROM connection.

Phone: (510) 795-8500.

Circle 1069 on Inquiry Card.

100 PLATTERS OF STORAGE

Pinnacle Micro's (Irvine, CA) Cascade CD 100 CD-ROM jukebox ($9995) stores up to 65 GB (i.e., 100 CDs) of audio, video, or data CDs in a single CD-ROM library system. The 39.7-pound unit has a disc transfer rate of 376 KBps and a disc-load time of less than 6 seconds. The jukebox is Mac and PC compatible.

Phone: (800) 553-7070 or (714) 727-3300.

Circle 1071 on Inquiry Card.

SPLIT KEYBOARD ▼

An ergonomic keyboard that enables you to physically arrange the keypad in multiple positions, the Ergo Max ($99) from Maxi Switch (Tucson, AZ) includes a 72-key main keypad and a 30-key numeric keypad. You can divide the main keypad in half and then separate the halves. You can raise and lower each half, locking each into place at your optimum typing level. The numeric keypad fits on either side of the main keypad. Options include a 40-key keypad with built-in calculator functions and LCDs and a wrist pad with a built-in trackball module.

Phone: (602) 294-5450.

Circle 1072 on Inquiry Card.

STEREO SOUND FOR YOUR LAPTOP

A pocket-size box for recording and playing sound, PC*Max (from $199) attaches to the parallel port of your laptop or desktop system. From Gilltro-Electronics & Associates (Santa Clara, CA), the PC*Max comes with two integrated speakers, an internal microphone, and a dynamic range of 72 dB. Windows-compatible, the unit uses up 480 KB of disk space for 60 seconds of sound.

Phone: (408) 727-6422.

Circle 1073 on Inquiry Card.

DATA IN THE FAST-AND-WIDE LANE

The SiliconExpress IV SCSI-2 accelerator card ($995) supports sustained 16-bit SCSI-2 data transfer rates of 20 MBps, according to Atto Technology (Amherst, NY). The card supports up to 15 peripherals without disabling the Mac's built-in SCSI port. The bus-mastering feature supports bus throttling, which smooths out the overall bandwidth of the bus, thus increasing overall data throughput. Bus mastering also transfers data independently of the CPU. The SiliconExpress IV supports fast NuBus block-mode transfers and contains an on-board RISC processor.

Phone: (716) 691-1999.

Circle 1133 on Inquiry Card.

SCSI HOST ADAPTER

The AMM-1572 SCSI Audio Host Adapter ($349) has a SCSI-2-compatible programmed I/O interface that supports synchronous bursts of up to 10 MBps. From Adaptec (Milpitas, CA), the board is SoundBlaster compatible and includes 16-bit audio, a DSP, XA-Audio for enhanced CD-ROM performance, a CD-ROM software cache, and an on-board BIOS that lets you boot from a SCSI hard disk.

Phone: (408) 945-8600.

Circle 1131 on Inquiry Card.

SHORT-RANGE MODEM

A short-range modem that you can operate at distances of up to 2000 feet over UTP wire, the Model 1225 ($65) from Patton Electronics (Gaithersburg, MD) works in pairs. You connect a transmitter unit to your PC's parallel port and a receiver unit to the parallel port of the output device, such as a printer or a fax. Designed to connect parallel devices within a building, the modem accepts data from a PC and sends it serially at data rates of 40 Kbps.

Phone: (301) 975-1000.

Circle 1134 on Inquiry Card.

FAULT-TOLERANT FILE SERVER

The San Francisco 466DS, a 66-MHz 486DX system, contains two completely redundant file servers in one chassis. Each server has 16 MB of RAM on its motherboard (which is upgradable to 256 MB), 1 MB of cache memory, two 500-MB hard drives, and two dual-channel SCSI connectors. Each server also has two modems, five network-interface cards, dual video cards, and two UPSes. The GUI-based MIS Manager software instantly pages or sends a fax to your designated technical-support engineers if either of the servers stops operating. The system ($9999) is from MicroAccess (Fremont, CA).

Phone: (800) 442-2221 or (510) 249-9988.

Circle 1074 on Inquiry Card.

What's New Hardware

MULTIPURPOSE PERSONAL PLAYER

Mac- and PC-compatible, the Reno Personal CD-ROM Player (from $399) is operable via nickel-cadmium batteries or AC power. The double-speed external drive has a 64-KB memory buffer and a standard SCSI-2 connection. You can use the drive as either a stand-alone audio CD player or a multisession Photo CD player. The unit has data transfer rates of up to 306 KBps and an access speed of less than 180 ms.

Contact: Media Vision, Fremont, CA, (800) 845-5870 or (510) 770-8600.

Circle 1062 on Inquiry Card.

FAXING WITH THE POWERBOOK DUO

The PowerPort/Mercury fax/modem for the PowerBook Duo ($399) is based on the V.32terbo standard, enabling it to transfer data at speeds of up to 19.2 Kbps and send and receive faxes at 14.4 Kbps. The Global Village (Mountain View, CA) unit includes GlobalFax OCR software, which lets you convert incoming faxes into word processing, spreadsheet, or database format and save them anywhere on your desktop or hard disk.

Phone: (800) 736-4821 or (415) 390-8200.

Circle 1136 on Inquiry Card.

POWER MULTIMEDIA ▼

MediaQuad ($5495) from Quadrant Components (Fremont, CA) features 16 MB of RAM (which is upgradable to 32 MB), 256 KB of cache memory, and a 1-GB hard drive. The 66-MHz 486DX system provides CD-quality audio via its Labtec speakers, and full-motion video with a real-time MPEG capture/compression card. MediaQuad includes eight 16-bit AT-bus expansion slots and two 32-bit VL-Bus slots; it also has five drive bays, a built-in fax/modem, and a CD-ROM drive.

Phone: (510) 656-9988.

Circle 1132 on Inquiry Card.

PERSONAL PRINTER

A color-upgradable 24-pin impact dot-matrix printer, the ActionPrinter 3260 ($299) from Epson America (Torrance, CA) has the ability to print up to 270 cps at 15 characters per inch in draft mode. In letter-quality mode, it can print 99 cps at 15 cpi with a noise level of 46.5 dB. The 360- by 360-dpi printer includes 10 built-in fonts, four of which are scalable.

Phone: (800) 289-3776 or (310) 782-0770.

Circle 1137 on Inquiry Card.

FOUR POUNDS OF POWER

The 4-pound Aspen 486 Color Subnote (from $1995) has 4 MB of RAM (expandable to 20 MB), 512 KB of VRAM, a removable 80-MB hard drive that's expandable to 120 MB, and a PCMCIA Type II slot. Its display is an 8-inch 640- by 480-pixel CCFT backlit VGA screen with enhanced passive color. The Aspen Computer (Buffalo, NY) system's expansion features include an AT-bus port for an optional docking station and an external VGA/CRT port.

Phone: (800) 472-3273 or (716) 626-0315.

Circle 1138 on Inquiry Card.

PENTIUM AND THE PCI LOCAL BUS

Micron Computer's (Nampa, ID) Pentium PCI Local Bus systems (from $2799) are designed for advanced graphics and memory-intensive applications. The low-end P60PCI ValueLine CD system features a 60-MHz Pentium processor, a double-speed CD-ROM drive, MPC-2 compliance, 8 MB of RAM (expandable up to 128 MB), 256 KB of 15-ns write-back cache, and a 340-MB hard drive. The PCI graphics accelerator has 2 MB of RAM.

Phone: (208) 465-3434.

Circle 1139 on Inquiry Card.

WATCH TV IN A SCALABLE WINDOW

WatchIt Pro ($595) from New Media Graphics (Billerica, MA) receives and displays live TV in a scalable window on your PC screen in up to 16.7 million colors. Completely self-contained, the board will not slow down other applications. An on-screen remote control lets you select channels and adjust the video. Available for Windows or DOS, the board supports noninterlaced resolutions of up to 1024 by 768 pixels, as well as local-bus and 32,000-color VGA for the rest of your display. With the board, you can grab individual frames of video in PCX, BMP, SVW, and TGA file formats and clips of video and sound under Video for Windows AVI format.

Phone: (508) 663-0666.

Circle 1140 on Inquiry Card.

GRAB IMAGES FOR SCIENCE

The DT55-LC ($695), a scientific-quality square-pixel frame grabber, uses Global Lab Acquire software to capture, save, and print images. The Windows-compatible board captures images from video cameras, VCRs, and still-video devices in real time and saves them in TIFF, PCX, or DT-IRIS format. From Data Translation (Marlborough, MA), the DT55-LC has four on-board input lookup tables. Operations include addition and subtraction of a constant as well as reverse video.

Phone: (800) 525-8528 or (508) 481-3700.

Circle 1141 on Inquiry Card.

A BRIDGE FOR ETHERNET

The LB2 Ethernet Bridge, a local bridge with a forwarding rate of 14,600 packets per second and a filtering rate of 28,000 pps, has

two AUI ports and a serial port for an ASCII terminal that's acting as a local management console. From Lantronix (Irvine, CA), the $1695 unit is compatible with Telnet, DECnet, SNMP, SunNet Manager, and HP OpenView and has configuration utilities for use with AppleTalk and NetWare.

Phone: (714) 453-3990.

Circle 1135 on Inquiry Card.

Introducing Win/TV-Celebrity

Advanced Features .. from $349.-

The best overlay/capture board. Period!

The new Win/TV-Celebrity combines the features that multimedia producers and video watchers have been asking for. It supports the video overlay and capture capabilities required by desktop publishers, presentation developers and kiosk builders. Watch television or capture, cut, edit and title your videos. The Win/TV-Celebrity uses a simple external connection, making it the easiest overlay/capture card to install!

Advanced family.

For sophisticated multimedia applications, other Win/TV family members include:

- **Motion JPEG capture** for full frame production-quality video capture (30 fields per sec.) with sound capture for a single slot audio/video editing solution
- **Recordable video output** for making high quality video tapes of your multimedia productions
- **Multi-video breakout box**, to make professional A/V cabling a snap.

Advanced features no other overlay/capture board can deliver.

The Celebrity is the *only* video capture board with built-in overlay and these advanced features:

- **Full motion video** on VGA monitors up to 1280x1024 with up to 16 million colors
- **Video overlay** for displaying full motion video from VCR or camcorder. And watch TV with the CelebrityN.
- **Easy to install.** No memory size limitations. Celebrity works with all SVGA boards in all graphics modes. No VGA limitations since the Celebrity does not use a feature connector!
- **Fast 320x240 clip capture** with built-in compression.
- **S-Video and 4:2:2 operation** for crystal clear video display and pro-quality 24-bit image captures.
- **Windows and Windows/NT compatible** (OS/2 coming soon).

Low price.

Win/TV-Celebrity is just **$349.-**
Win/TV-CelebrityN with cable ready 122 channel tuner is only **$449.-** The Win/TV Family: single slot solutions for your TV viewing, multimedia production, desktop publishing or video kiosk applications. Developers can get our Win/TV Programmers Toolkit so you can add full motion video to your C or Visual Basic applications.

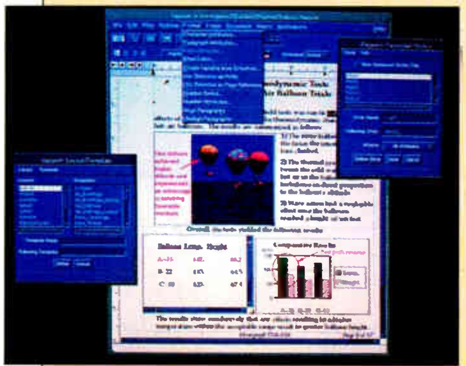
Hauppauge!

Hauppauge Computer Works, Inc.
91 Cabot Court, Hauppauge, NY 11788
Telephone: 516-434-1600 Fax: 516-434-3198
1-800-443-6284
GSA# GS00K92AGS6156 PS01

Available through your local computer dealer or by mail: PC Connection, MicroWarehouse and Misco.

Circle 89 on Inquiry Card (RESELLERS: 90).

What's New Software



State-of-the-Art Word Processing for Unix

An object-based word processing program for Unix, Rapport Script combines ease of use for the casual user with sophisticated elements for creating complex documents and presentations. To access functions in Rapport Script's basic mode, you point and click on the control panel; an advanced mode lets you access high-level layout and formatting options. You can create and edit nontext elements, such as spreadsheets, without having to open a new window. You can also use multiple flows on a page, mix portrait and landscape pages, and automatically align paragraphs horizontally. Slide-presentation support includes master slides, slide templates, and a thumbnail view of the slide set. You can drag and drop material that you've prepared in other applications. The FLEX (Facility for Linkage and Extension) feature lets you customize the menus and control panel; it works with standard programming languages and interface tools. A floating license costs $695.

Contact: Clarity Software, Mountain View, CA, (800) 235-6736 or (415) 691-0320.

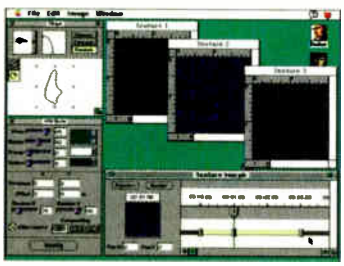
Circle 1271 on Inquiry Card.

CREATE TILEABLE TEXTURES ▼

Specular TextureScape ($195) from Specular International (Amherst, MA) enables you to create high-resolution synthetic textures and images on your Macintosh that you can animate and morph over time. The textures are tileable and can be rendered at any resolution; each texture can contain multiple layers that you can rearrange at any time. Each layer is defined by a grid that lets you tile the shapes and randomize each shape position. Each layer also has as many as four lights; each light has an angle, direction, and intensity setting. Surface settings include gloss, bump, transparency, softness, and color. The software has the ability to write image files as PICT or TIFF and animation files as PICS, numbered PICTs, and QuickTime movies.

Phone: (413) 253-3100.

Circle 1275 on Inquiry Card.



RAID FOR OS/2

With EZRAID for OS/2 ($795) you can create your own OS/2 RAID subsystem using most off-the-shelf drives and drive controllers. Your software-managed disk array can use RAID levels 0, 1, 4, and 5. EZRAID provides seamless compatibility with industry-standard drives and host adapters and supports all the major interfaces, including HIPPI, ESDI, SCSI, and IDE, according to the manufacturer, Pro Engineering (Ottawa, Ontario, Canada). The software includes support for non-SCSI equipment and works transparently with any OS/2 or DOS/Windows application.

Phone: (613) 738-3864.

Circle 1276 on Inquiry Card.

NEW LIFE FOR YOUR RAM DISK

Designed to make file access faster and extend the battery life of Mac PowerBooks, Atticus RAMDiskSaver ($69.95) makes scheduled automatic backups of your installed RAM disk. From Atticus Software (Stamford, CT), the utility lets you shut down your PowerBook without losing files stored on your RAM disk; file synchronization automatically maintains identical copies of files on the hard disk and the RAM disk. With the disk saver installed, you can use the RAM disk as a start-up disk.

Phone: (203) 348-6100.

Circle 1278 on Inquiry Card.

ELECTRONIC PUBLISHING

The graphical interface of the NeoBook electronic publishing package (from $45) consists of a tool palette and a command bar. To create a publication, you draw frames to contain your text and images; you then add command buttons that let the reader turn pages, exhibit additional information, and pop up comic book–style speech balloons. Tools are provided that allow you to add other graphical elements, which you can display on one page or over many pages. From NeoSoft (formerly OSCS Software Development, Bend, OR), NeoBook links to existing text editors and paint programs.

Phone: (800) 545-1392 or (503) 389-5489.

Circle 1279 on Inquiry Card.

GATHER INFORMATION IN REAL TIME

A Unix server for rapid storage and retrieval of time-critical transaction data, TickBase (from $500 per end user) allows you to rapidly access, review, and analyze vast amounts of real-time information. Initially targeted toward users of real-time financial data, TickBase also supports most other data sources. From Leading Market Technologies (Cambridge, MA), TickBase stores the "tick" data in real time and builds a central, shareable reservoir of tick-data history. You can set filters to trap bad data and specify optional time frequencies with which to normalize or reduce captured data as it is stored. Multiple simultaneous queries and data captures are supported; an open API lets you interface to your own data-analysis and calculation program.

Phone: (617) 494-4747.

Circle 1280 on Inquiry Card.

QUICK PREVIEW BROWSING

A preview and file manager for Windows, Turbo Browser ($69) automatically previews thumbnail video and animation clips, graphical images, and sound bites

along with a tabulation of associated file data. You can copy and delete files, save files in different formats, and print them with an audiovisual association. You can convert bit-mapped files and file-compression options to different file formats and link the files directly to an associated editor or program. Turbo Browser supports multimedia file formats, such as AVI, FLC, FLI, MID, and WAV, and most image file formats, as well as a full range of color. The package is from Pacific Gold Coast (Glen Cove, NY).

Phone: (516) 759-3011.

Circle 1277 on Inquiry Card.

TOOLKIT FOR MWAVE

Intermetrics' (Cambridge, MA) Mwave Developers Toolkit ($495) provides a link for building multimedia applications for IBM's Mwave technology. You can write Windows-based applications and incorporate capabilities such as voice, audio, fax, modem, telephony, and images. You can add or enhance Mwave system capabilities using the MDK's C development tools to program the Mwave technology platform's DSP. The Mwave Developers Toolkit includes APIs, tools, and sample code.
Phone: (800) 356-3594 or (617) 661-1840.
Circle 1281 on Inquiry Card.

VISUAL NETWORK MANAGEMENT

LANtastic Management Services software (from $199) provides basic visual monitoring of a network from a Windows-based platform. The Artisoft (Tucson, AZ) software graphically displays information about an entire network, enabling administrators to view how the network is performing at any given time. Features include node discovery, preset alarms, trouble reports, and icons that let the administrator organize the network into a virtually unlimited hierarchical schematic. The advanced version adds inventory management, which runs automatically when users start up the network; user-definable alarms and data gathering; and DDE support.
Phone: (602) 670-7100.
Circle 1282 on Inquiry Card.

CLIP-ART MANAGER

Corel Gallery ($129) contains a collection of 10,000 clip-art images that you can drag and drop into any OLE-compatible application. From Corel (Ottawa, Ontario, Canada), the package lets you export images to a variety of standard file formats. Compatible programs include Word for Windows, WordPerfect for Windows, Ami Pro, Microsoft Publisher, and Harvard Graphics for Windows.
Phone: (613) 728-8200.
Circle 1283 on Inquiry Card.

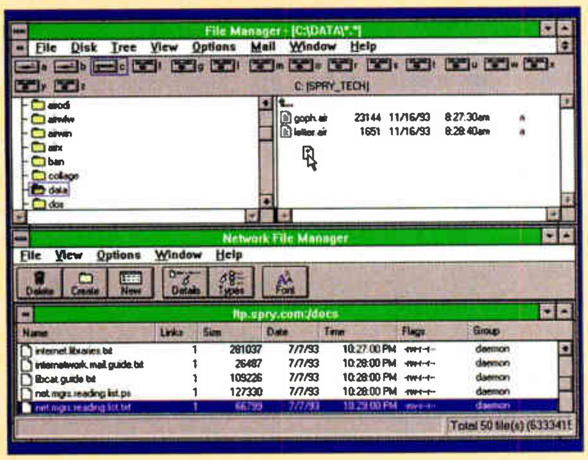
PROACTIVE TIME MANAGEMENT

A time management program for long- and short-term planning, First Things First Proactive ($149) helps you define priorities and goals and then determine the daily path to achieving them. The Macintosh program, from Visionary Software (Portland, OR), consists of five integrated modules: an outliner, a calendar, reminders, a linker of calendars or task lists, and a means to attach related files to an item and then launch them from an outline, calendar, or reminder.
Phone: (503) 246-6200.
Circle 1284 on Inquiry Card.

3-D ANIMATION SAVES SCREENS

A Windows screen saver from Forté (Carlsbad, CA), 3DPC ($19.99) combines photo-realistic, 3-D animation with surrealism. The animation includes visual effects such as morphing, texture mapping, 3-D imaging, montages, video fusion, opacity mapping, and virtual reality.
Phone: (619) 431-6400.
Circle 1297 on Inquiry Card.

TRAVEL THE INFORMATION HIGHWAY ON YOUR PC



Developed jointly by Spry and O'Reilly & Associates, Internet-In-A-Box lets you easily access the Internet from your PC. Spry's graphical network applications provide FTP, Telnet, Gopher, mail, news, WAIS, and Mosaic to let you access O'Reilly's Global Network Navigator as well as other Internet applications. The point-and-click tools are virtually transparent, according to Spry. In addition to Spry's TCP/IP applications, the package includes O'Reilly's The Whole Internet User's Guide and Catalog. NovX InterServ provides TCP/IP-based Internet services via SprintLink toll-free data services. The single-user version costs $100; the LAN version is $250. A Mac version is in the works.

Contact: Spry, Inc., Seattle, WA, (800) 777-9638 or (206) 447-0300.
Circle 1272 on Inquiry Card.

Software Update

MicroTap 3.0, Paladin Software (San Diego, CA), adds EGA/VGA font maps with an integrated font-map editor, a Hypertext reader with direct links to program-setup fields, expanded log capacity to 64 MB, and PostScript file exportation. $349.

Phone: (619) 490-0368.
Circle 1298 on Inquiry Card.

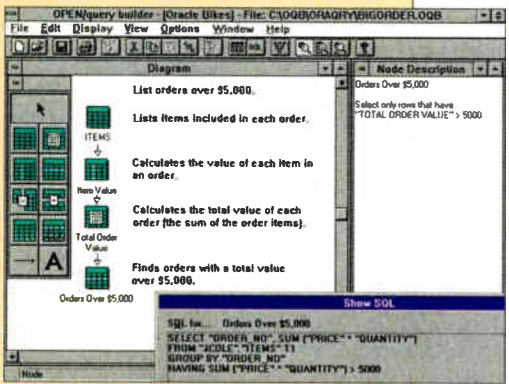
TeamOffice 3.0, TeamWare Division, ICL (Santa Clara, CA), integrates seamlessly with your existing Windows applications via TeamFlow, supports Windows NT, adds a Windows interface for asynchronous dial-up client connection, provides forum support for X.400 addresses for senders external to TeamOffice, and supports Windows for Workgroups Microsoft Mail clients using a TeamOffice back end. $495 per user for 10-user starter license.
Phone: (800) 240-8326 or (408) 982-9141.
Circle 1299 on Inquiry Card.

Calendar Manager 5.0, Russell Information Sciences (Laguna Hills, CA), lets you more easily schedule meetings and send messages to meeting schedulers; create to-do lists; and view and select Calendar Manager users, resources, and facilities across all enterprise servers. It also includes a Windows client GUI and has an optional Executive Desktop that lets you use the software as a personal appointment book and scheduler in diary format. $60 to $300 per seat; first server, $995; subsequent servers discounted.

Phone: (714) 362-4000.
Circle 1300 on Inquiry Card.

What's New Software

INTUITIVE QUERIES



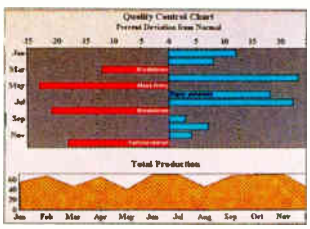
An intuitive client/server, decision-support, and data-retrieval tool, Open/query builder helps you access databases such as dBase, SQL Server, Sybase, and Oracle via ODBC. The software's graphical step-by-step approach lets you develop ad hoc queries by pointing and clicking on icons; at each step, the software prompts you for the required information. Each step is automatically documented, letting you modify, maintain, reuse, and share the results as well as the query diagram. The program costs $395.

Contact: Wang Laboratories, Lowell, MA, (800) 421-8006 or (508) 459-5000.

Circle 1273 on Inquiry Card.

FLIP THROUGH GRAPHICS IN FOXPRO

Flipper for FoxPro ($349) is a graphics library that simplifies adding charts and drawings to FoxPro for Windows programs. From ProWorks (Hermiston, OR), the software is an FLL (FoxPro DLL), which lets you use it directly from the command Window or from a FoxPro executable program. Flipper for FoxPro can display data in 2-D or 3-D and permits multiple graph types on one screen and unlimited graphs on a page. You can rotate 3-D charts to any angle or elevation and reverse *x* and



y axes on 2-D charts. The program also includes automatic axis scaling and permits two independent *y* axes. Low-level drawing functions are also available.

Phone: (503) 567-1459.

Circle 1285 on Inquiry Card.

REAL-TIME BACKUP FOR NT

Real-time backup and recovery software for Windows NT, Octopus (from $3975) protects against loss of data from problems such as electrical failure and accidental human interference. From P&W Technologies (Washington Crossing, PA), Octopus is based on electronic vaulting technology. All transactions on one computer system are automatically shadowed on another. In the event of a system failure, Octopus immediately notifies the user and begins to log the unsent file activity; recovery and restart are automatic. The one-to-many and many-to-one data-recovery system can be LAN- or WAN-based.

Phone: (215) 321-2250.

Circle 1286 on Inquiry Card.

IMPROVE YOUR WINDOWS DISPLAY

DisplayMate for Windows ($79 until May 31; $129 thereafter) improves monitor picture quality by improving sharpness and contrast, reducing certain forms of geometric distortion, minimizing or eliminating moiré patterns, and improving color and gray-scale accuracy. The Sonera Technologies (Rumson, NJ) software provides step-by-step advice on how to obtain optimum picture quality from your monitor and video board. It supports all color modes, from monochrome up through full 24-bit color.

Phone: (800) 932-6323 or (908) 747-6886.

Circle 1287 on Inquiry Card.

LISTEN TO YOUR E-MAIL

The eNote for cc:Mail package ($49), a front end to cc:Mail, lets you filter important mail messages and route them directly to the screen. From the E Ware division of Visual Cybernetics (New York, NY), the program uses cc:Mail's filtering ability so that you can screen messages by user name, priority, or subject. When both the sender and the recipient are using eNote for cc:Mail, eNote-specific data, such as sound and voice files, can be attached to the message. With the text-to-speech feature, you can tell the software to read your eNote messages aloud.

Phone: (800) 743-8645 or (212) 564-7791.

Circle 1288 on Inquiry Card.

SCANNING IN UNIX

The PixelScan plug-in module for Adobe Photoshop 2.5 ($499 until June 30; $799 thereafter) enables you to connect to scanners from most major companies while using Silicon Graphics and Sun versions of Photoshop. From Mentalix (Plano, TX), the module lets you scan all types of images and adjust and reposition an image or a portion of it; you can also control image attributes, such as contrast, intensity, and gamma, before you start scanning.

Phone: (214) 423-9377.

Circle 1289 on Inquiry Card.

Software Update

Conversion Artist 2.0, North Coast Software (Barrington, NH), supports Photoshop CMYK TIFF files and features for image color correction, stylized filters, and color separation. It also adds image editing, JPEG image compression, and a JPEG-based viewer and self-extractor. $149.95.

Phone: (603) 664-6000.

Circle 1301 on Inquiry Card.

MacFortran II 3.3, Absoft (Rochester Hills, MI), includes a full-screen source-level symbolic debugger; improved support for the 68040 CPU; MIG, a graphics library integrated with the company's Macintosh Runtime Window Environment; a software FPU; and a software emulator for machines without a math coprocessor. $595.

Phone: (313) 853-0050.

Circle 1302 on Inquiry Card.

TeleFinder 3.2, Spider Island Software (Irvine, CA), lets you view GIF files while online and automatically decompress and view graphics files while downloading them. It also has built-in drivers for V.Fast modems and supports Internet Mail access. $425.

Phone: (714) 669-9260.

Circle 1303 on Inquiry Card.

Progress 7, Progress Software (Bedford, MA), adds graphical and event-driven extensions to the 4GL and enhances the DataServer Architecture and the RDBMS. From $1400.

Phone: (617) 280-4000.

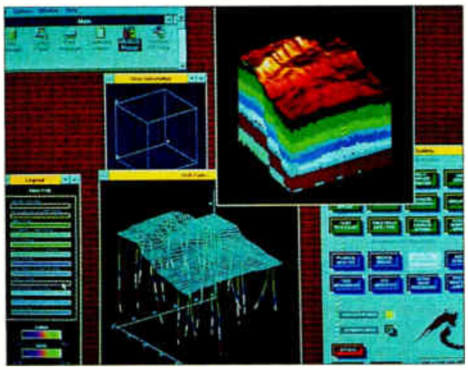
Circle 1304 on Inquiry Card.

Koyn Fractal Studio 2.0, Koyn Software (St. Louis, MO), adds color, an easy-to-use

graphical editor, high-resolution rendering capability, templates, and floating-point coprocessor support. Single-user version, $149.95.

Phone: (314) 878-9125.

Circle 1305 on Inquiry Card.



VISUAL DATA ANALYSIS ▲

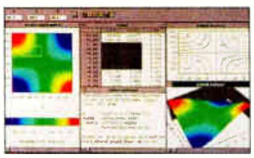
PV-Wave Personal Edition ($695), a native 32-bit application for Windows, lets you visually analyze large amounts of complex data. You can use the Visual Numerics (Boulder, CO) software to interactively explore, manipulate, analyze, and present large amounts of data quickly. Features include integrated 2-D and 3-D graphics; surface and vector plot types; image and signal processing; and support for time-series data.
Phone: (303) 530-9000.
Circle 1291 on Inquiry Card.

ERROR-LOG MONITORING

The LANStor RedAlert network management utility ($295) has the ability to proactively monitor NetWare error-log events and automatically distribute the information via a twenty-fifth line console, a pager, a workstation broadcast, cc:Fax, or cc:Mail. From Storage Dimensions (Milpitas, CA), the LANStor RedAlert utility collects and reports error information originating from any vendor-independent server, software, or peripheral that reports to the NetWare error log, according to the company. The software includes queue management and lets you customize reporting options for specific personnel.
Phone: (408) 954-0710.
Circle 1292 on Inquiry Card.

DATA ANALYSIS FOR WINDOWS ▼

Spyglass Transform ($595) has expanded to Windows and Windows NT. The visual data-analysis tool enables you to quickly analyze large matrix and image data sets. You can use the Spyglass (Savoy, IL) point-and-click options to create surface plots, color raster images, line graphs, contour plots, and vector plots from matrix data arrays. You can import data sets from ASCII spreadsheets or binary data files and add floating-point annotations, titles, axis labels, numerical scales, tick marks, and color bars.



Phone: (217) 355-6000.
Circle 1290 on Inquiry Card.

NEURAL OCR SCANNING

CharacterEyes OCR software ($695), from Ligature Software (Burlington, MA), uses advanced neural network technology to let you capture text at up to 300 characters per second with a recognition accuracy of up to 99.6 percent. You scan a document with a single click of a mouse button; the software then analyzes the page layout and recognizes and captures the text, which you can export directly into your word processor. CharacterEyes supports obscure typefaces and can read faxes, small typefaces, dot-matrix text, and degraded documents. Available for Windows and the Mac, the software runs in 32-bit mode and incorporates Hewlett-Packard's AccuPage scanning technology.
Phone: (800) 888-0060 or (617) 238-6734.
Circle 1293 on Inquiry Card.

.INI FILE CONTROL

A Windows .INI file editor, iniExpert ($34.95) has a comprehensive on-line reference. From Chattahoochee Software (Atlanta, GA), iniExpert helps you to fine-tune your .INI files by speeding up performance, avoiding system crashes, changing hardware drivers, and customizing the look and feel of Windows. By using the menu-driven interface, you can turn entries on and off without removing them.
Phone: (404) 633-3872.
Circle 1294 on Inquiry Card.

INTERACTIVE DOCUMENT CONFERENCING

Based on Unix and X Window System 11, Sietec's jointX is an independent component placed between an X server and an X client to permit interactive document conferences composed of participants in different locations. Changes made by any participant are instantly shown on the terminals of all other participants, according to the company. The package allows any TCP/IP network connection.

Three basic components make up jointX: The sharing component distributes the X events, the coordination component structures communication, and the administration component controls document access and security. The audio and video components of jointX are integrated into the system via the conference control process and run on the user's computer rather than on the conference server. Cost for the package starts at 7000 deutsche marks.

Contact: Sietec GmbH, Berlin, Germany, +49 30 386 28244; fax +49 30 386 23780.
Circle 1274 on Inquiry Card.

Software Update

PixelFX 2.5, Mentalix (Plano, TX), adds user-transparent links to FrameMaker and Interleaf programs; supports additional input, output, and image-compression file formats; enhances OCR capabilities; supports additional Unix operating systems; integrates with the ER Mapper earth-science image-processing application; and expands scanner support. $1599.
Phone: (214) 423-9377.
Circle 1306 on Inquiry Card.

Forest & Trees 3.1, Trinzic (Palo Alto, CA), includes the ability to call external DLLs; adds four database interfaces; enhances the reporting feature so you can add pictures, business graphics, and color to reports; adds a "drill down" capability to get to the appropriate level of graphical or numerical detail; expands its graphical data-analysis capabilities; and increases user-interface options. $695.
Phone: (603) 427-0444.
Circle 1307 on Inquiry Card.

Remotely Possible/LAN and Dial 4.0, Avalan Technology (Holliston, MA), includes DOS and Windows in one package, supports full-screen DOS and data transfer speeds of up to 230.4 Kbps, adds DES encryption security, supports more than 150 modems and asynchronous modem pooling, and adds remote keyboard- and screen-disabling capability and printer redirection. $199.
Phone: (508) 429-6482.
Circle 1308 on Inquiry Card.

MetaCard 3.1, MetaCard (Boulder, CO), can import and run stacks developed in HyperCard 1.2.5 and 2.1, supports object-oriented graphics and the import and display of PostScript EPS graphics, plays back FLI/FLC format animation, and adds functions for spawning and managing external processes. $495.
Phone: (303) 447-3936.
Circle 1310 on Inquiry Card.

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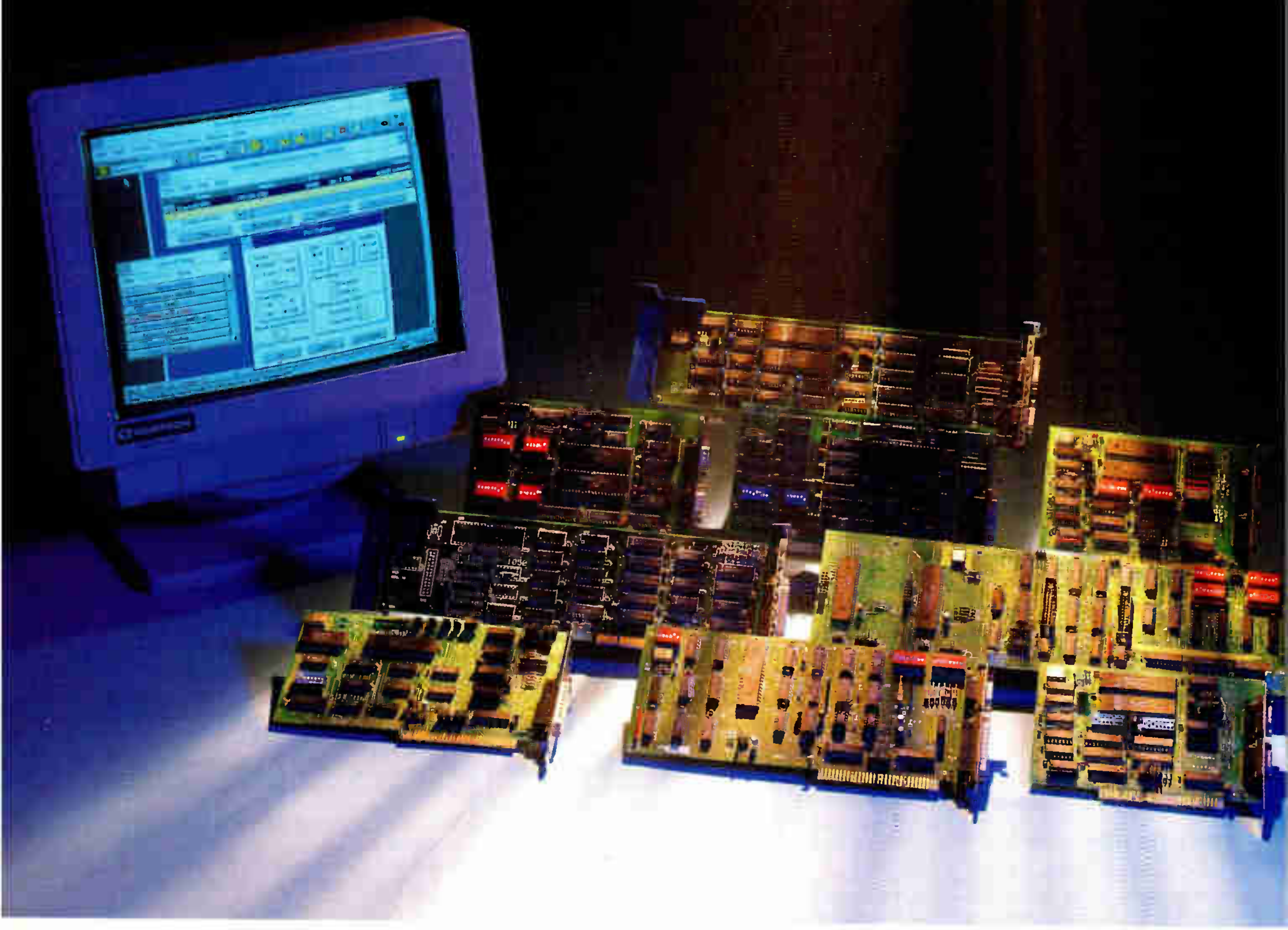

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IBM

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Texas Instruments

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T3100SX, 3200SX, SXC	2MB	$79
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T3200	3MB	$159
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IBM Continued

PS/2 90 XP, 95 XP, P75 (pairs), 56, 57 (all), PS/1 Consultant, Essential, Expert models x11, x13, x14, PS/1 Pro M2123, RS/6000 POWERstation/POWERserver 220 series					
4MB	6450128	$181	8MB	6450130	$354
PS/2 80-111; 311; 121; 321; 081; 161					
2MB	6450379				$103
PS/2 80-A21; A31; A16					
4MB	6451060				$119
Expansion boards for 50, 50Z, 55SX, 60, 65SX					
2-8MB w/2MB	1497259				$199
4-16MB w/4MB	6450609				$379
Expansion boards for all models 70, 80					
2-14MB w/2MB	34F3077				$226
4-16MB w/4MB	34F3011				$317

NEC

NEW Image 425, 433, 466					
4MB	410-12002	$181	16MB	410-12003	$647
Ready 425, 433					
4MB	N/A	$195	16MB	N/A	$649
PowerMate 386/33i; Express Te, e series					
4MB	OP-410-6205	$181	16MB	OP-410-6206	$640
PowerMate 286/12; SX/16, SX/20					
2MB Kit	OP-410-8103				$96
PowerMate 386SX/20i 20vi, 16i; 25i; 486/50i; 486/33i					
8MB Kit	OP-410-2101				$319
PowerMate SX/20					
2MB CPU Upgrade	OP-410-8101				$159
2MB Exp. Board	OP-410-8102+8103				$180
PowerMate 386/20, 25					
2MB	APC-H655	$229	8MB	APC-H656	$679

Zenith

NEW Z-300/400 Series Plus, Z-420/SX, Z-425/SX, Z-433/DX, Z-433/SX					
4MB	ME-100	$181	16MB	ME-90	$640
NEW Z-Station 325Sh, 325Sn, 420SEh; Sh; Sn, 425Sh, 433Deh, 433Dh, 450XEn					
1MB	ME-70	$39	4MB	ME-100	$181
Zenith Z-386/20; 25; 33, 33E					
1MB	ZA3800ME	$39	4MB	ZA3800MK	$181
Zenith Z-386SX/20, 286LP+, Z-LS					
2MB Kit	Z-605-1				$92

LASER PRINTER MEMORY

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2MB	MB-420	$147	4MB	MB-440	$225
Brother HL-8e, HL-8d, HL-8					
1MB	MB-810	$80	2MB	MB-820	$120
Brother HL-10V/DV					
2MB	MB-1020	$119	4MB	MB-1040	$219
Canon LBP-4SX					
2MB	R03-0020-000				$189
Canon LBP-4, 4Lite, 4Plus					
2MB	N/A				$145
Canon LBP-8II, 8IIR, 8IIT					
2MB	S63-1880	$111	4MB	N/A	$189
Canon LBP-III, 8III Plus					
2MB	S63-2350				$145
Epson EPL 6000					
2MB	IBS401	$120	4MB	N/A	$198
Epson ActionLaser II, EPL-8000					
2MB	N/A	$135	4MB	N/A	$213
Epson EPL-7500					
4MB	C822021				$235
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1MB	C2024A				$49
HP LaserJet IIP, III, IIIP, IIID					
2MB	33475B	$97	4MB	33477B	$170
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HP LaserJet IIIsi, 4, 4M, 4Si, 4SiMX, XL300, DeskJet 1200c					
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4MB	C2065A	$181	8MB	C2066A	$354
HP DeskJet 500, 500C					
256K	22707B				$40
HP DesignJet 600 Inkjet Plotter					
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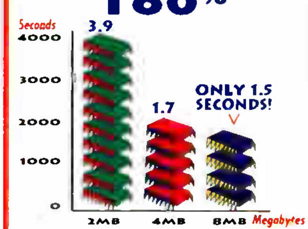
Increase Windows Performance

160%



- An upgrade from 2MB to 8MB can increase performance
- Memory allows Windows to run faster
- Reduces your system's need to access the hard disk
- Speeds up programs which use virtual memory
- Utilize numerous & extensive applications at the same time

*This graph displays the amount of time it takes to run one specific Windows application with the indicated amount of memory

IBM/Lexmark Laser 4029 All Models					
2MB	1183334	$96	4MB	1183335	$157
IBM/Lexmark Laser 4019, 4019e					
2MB	1039137	$115	3.5MB	1038675	$173
IBM Lexmark Laser 4039, 4079 All Models					
4MB	1328363	$167	8MB	1328365	$326
NEC SilentWriter 95 & 97 series					
2MB	N/A				$100
OkiLaser 400					
1MB	70014701	$67	2MB	N/A	$106
OkiLaser 800, 820					
2MB	N/A	$157	4MB	N/A	$190
Panasonic LaserPartner 4410, 4430					
2MB	KX-P444	$113	4MB	N/A	$191
Panasonic LaserPartner 4450I, 4420					
2MB	KX-P441	$129	4MB	N/A	$189
Texas Instruments MicroLaser, XL					
1MB	2555739-0001				$46

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TI 4000	4MB	2581265-001	$279	$189
Toshiba 4600	4MB	PC-PA2012U	$399	$219
Toshiba 1900	4MB	PC-PA2012U	$399	$219
IBM PS/Valuepoint	8MB	6450130	$695	$354

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256 x1	3 00	2 75	2 50	2.25
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64x1	–	–	–	2 00

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8087-1	85.00
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80387-16 DX	45 00
80387-20 DX	55 00
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Ambra NC 425SL	2/4/8 Meg	109 00/209 00/449 00
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4Meg x 9		–	165 00	159 00	149 00	–
16Meg x 9 (9 chip)	–	–		799 00	–	–

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256 x 36 1Meg	–		–	–	59 00	–
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1 x 36 4Meg		–	190 00	180 00	175 00	–
2 x 36 8Meg		–	359 00	389 00	409 00	–
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MODEL	AMT UPGRADED	AST PART #	PRICE
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	4Meg	500987 002	179 00
	8Meg	500987 003	419 00
	16Meg	500987 004	619 00
	32Meg	500987 005	1399 00
Premium 486/25 25E 33, 33E			
Premium 386/33TE 486/25TE 33TE			
Prem Serv Prem II 386SX/20 25			
Prem II 386/25 386/33 486/33 486SX/20	8Meg	500780 001	398 00
Premium 386/33T Prem 386SX/16			
Prem II 386SX/20 25		500780 004	189 00
Premium 386/25 33 386/33T 386SX/16		500780 003	59 00
Prem II 386SX20 25		500780 001	59 00
Premia	8Meg	501159 002	379 00
Premia	16Meg	501159 003	789 00
Premia	32Meg	501159 004	1469 00
Premia	64Meg	501159 005	3111 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	180.00
Z386SX	2Meg	Z-605-1 modules	119 00

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0Meg	2Meg	4Meg	8Meg	16Meg	32Meg	64Meg
$139.00	$238.00	$319.00	$499.00	$859.00	$1599.00	CALL

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30F5360 (2Meg)	30-286, 25-286, 50 MTHR BD	104.00
6450375 (1Meg)	80-041	79.00
6450379 (2Meg)	80-111, 311-121, 321, 081, 161	84 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	90.00
78X8955 (128K)	25	35.00
34F2933 (4Meg)	35SX 40SX 55SX 65SX, 56LS, 65LS	180.00
87F9977 (4Meg)	55SX, 55LS, 65SX, 40SX, 35SX, 35LS	180.00
1057035 (512K)	P/S1-286	49.00
92F9935 (2Meg)	P/S1 & P/S1/386SX-2121	99.00
92F9694 (4Meg)	P/S1 & P/S1/386SX Model-2121	189 00
6450902 (2Meg)	56, 57, 57SX, 90, 95, P-75, 57SLC Value Point 77 486DX2, 486SX, SVR 85	90 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	175 00
6450129 (8Meg)	35SX, 40SX	379 00
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4033 (32 Meg kit)	RISC System/6000	1699.00
4036 (64 Meg kit)	RISC System/6000	3319 00

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79F0999 (2Meg)	LX40, N33SX, PS Note	103.00
79F1000 (4Meg)	LX40, N33SX, PS Note, Thinkpad 350, 350c	199.00
79F1001 (8Meg)	LX40, N33SX, PS Note	349.00
07G1826 (2Meg)	N51 (all)	103.00
07G1827 (4Meg)	N51 (all)	199.00
07G1828 (8Meg)	N51 (all)	419 00
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07G1414 (2Meg)	Thinkpad 750, 750c	119 00
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07G1416 (8Meg)	Thinkpad 750, 750c	399 00
66G0094 (16Meg)	Thinkpad 750, 750c	879 00
07G1420 (4Meg)	CL57LSX LpTp, Thinkpad 700, 700C, 720, 720C	199 00
07G1421 (8Meg)	CL57LSX LpTp, Thinkpad 700 700C, 720, 720C	399 00
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60G0379 (16Meg)	Thinkpad 350, 350c	669 00
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MODEL	AMT. UPGRADED	CMPQ PART #	PRICE
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	8Meg Module	116561-001	429 00
	32Meg Module	116568-001	1459.00
DeskPro 386/33L, 486/33L	(Exp Bd)	116569-001	279 00
DeskPro 386/25, 386/20	1Meg Module	113131-001	79 00
	4Meg Module	113132-001	219 00
DeskPro 386S-16MHz	1Meg Exp Bd	113633-001	149 00
	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 386/25F	4Meg Exp Bd	113645-001	329 00
	1Meg Module	113131-001	79 00
	4Meg Module	113132-001	219 00
DeskPro 286N, 386N, 386SX/20, 386/25M, 486/33M, 486S/25M, 486S/16M	1Meg Module	118688-001	59 00
	2Meg Module	118689-001	89 00
	4Meg Module	118690-001	180 00
Port I Series 486C	8Meg Module	128877-001	389.00
M Series Exp Bd	0-64Meg	129160-001	279 00
DeskPro 386/16	1Meg Kit	108071-001	99.00
	4Meg Kit	108072-001	299 00
	1-2Meg Exp Bd	108069-001	239 00
	4-8Meg Exp Bd	108070-001	437.00
DeskPro 286	512K Kit	113012-001	49 00
DeskPro 5/60, 5/66M, 5/66M (ALL OF THESE MACHINES USE THESE MODULES)	8Meg Kit	149911-001	389 00
Prosignia 5/60	16Meg Kit	149949-001	739 00
Proliant 100 5/60	32Meg Kit	149912-001	1599 00
Proliant 2000 4/30, 5/66	64Meg Kit	149913-001	2700 00
Proliant 4000 4/50, 5/66	128Meg Kit	149914-001	5900 00
Prolinea 386 3/25S, 3/252S	2Meg	141738-001	109 00
	8Meg	141742-001	320.00
Prolinea 486 4/25S, 4/33, 4/50, 4/66, CDS	2Meg	141683-001	95 00
	4Meg	141684-001	180.00
	8Meg	141685-001	399.00
Prosignia PC Server, 486/33, 486 DSX/66	8Meg	141685-001	399 00
	16Meg	149320-001	719.00
	32Meg	149147-001	1525.00

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LTE/286	2Meg Bd	117081 002	99 00
LTE/286	4Meg Bd	117081-003	179.00
LTE/386S/20	4Meg Module	121125-002	209.00
LTE LITE/20, 25, 25C	4Meg Module	129769-002	209.00
LTE LITE/20, 25 25C	8Meg Module	129769-003	389.00
LTE LITE/20, 25, 25C	16Meg Module	129769-004	809.00
LTE LITE 4/25C, 4/23E, 433C	4Meg Module	142337-002	189.00
LTE LITE 4/25C, 4/23E, 433C	8Meg Module	142337-003	379.00
LTE LITE 4/25C, 4/23E, 433C	16Meg Module	142337-004	774 00
SLT/286	1Meg Module	110235-001	75 00
SLT/286	4Meg Module	110237-001	249 00
SLT/386	1Meg Module	118303-001	79 00
SLT/386	2Meg Module	118304-001	109 00
SLT/386	4Meg Module	118305-001	219 00
Concerto	4Meg	144790-001	229 00
	8Meg	144790-002	429 00
	16Meg	144790-003	CALL
Contura 320, 325	2Meg	139497-001	99 00
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		Lan Ethernet (10 Base T)	219.00
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T2000/T2000SX	2Meg	PC18-PA8317U	94.00
T2000SX/T1000LE	4Meg	PC-PA8314U	189.00
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	189.00
T2000SXE/2200SX/T1800, 1850, C	8Meg	PC-PA2002U	369 00
T4400SX, SXC T6400	4Meg	PC-PA2004U	199 00
T4400SX, SXC T6400	8Meg	PC-PA2005U	379 00
T4400SX, SXC T6400	16Meg	PC-PA2010U	699 00
T4500, T4500C, T4600, T1900, T1900C (3.3 v)	4Meg	PC-PA2012U	209.00
T4500, T4500C, T4600, T1900, T1900C (3 3 v)	8Meg	PC-PA2013U	429.00
T4500, T4500C, T4600, T4700, T1900, T1900C, T1950 (3.3 v)	16Meg	PC-PA2014U	884.00
T3300SL	6Meg	PC-PA2008U	268 00
T3300SL	16Meg	PC-PA2009U	699.00
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T1200XE	2Meg	PC13-PA8306	99.00
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T3100SX	2Meg	PC15-PA8308U	109 00
T3100SX	4Meg	PC15-PA8310U	209 00
T3200	3Meg	PC6-PA7137U	185.00
T3200SX	2Meg	PC12-PA8307U	119.00
T3200SX	4Meg	PC12-PA8909	209.00
T3200SXC	2Meg	PC19-PA8318U	119.00
T3200SXC	4Meg	PC19-PA8319U	219.00
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T5200/T8500	8Meg	PC10-PA8313U	419.00

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MODEL	AMT. UPGRADED	MANU. PART #	PRICE
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ACER 750	4Meg/8Meg/16Meg		199/459/869
ALR Venture	4Meg	12407980	249 00
AST Bravo & Explorer	4Meg, 16Meg	501255-001, -002	199 00/829 00
AST Notebook Prem Exec 386SX/20/25/25L	4Meg	500814-003	189 00
AST Power Exec 3/25C, 425EL	4Meg		199 00
AST Power Exec 3/25C, 425EL	16Meg		819 00
AST Power Exec 425SL	4Meg	501166-001	199 00
AST Power Exec 425SL	16Meg	501166-003	819 00
AST Power Exec 4/33SL	4Meg/16Meg	501318-001,002	CALL/CALL
AT&T Safari NSX/20	4Meg	PEC 37651	259 00
Bondwell B310, Plus	1Meg	23050-09100	109 00
Bondwell B310V, SX	1Meg		109 00
Bondwell B310V, SX	4Meg		229.00
Dec pc 425SL	4Meg/16Meg		CALL/CALL
Epson NB3	4Meg	A808511	199 00
Everex Tempo LX, LX20, Carrier	2Meg	FCA 00053-0001	109 00
Gateway 2000 Nomad 425 DXL/DXL	4Meg/16Meg		199 00/1549 00
Gridstar GS520 386SX/16	4Meg	S386 4M	249 00
Magnavox Metals	1Meg, 4Meg	286, 386SX	109 00,199 00
NEC Prospeed 286, 386SX-16	1Meg	PC21-21	79 00
NEC Prospeed 286, 386SX-16	4Meg	PC21-22	199 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	199 00
NEC Ultralite III/20, 20P, 25C	2Meg	PC47-21	109 00
NEC Ultralite III/SL/25C	4Meg	PC47-22	199 00
NEC Ultralite SL/20, 20P	6Meg	PC49-21	309 00
NEC Ultralite III/25C	8Meg	PC47-23	389 00
NEC Ultralite Versa	4 Meg/8Meg/16Meg/20Meg	OP4104	183, 369, 799, 988
Packard Bell 386SX, 286	1Meg 4Meg	286, 386SX	109 199
Panasonic CF170, CF270 CF370	1Meg	CF-BA165	49 00
Panasonic CF380	2meg/4Meg/6Meg		CALL/CALL/CALL
Panasonic CF480	2Meg/6Meg		CALL/CALL
Sanyo 17/18 NB	2Meg	MBC-NBMEM2	109 00
Sharp 6781, 6881, 6785	2Meg/4Meg		109 00/199 00
Sharp PC 6220	1Meg	CE 621B	79 00
Tandon, PC Brand, Dataworld	2Meg, 8Meg	NB386SX-20	119 00 429 00
TI Travelmate 2000	1Meg	2568034-0001	79 00
TI Travelmate 3000	2Meg	2566996-1	84 00
TI 4000	4Meg, 16Meg		199 00 1549 00
Twinhead Altima, Compudyne Tandy 4860, 486SX, Ox	4Meg/16Meg		199 00/859 00
Zeos 386Sx Notebook	2Meg		109 00
Zenith Master Sport 386SX	2Meg	ZA-300-1	114 00
Zenith Master Sport SL, SLE	2Meg	ZA-4 4	119 00
Zenith Super Sport 286 286E	1Meg	ZA-180-66	99 00
286E SX	2Meg	ZA-180-64	179 00
SX Alpha	2Meg	ZA-180-86	179 00
SX Beta	2Meg	ZA-180-87	179 00
Zenith Z-Note 325L LC	2Meg/8Meg	ZA3250-4/5	129 00/419 00
Zenith Z-Note 425LN LNC LNP	4/8/16Meg		269/519/839

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AMOUNT UPGRADED	OK Bd	256k	1	2	3	3 5	4	5	6	8	16	32
Canon LBP4, 4Lite 4plus	-	-	159	219	-	-	-	-	-	-	-	-
Compaq Pagemarq	-	-	-	99	-	-	180	-	-	369	-	-
Epson 6000, Action Laser	-	-	-	139	-	-	229	-	-	-	-	-
Epson Action Laser II	-	-	89	-	Call		-	Call	-	-	-	-
Epson 8000	-	-	89	-	Call	-	-	Call	-	-	-	-
Epson 1000 1500	-	-	-	Call	-	-	Call		Call	-	-	-
HP 2 2D	-	-	-	109	-	-	189	-	-	-	-	-
HP 3, 3D, 3P, 2P 2P+	-	-	-	101	-	-	179		-	-	-	-
HP 4, 4M, 4SI, 4SIMX, 4P, 4MP	-	-	-	89	-	-	180	-	-	364	-	-
HP 4L	-	-	59	-	-	-	-	-	-	-	-	-
HP 3SI	-	-	69	-	-		180	-	-	359	-	-
HP 4SI	-	-	-	69	-		180	-	-	359	-	-
HP Design Jet 600, 650	-		-		-		180	-	-	359	-	-
HP Deskjet 500, 500C, 550	-	59	-	-	-		-	-	-	-	-	-
HP Deskjet 1200C, 1200C/P	-	-	-	89	-		180	-	-	359	-	-
HP Paintjet XL300	109		-		-	-	289	-	-	469	837	-
IBM Laser 4019, 4019E	-	-	-	-	-	159	-			-	-	-
IBM Laser 4029	-	-	-	-	-		180	-	-	-	-	-
IBM Laser 4039, 4079	-	-	-	99	-		180	-		350	-	-
NEC 90 290	-	-	-	139	-	-	-	-	-	-	-	-
NEC 95 97	-	-	-	99	-	-	-	-	-	-	-	-
Oki 400	-	-	-	89	-				-	-	-	-
Oki 400 E	-	-	135	189	-	-	-	-	-	-	-	-
Oki 830, 840	-	-	-	109	-	-	-	-	-	-	-	-
Packard Bell PB 9500	-	-	-	139	-	-	227	-	-	-	-	-
Packard Bell 9815	-	-	-	180	-	-	299	-	-	-	-	-
Panasonic 4420/4450i	-	-	-	129	-	-	209	-	-	-	-	-
Panasonic 4410/4430	-	-	-	126	-		195	-	-	-	-	-
Panasonic 4450	-	-	99	-	-	-	-	-	-	-	-	-
TI XL/PS17/PS35	-	-	55	-	-	-	-	-	-	-	-	-

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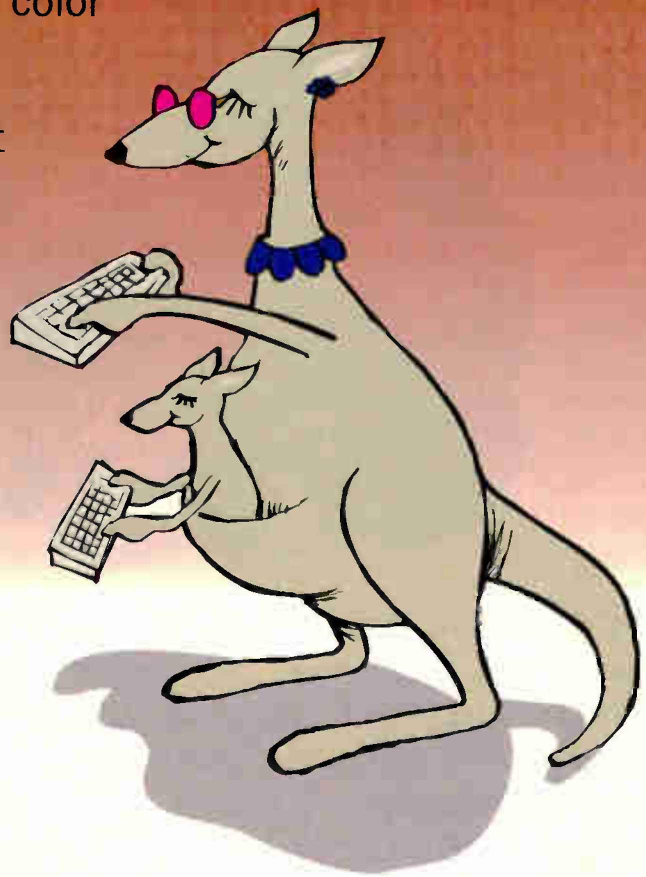

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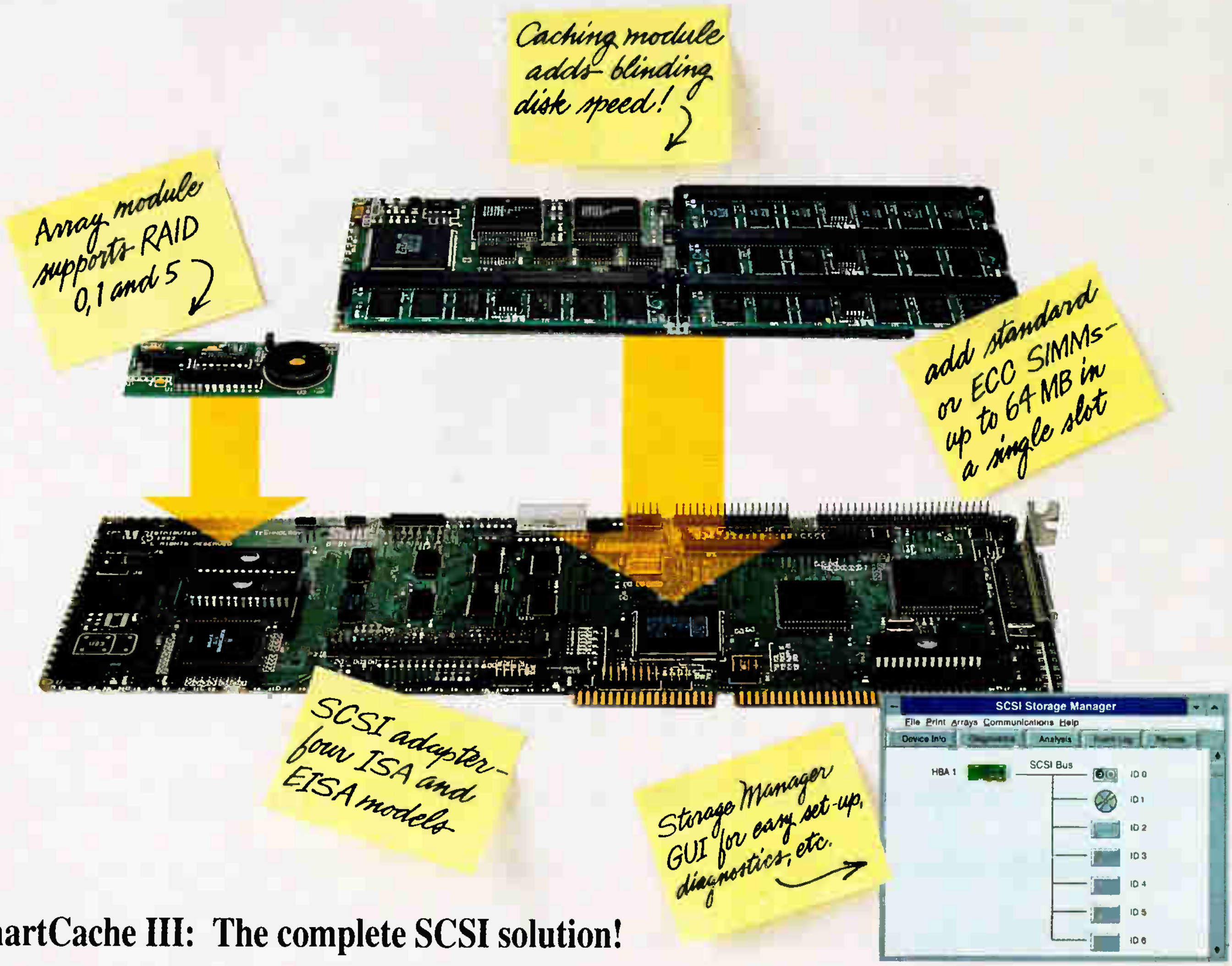

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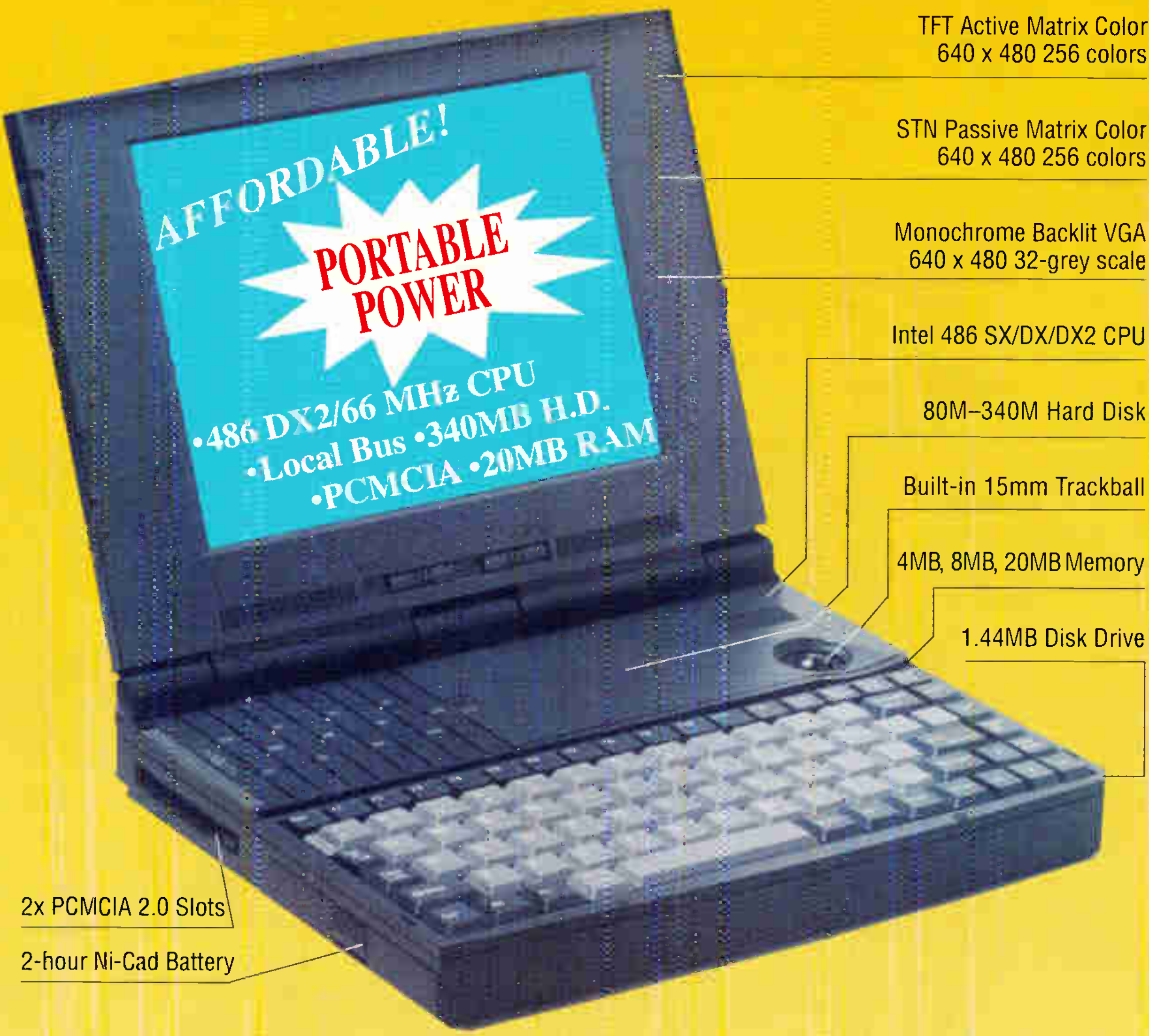

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SVC Mirror Boards control sets of 2 identical IDE drives. All data written to the primary drive is simultaneously written to the second drive. If either drive fails, an alarm sounds and you are automatically shifted to the other drive. The average life of a hard disk is 4 years. If data integrity is important to your business, there is no safer, faster or more trouble-free data insurance.

Technical details:

On-board 33MHz or 75MHz (equivalent to Intel™ 8051) CPU. 16K Static Cache. On-board BIOS is self installing and totally transparent to the operating system, other controller cards on the bus, and network software. Operates at the full speed of the bus. No software or expensive software upgrades are ever required. RAID1 compatible. Far faster than software based RAID solutions. Only available from SVC. World leaders in fast I/O.

ISA 16-bit Mirroring IDE Drive Controllers:

ADP104 - Controls 2 sets of 2 hard drives to 8GB **$75**

ADP108 - Controls 2 sets of 2 hard drives to 8GB plus 4 mixed capacity floppy drives to 2.88MB **$125**

VESA 32-bit Mirroring IDE Drive Controllers:

ADP111VL Super I/O - Single-board control for 2 sets of 2 mirrored hard drives to 8GB, plus 2 IDE devices (HD, tape or CD-ROM) and 2 mixed floppy drives to 2,88 MB. 2 serial, 1 parallel and 1 game port **$145**

VESA 32-bit Super I/O Controller

ADP90VL - Controls 4 independent IDE hard drives of any capacity to 8GB, plus 2 mixed floppy drives to 2.88 MB. Provides 2 serial, 1 parallel and 1 game port **$59**

Universal IDE Controllers

ADP60F 16-bit IDE Controller. Works with all 16-bit ISA systems. Controls 2 IDE drives to 1.6 Gigabytes. Controls 2 floppies of any capacity. On-board intelligent BIOS is relocateable. **$49**

ADP50 8-bit IDE Controller. Interfaces 2 16-bit IDE hard drives to the 8-bit bus. Works with all XT compatibles including IBM, Compaq, Tandy and ATT. **$39**

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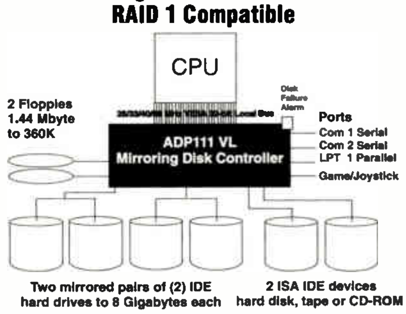

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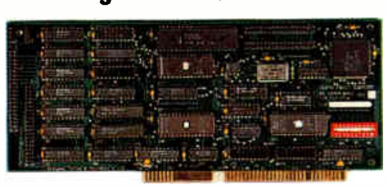
Mirroring IDE Drive Kits



ISA 16-bit ADP104 plus 1 drive

210 MB	14ms Conner Drive	$295
420 MB	14ms Conner Drive	$395
540 MB	10ms Conner Drive	$495
810 MB	10ms Conner Drive	$695
1080 MB	10ms Conner Drive	$795

Above kits with ADP111 32-bit VESA Mirroring (automatic backup) add: **$45**

SVC 8-bit or 16-it Hard Drive Kits Featuring Fast Conner Hard Drives

These kits work with any 8 or 16-bit ISA Bus PC or AT machine including Compaq, IBM, AST, Tandy, ATT, Dell, Gateway and other ISA-bus compatibles. On-board ROM BIOSs are self-installing and co-exist with other controllers on the bus.

All kits include: **High-speed SVC IDE controller, Conner caching drive, cables and installation instructions.**

Capacity	Speed	Throughput	Price
210 MB	14ms	7.5 MBPS	$224.00
420 MB	14ms	7.5 MBPS	$314.00
540 MB	10ms	8.0 MBPS	$444.00
810 MB	10ms	8.0 MBPS	$644.00
1080 MB	10ms	8.0 MBPS	$724.00

8-bit kits interface 16-bit drives to any ISA PC or AT 8-bit slot. Controllers are available separately.

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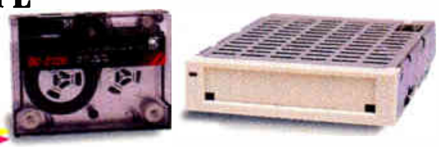

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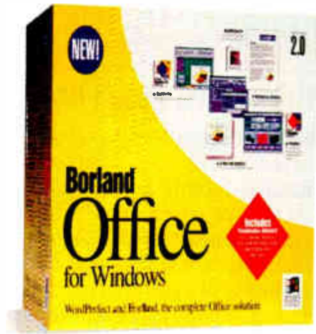
This QIC-80 Tape Unit, from CORE International, is a slim, high performance 250MB tape drive. AIWA, the parent company, has been in the tape business longer than anyone. Here's what makes this tape backup attractive besides a very competitive price? 1) Ferrite read/write heads. (Brass is used by all other manufacturers because it costs less). 2) It'll fit in your 3.5" drive bay, but comes with a 5.25" adapter as well which means it going to save you space. 3) It comes with the award winning Central Point Back-up Program. 4) It will read and write tapes backed up on other brands. 5) It has an incredible data transfer rate of as much as 1Mbps. 6) It comes with a simple step-by-step manual making installation a snap. Quality, Flexibility, Speed and Compatibility and look at the price. Order #40209.



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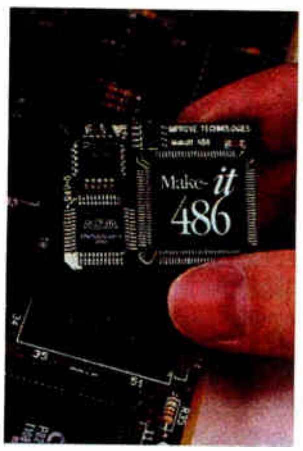

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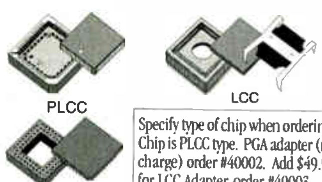

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Place: McGraw-Hill World Headquarters, New York City

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MA15F-6	15 female to RJ-11	3.50	2.80	2.40
MA25M-6	25 male to RJ-11	3.00	2.40	1.90
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Part#	Description	Each	25-99	100+
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MA15F-8	15 female to RJ-45	4.00	3.20	2.80
MA25M-8	25 male to RJ-45	3.50	2.80	2.40
MA25F-8	25 female to RJ-45	3.50	2.80	2.40

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MA25M-6TS	25 male to RJ-11	1.99	1.69	1.39
MA25F-6TS	25 female to RJ-11	1.99	1.69	1.39
MA9M-8TS	9 male to RJ-45	1.99	1.69	1.39
MA9F-8TS	9 female to RJ-45	1.99	1.69	1.39
MA25M-8TS	25 male to RJ-45	1.99	1.69	1.39
MA25F-8TS	25 female to RJ-45	1.99	1.69	1.39
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Modular Adapter Kits for DEC Systems

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MA9M-6D	9 male to 6 pin DEC	$4.50	$4.00	$3.50
MA9F-6D	9 female to 6 pin DEC	4.50	4.00	3.50
MA25M-6D	25 male to 6 pin DEC	4.50	4.00	3.50
MA25F-6D	25 female to 6 pin DEC	4.50	4.00	3.50

Modular Cord Couplers

Part#	Desc.	Each	25-99	100+
CC-6C	6 wire	$1.50	$1.20	$1.00
CC-8C	8 wire	2.00	1.60	1.33

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Part#	Each	25-99	100+
MTC-6C	$1.73	$1.38	$1.15
MTC-8C	2.43	1.94	1.62

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60-3011	Flat Cable Cutter & Stripper	$5.95
MCT-06	Modular Crimping Tool (MP-4/6)	12.95
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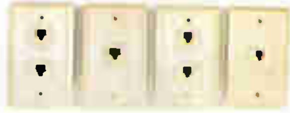

Modular Wall Plates

Modular jacks to screw terminals

Part#	Description	Each	25-99	100+
MWP6-1	6 conductor 1 jack	$1.83	$1.46	$1.22
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MWP8-1	8 conductor 1 jack	1.85	1.48	1.23
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BNC Wall Plates

Part#	Description	Each	25-99	100+
BNC1-3/8	One Hole 3/8"	$1.76	$1.60	$1.47
BNC2-3/8	Two Hole 3/8"	1.76	1.60	1.47
BNC1-1/2	One Hole 1/2"	1.76	1.60	1.47
BNC2-1/2	Two Hole 1/2"	1.76	1.60	1.47
BNC1-5/8	One Hole 5/8"	1.76	1.60	1.47
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Part#	Description	Each	25-99	100+
SM-6	6 Cond. surface mt.	$1.83	$1.46	$1.22
SM-6-2IDC	6 Cond. surface mt. IDC type	3.30	3.00	2.75
SM-8	8 Cond. surface mt.	3.08	2.46	2.05
SM-8-2IDC	8 Cond. surface mt. IDC type	3.76	3.42	3.13

IDC Punch Down Type

Part#	Description	Each	25-99	100+
SM-4IDC	4 Cond. IDC type	$3.87	$2.90	$2.32
SM-6IDC	6 Cond. IDC type	4.30	3.23	2.58
SM-8IDC	8 Cond. IDC type	4.80	3.60	2.88

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Part#	Description	1-99	100-999	1000+
MP-4M	4 pin handset plug 4x4	$.20	$.15	$.11
MP-4	4 pin RJ-11 plug 4x6	.20	.15	.11
MP-6	6 pin RJ-12 plug 6x6	.25	.18	.14
MP-8	8 pin RJ-45 plug 8x8	.30	.22	.17
MP-10	10 pin - 10 x 10 plug	.58	.46	.40
MP-4S	4 pin for 24 AWG Solid Wire	.24	.18	.14
MP-6S	6 pin for 24 AWG Solid Wire	.29	.22	.18
MP-8S	8 pin for 24 AWG Solid Wire	.35	.26	.21

Modular Plugs for DEC Systems

Part#	Description	1-99	100-999	1000+
MP-6D	Locking key is on side	$.45	$.35	$.27

Modular Wire

Part#	Description	Per Ft.	100 Ft.	1000 Ft.
MW-4	4 conductor	$.08	$.04	$.033
MW-6	6 conductor	.14	.07	.054
MW-8	8 conductor	.17	.08	.067
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8W-6P	8 wire 6 port	14.89

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Part#	Description	Each
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66M2-1	Punch Down Block w/1 Telco Conn.	22.85
66M2-2	Punch Down Block w/2 Telco Conn.	32.31

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66PDT	Punch Down Tool	$13.99

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Part#	Description	1-99	100-499	500+
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CCW2P1000	2 Pair on 1000 Foot Spool	29.99

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T50MM-25	25 ft.	15.79	T50FF-25	25 ft.	15.79
T50MM-50	50 ft.	22.99	T50FF-50	50 ft.	22.99
T50MM-100	75 ft.	31.39	T50FF-75	75 ft.	31.39
T50FF-100	100 ft.	37.69	T50FF-100	100 ft.	37.69

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T50MF-10	10 ft.	11.49
T50MF-15	15 ft.	12.89
T50MF-25	25 ft.	15.79
T50MF-50	50 ft.	22.99
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BC-750LAN	750VA, 4 Outlet, LAN Port	309
BC-900LAN	900VA, 4 Outlet, LAN Port	379
BC-1250LAN	1250VA, 4 Outlet, LAN Port	529
BC-4000LAN	4000VA, 4 Outlet, LAN Port	2549
OMNI-500LAN	500VA, 4 Outlet, LAN Port	275
OMNI-750LAN	750VA, 4 Outlet, LAN Port	415
OMNI-900LAN	900VA, 4 Outlet, LAN Port	505
OMNI-1250LAN	1250VA, 4 Outlet, LAN Port	635
OMNI-2000LAN	2000VA, 4 Outlet, LAN Port	1065

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LC-1200	1200W, 4 Outlets	139
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IB4	4 Outlet, 6 ft. Cord	43
IB6	6 Outlet, 6 ft. Cord	51
IB8	8 Outlet, 12 ft. Cord	61
IBR-12	12 Outlet, 19" Rack Mnt.	89
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IB6ULTRA	6 Outlet, 3 Filtered, 6 ft Cord	56
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ISOTELULT6	6 Outlet, 3 Fltrd, RJ11 Jacks, 6' Cord	62
ISOTELULT8	8 Outlet, 4 Fltrd, RJ11 Jacks, 6' Cord	74
IB2ULT428	2 Outlet, Direct Plug-In, 15A	32
IB2ULTCOPY	2 Outlet, Direct Plug-In, 20A	44
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RG-62U	93 Ohm Arcnet	0.11	0.073
PRG-62U	93 Ohm Arcnet (Plenum)	0.36	0.243
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9201-BEL	RG-58/U, 20AWG .033 Solid, 78% Shield	0.14	0.11
9907-BEL	Thin Ethernet, 20AWG (19x32) Strd, 100% Shield, NEC CL2 CSA	0.19	0.15
PLENUM (50 OHM) COAXIAL COMPUTER-INSTRUMENTATION CABLE			
89907-BEL	Thin Ethernet, 20AWG (19x32), 100% Shield, NEC CL2P CSA	0.34	0.27
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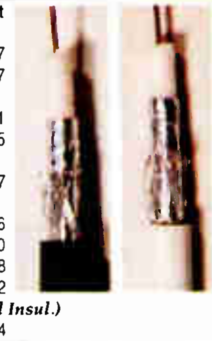
1596A-BEL	Level 4, Two Pair, Poly insulated, PVC Jacket,NEC CM CSA	0.07	0.06
1455A-BEL	Level 4, Four Pair, Poly insulated, PVC Jacket,NEC CM CSA	0.12	0.10
1588A-BEL	Level 5E, Two Pair, Poly ins., PVC Jacket,NEC CM CSA	0.10	0.08
1583A-BEL	Level 5E, Four Pair, Poly ins., PVC Jacket,NEC CM CSA	0.15	0.12
TYPE 1A MEDIA IEEE 802.5 IBM CABLING (Bare 22AWG Copper, Beldfoil Paired Insul.)			
9688-BEL	2Pair, 150ohm, 65% braid shield, Black, NEC MP/CM CSA	0.31	0.24



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27-9101	BNC 3 Pc. Male Crimp (RG58)	1.28	1.18	1.09
27-9100	BNC 3 Pc. Male Crimp (RG59/62)	1.28	1.18	1.09
27-9201	3 Pc. RG-58AU Crimp On	1.95	1.80	1.67
27-9208	BNC 3 Pc. Crimp On (Teflon)	1.95	1.80	1.67
27-9000	BNC 2 Pc. Male Crimp (RG59/62)	1.43	1.32	1.22
27-9001	BNC 2 Pc. Male Crimp (RG58)	1.43	1.32	1.22
27-9050	BNC Male Twist On (RG59/62)	1.17	1.08	1.00
27-9051	BNC Male Twist On (RG58)	1.17	1.08	1.00
27-9059	BNC Twist On for 58 Plenum	2.17	2.00	1.86
27-8140	BNC T (2 Female, 1 Male)	2.93	2.70	2.51
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58BC-25	RG58 M-M, 25', Ethernet	6.79	5.66	4.24
58BC-50	RG58 M-M, 50', Ethernet	8.89	7.41	5.56
62BC-10	RG62 M-M, 10', Arcnet	6.89	5.74	4.31
62BC-25	RG62 M-M, 10', Arcnet	9.39	7,82	5.87
62BC-50	RG62 M-M, 50', Arcnet	13.89	11.58	8.69

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APT-001	8P MiniDIN Male to Two 3P Min DIN Females	21.99
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MCP20P	Male Machined Contacts	0.20	0.18
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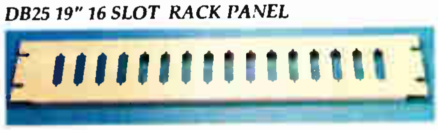

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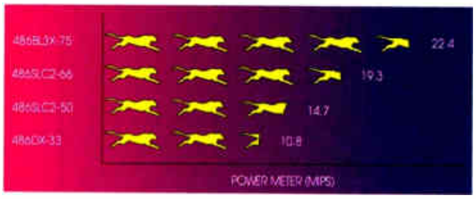

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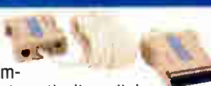

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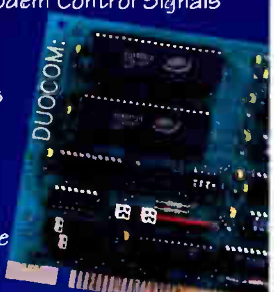

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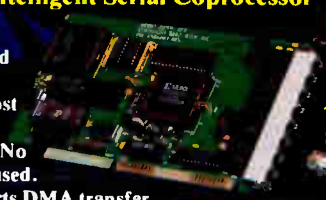

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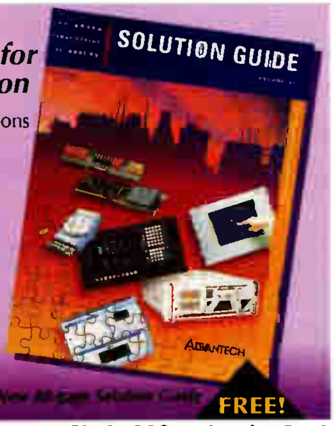

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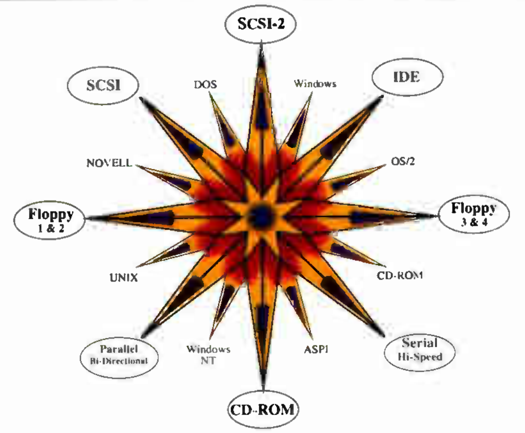

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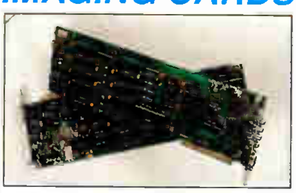

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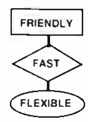

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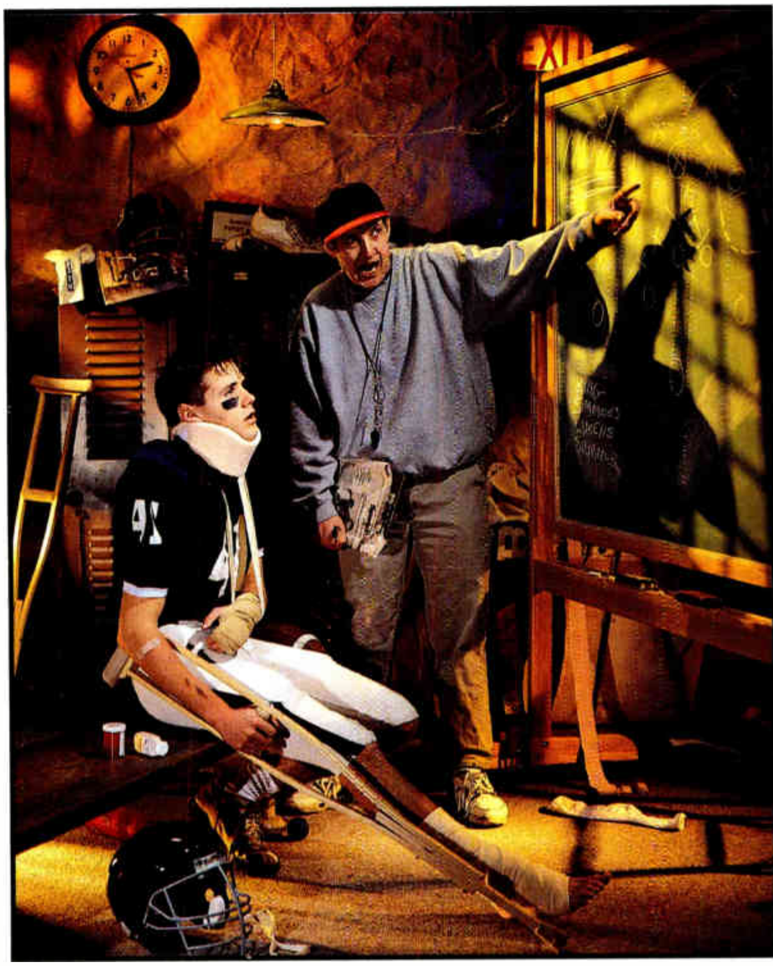

Photo by Dana Simmons

Commentary **Fred R. Shapiro**

The First Bug

Exposing the myth behind the first bug reveals a few tales

ALAN S. ORLING © 1994

Etymological folklore is remarkably persistent. Neither lack of documentation, nor lack of plausibility, nor even outright disproof seems to pose much of an obstacle to the career of a colorful word-story. For example, the term *hooker*, meaning "prostitute," is frequently said to be derived from the name of a Civil War general. The fact that the *OED* (*Oxford English Dictionary*) records the use of *hooker* in this sense as early as 1845, long before General Hooker came on the scene, has had little impact on the popularity of this tale.

A spurious account of the origin of the computer terms *bug* ("a defect in hardware or software") and *debug* ("to eliminate such defects") has become the most popular item of etymological folklore of our time. The legend derives the terms from an actual moth found inside an early computer by the pioneer computer scientist Grace Murray Hopper. A typical recital runs as follows:

"One day in the 1940s, Harvard's famed Mark I—the precursor of today's computers—failed. When the Harvard scientists looked inside, they found a moth that had lodged in the Mark I's circuits. They removed the moth with a pair of tweezers, and from then on, whenever there was a problem with the Mark I, the scientists said they were looking for bugs. The term has stuck through the years." (*Dun's Business Month*, February 1983)

In some versions, the moth is said to have inspired the scientists to speak from then on of *debugging* the computer, with *bug* originating as a later derivative of *debug*.

This moth myth has been repeated in countless computer dictionaries, textbooks, guides, and histories. Even an ostensibly scholarly journal, the *Annals of the History of Computing*, has worked hard to promote the story.

I must note that there does appear to have been a moth found in the Mark II (not the Mark I) by Hopper and her colleagues at Harvard. It is preserved at the Naval Museum in Dahlgren, Virginia, taped to Hopper's log of September 9, 1945. However, the claim that computer defects are called bugs *because* the moth was found is easily disproved. The *OED* records such a meaning of *bug* (4b; "a defect or fault in a machine, plan, or the like") as early as 1889. In that year, the *Pall Mall Gazette* (March 11) reported that "Mr. Edison... had been up the two previous nights discovering a 'bug' in his phonograph—an expression for solving a difficulty, and implying that some imaginary insect has secreted itself inside and is causing all the trouble."

On November 18, 1878, Edison wrote to Theodore Puskas, "It has been just so in all my inventions. The first step is an intuition—and comes with a burst, *then* difficulties arise. This thing gives out and then that—"Bugs"—as such little faults and difficulties are called—show themselves and months of anxious watching, study and labor are requisite before commercial success—or failure—is certainly reached" (Matthew Josephson, *Edison: A Biography*, John Wiley & Sons, 1992, page 198).

It is plain from citations in the *OED*, the *Dictionary of Americanisms*, and the 1878 Edison quotation that, moth notwithstanding, the computer term *bug* was merely a specialized application of a general engineering term dating from the 1800s. This meaning was common enough by 1934 to be recognized in *Webster's New International Dictionary*: "bug, n... 3. A defect in apparatus or its operation... *Slang, U.S.*"

Hopper and her colleagues must have thought the discovery of the moth remarkable because mechanical defects were *already* called bugs. Her September 9, 1945, log entry, which reads, "First actual case of bug being found," makes this quite clear. Even the verb *debug* must have predated Mark II, since the *OED* cites a 1945 use in the *Journal of the Royal Aeronautical Society*, which was probably preceded by several years of oral use in engineering slang.

The argument is clinched by remarks made by J. Presper Eckert, the coinventor of ENIAC, the first fully electronic digital computer. In an interview in *Computerworld* (George Harrar, "In the Beginning...," November 3, 1986), Eckert was asked, "Do you know how the term *bug* originated?" He replied, "I know how Grace Hopper thinks it originated. She tells this fanciful story. As far as I know, this was a term in use by engineers, both mechanical and electrical, for difficulties in the equipment long before Grace Hopper ever heard of any of these things. What it amounts to is that it was a new term to Grace. I've never called her up and told her that that's nuts, but it is nuts. That term was in wide use before then." ■

Fred R. Shapiro is associate librarian for public services and lecturer in legal research at Yale Law School. He is also the editor of the Oxford Dictionary of American Legal Quotations *(Oxford University Press, 1993). He can be reached on the Internet at shapiro@yalevm.cis.yale.edu, or on BIX c/o "editors."*

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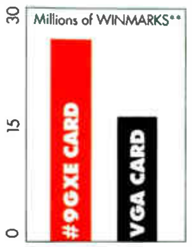

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